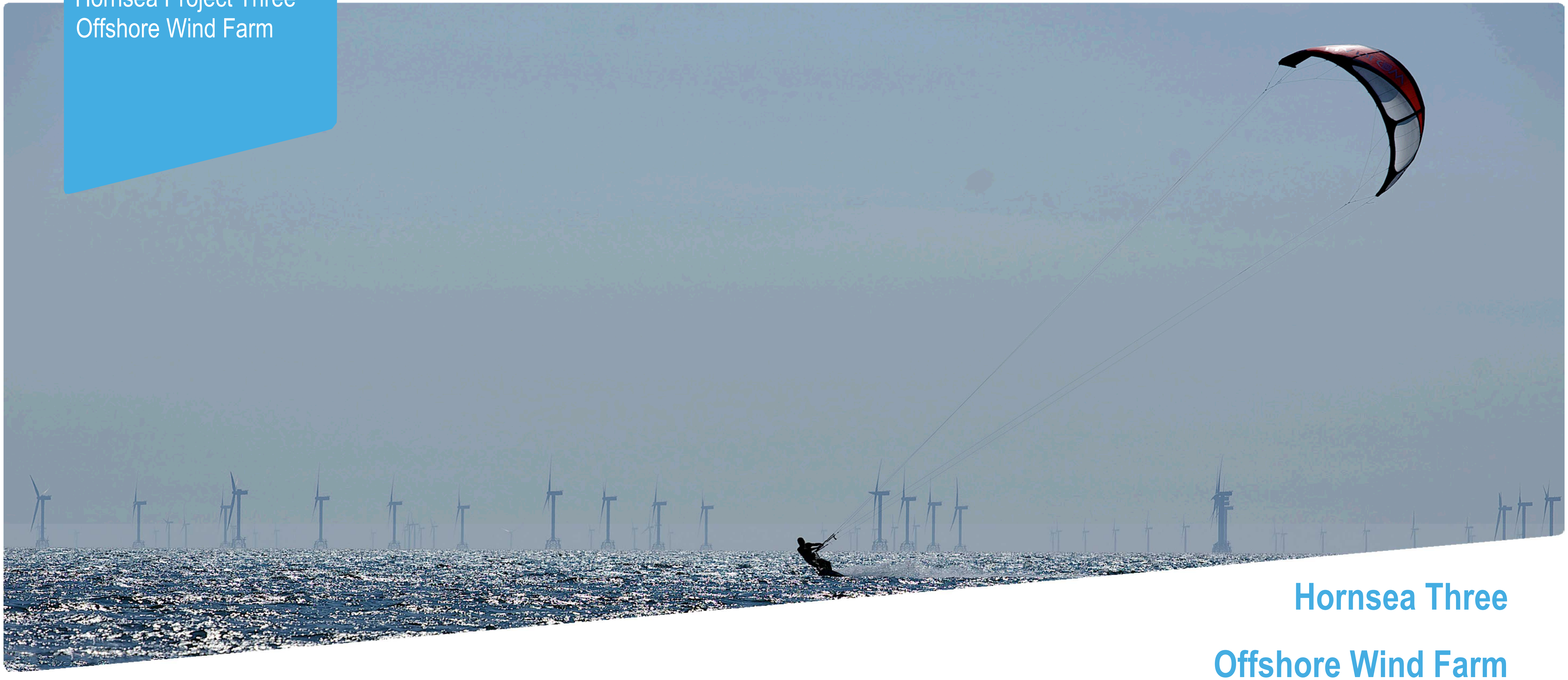
Hornsea Project Three
Offshore Wind Farm



Hornsea Three

Offshore Wind Farm

Environmental Statement:
Volume 2, Chapter 5 - Offshore Ornithology

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Hornsea 3
Offshore Wind Farm

Ørsted

Environmental Impact Assessment

Environmental Statement

Volume 2

Chapter 5 – Offshore Ornithology

Report Number: A6.2.5

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Glossary

Term	Definition
Bathymetry	The measurement of water depth in oceans, seas and lakes
Birds Directive	European Parliament and Council Directive 2009/147/EC on the conservation of wild birds – a key legislative measure for the protection of birds in the European Union
Environmental Statement	Includes relevant information required to assess the likely significant environmental effects of the development listed
Former Hornsea Zone	The Hornsea Zone was one of nine offshore wind generation zones around the UK coast identified by The Crown Estate (TCE) during its third round of offshore wind licensing. In March 2016, the Hornsea Zone Development Agreement was terminated and project specific agreements, Agreement for Leases (AfLs), were agreed with The Crown Estate for Hornsea Project One, Hornsea Project Two, Hornsea Project Three and Hornsea Project Four. The Hornsea Zone has therefore been dissolved and is referred to throughout the Hornsea Project Three Scoping Report as the former Hornsea Zone.
Hornsea Project One	The first offshore wind farm project within the former Hornsea Zone. It has a maximum capacity of 1.2 gigawatts (GW) or 1,200 MW and includes all necessary offshore and onshore infrastructure required to connect to the existing National Grid substation located at North Killingholme, North Lincolnshire. Referred to as Hornsea Project One throughout the ES.
Hornsea Project Three offshore wind farm	The third offshore wind farm project within the former Hornsea Zone. It has a maximum capacity of 2.4 GW (2,400 MW) and includes offshore and onshore infrastructure to connect to the existing National Grid substation located at Norwich Main, Norfolk. Referred to as Hornsea Three throughout the ES.
Hornsea Project Two	The second offshore wind farm project within the former Hornsea Zone. It has a maximum capacity of 1.8 GW (1,800 MW) and includes offshore and onshore infrastructure to connect to the existing National Grid substation located at North Killingholme, North Lincolnshire. Referred to as Hornsea Project Two throughout the ES.
Mean High Water Spring (MHWS)	The height of mean high water during spring tides in a year.
Statutory Nature Conservation Bodies	Comprised of JNCC, Natural Resources Wales, Department of Agriculture, Environment and Rural Affairs/Northern Ireland Environment Agency, Natural England and Scottish Natural Heritage these agencies provide advice in relation to nature conservation to government

Acronyms

Unit	Description
ASL	Above Sea Level
BDMPS	Biologically Defined Minimum Population Scale
CV	Coefficient of Variation
DCO	Development Consent Order
DECC	Department for Energy and Climate Change
EIA	Environmental Impact Assessment
ES	Environmental Statement
EU	European Union
EWG	Expert Working Group
FAME	Future of the Atlantic Marine Environment
GPS	Global Positioning System
HRA	Habitats Regulations Assessment
HVAC	High Voltage Alternating Current
IPC	Infrastructure Planning Commission
JNCC	Joint Nature Conservation Committee
MHWS	Mean High Water Spring
MMO	Marine Management Organisation
PCH	Potential Collision Height
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
pSPA	Potential Special Protection Area
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
SD	Standard Deviation
SMP	Seabird Monitoring Programme
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area

Unit	Description
SOSS	Strategic Ornithological Support Services
SOSS MAT	Strategic Ornithological Support Services (SOSS) Migration Assessment Tool (MAT)
SSSI	Site of Special Scientific Interest
STAR	Seabird Tracking and Research
UK	United Kingdom
VOR	Valued Ornithological Receptor
WTG	Wind Turbine Generator

Units

Unit	Description
km	Kilometre (distance)
m	Metre (length)
kJ	Kilojoules (energy)
MW	Megawatt (power)

5. Offshore Ornithology

5.1 Introduction

5.1.1.1 This chapter of the Environmental Statement presents the findings of the Environmental Impact Assessment (EIA) for the potential impacts of the Hornsea Project Three offshore wind farm (hereafter referred to as Hornsea Three) on bird species occurring offshore. Specifically, this chapter considers the potential impact of Hornsea Three within a geographical remit seaward of Mean High Water Springs (MHWS) during its construction, operation and maintenance, and decommissioning phases. The potential impacts of Hornsea Three on bird species occurring landward of MHWS are considered in volume 3, chapter 3: Ecology and Nature Conservation.

5.1.1.2 This chapter describes the existing environment with regard to offshore bird interest within Hornsea Three and the former Hornsea Zone (see section 5.7) and in the context of the wider region of the North Sea. Section 5.7 characterises the distribution, abundance and behaviour of ornithological species known to occur, or which have been recorded within Hornsea Three, the former Hornsea Zone and wider region through site-specific digital video aerial surveys and desk-based research. The subsequent assessment (section 5.11) presents the potential impacts of construction, operation and maintenance, and decommissioning of Hornsea Three on the avifauna present, and in particular on identified species of conservation concern.

5.1.1.3 This chapter summarises information contained within the following Annexes:

- Volume 5, annex 5.1: Baseline Characterisation Report;
- Volume 5, annex 5.2: Analysis of Displacement Impacts on Seabirds; and
- Volume 5, annex 5.3: Collision Risk Modelling.

5.1.1.4 It also draws on information presented in the Report to Inform Appropriate Assessment, annex 3: Phenology, connectivity and apportioning for features of FFC pSPA.

5.2 Purpose of this chapter

5.2.1.1 The primary purpose of the Environmental Statement is to support the Development Consent Order (DCO) application for Hornsea Three under the Planning Act 2008 (the 2008 Act) which accompanies the application to the Secretary of State for Development Consent.

5.2.1.2 It is intended that the Environmental Statement will provide statutory and non-statutory consultees with sufficient information to complete the examination of Hornsea Three and will form the basis of agreement on the content of the DCO and/or Marine Licence conditions (as required).

5.2.1.3 In particular, this Environmental Statement chapter:

- Presents the existing environmental baseline established from desk studies, dedicated offshore surveys and consultation;
- Presents the potential environmental effects on offshore birds arising from Hornsea Three, based on the information gathered and the analysis and assessments undertaken;
- Identifies any assumptions and limitations encountered in compiling the environmental information presented within; and
- Highlights any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental effects identified in the EIA process.

5.2.1.4 Three key potential legislative impact pathways on offshore birds during the construction, operation and maintenance, and decommissioning of Hornsea Three have been identified:

- The potential for Hornsea Three to adversely affect qualifying ornithological features of nearby designated sites (Special Protection Areas (SPAs), proposed Special Protection Areas (pSPAs), Sites of Special Scientific Interest (SSSIs) and Ramsar sites);
- The potential for Hornsea Three to adversely affect seabirds of highest conservation concern, listed on Annex I of the Birds Directive and/or Schedule 1 of the Wildlife and Countryside Act 1981 (as amended); and
- The potential for Hornsea Three to adversely affect other species in internationally, nationally, or regionally important numbers, overwinter, during migration, or whilst commuting locally between foraging and breeding grounds.

5.2.1.5 Based on reviews of other offshore wind farms and their potential impacts on birds, (e.g. Drewitt and Langston (2006); Dierschke *et al.* (2006); Langston (2010); and Wade *et al.* (2016)), for each of the above, direct adverse impacts may arise through loss of foraging habitat, disturbance, displacement, pollution, collision with turbines or barrier effects (when a bird's avoidance of wind turbines results in an increase in energy use to circumvent the turbine area (Goodale and Divoll, 2009). Indirect impacts may arise due to effects upon the distribution and abundance of prey species.

5.3 Study area

5.3.1.1 For the purposes of the Hornsea Three Offshore Ornithology EIA, four study areas are defined:

- The former Hornsea Zone offshore ornithology study area - The former Hornsea Zone plus 10 km buffer. Boat-based surveys have been conducted across this area between March 2010 and February 2013 and allow for consideration of trends in the abundance of seabirds across wider spatial and temporal scales;
- The Hornsea Three offshore ornithology study area - The Hornsea Three array area plus 4 km buffer. The extent of buffer is defined based on guidance from JNCC *et al.* (2017) in relation to the

assessment of displacement impacts which, for the most sensitive of species (divers and seaducks), is a buffer of up to 4 km is recommended. Surveys undertaken across the former Hornsea Zone have overlapped spatially with the proposed Hornsea Three array area;

- The Hornsea Three offshore cable corridor study area - The Hornsea Three offshore cable corridor plus 2 km buffer – all areas of the Hornsea Three offshore cable corridor and intertidal area that are seaward of MHWS plus a 2 km buffer. The 2 km buffer is considered sufficiently precautionary when assessing offshore bird receptors given they are considered most at risk during export cable installation and to operations that are expected to be highly localised e.g. cable laying vessels which are moving slowly during cable installation; and
- The regional Offshore Ornithology study area - The North Sea coinciding with the northern and southern North Sea (see Figure 1.2, volume 5, annex 5.1: Baseline Characterisation Report) as defined by the regional seas identified by JNCC for implementing UK nature conservation strategy (JNCC, 2004). This North Sea offshore ornithology study area provides a wider context for the site-specific data and is the area covered by the desktop review including consideration of species specific foraging ranges, migration routes and wintering areas.

5.3.1.2 The first three study areas listed above i.e. the former Hornsea Zone offshore ornithology study area, The Hornsea Three offshore ornithology study area and The Hornsea Three offshore cable corridor study area, were identified for the purposes of defining the baseline environment and undertaking the Hornsea Three alone assessment. The regional Offshore Ornithology study area represents the maximum extent of the area within which the Cumulative Effects Assessment (CEA) is conducted, with the boundary used for that area dependent on the particular impact as well as each species' population distribution and behaviour (e.g. foraging range).

5.3.1.3 Figure 5.1 presents the Hornsea Three array area and offshore cable corridor, as well as their associated buffers which comprise the study areas.

5.3.1.4 Further details on the Hornsea Three and former Hornsea Zone offshore ornithology study areas and the surveys carried out are presented in volume 5, annex 5.1: Baseline Characterisation Report.

5.4 Planning policy context

5.4.1 National Policy Statements

5.4.1.1 Planning policy on offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to offshore birds, is contained in the Overarching National Policy Statement (NPS) for Energy (EN-1; DECC, 2011a) and the NPS for Renewable Energy Infrastructure (EN-3, DECC, 2011b).

5.4.1.2 NPS EN-1 and NPS EN-3 include guidance on what matters are to be considered in the assessment. These are summarised in Table 5.2 and Table 5.2.

Table 5.1: Summary of NPS EN-1 policy relevant to offshore ornithology and consideration of the Hornsea Three assessment.

Summary of NPS EN-1 policy relevant to the assessment of offshore ornithology	How and where considered within the Hornsea Three assessment
Biodiversity	
Where the development is subject to EIA the applicant should ensure that the Environmental Statement clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. The applicant should provide environmental information proportionate to the infrastructure where EIA is not required to help the IPC consider thoroughly the potential effects of a proposed project (paragraph 5.3.3).	Effects on offshore ornithology, including species of conservation importance, including those listed as features of designated sites, are fully considered in sections 5.11.1 (construction phase), 5.11.2 (operation and maintenance phase) and 5.11.3 (decommissioning phase). Baseline information on these receptors is presented in section 5.7, with valuation of these receptors in the context of their conservation importance considered in annex 5.1: Baseline Characterisation Report.
The most important sites for biodiversity are those identified through international conventions and European Directives. The Habitats Regulations provide statutory protection for these sites but do not provide statutory protection for potential Special Protection Areas (pSPAs) before they have been classified as a Special Protection Area. For the purposes of considering development proposals affecting them, as a matter of policy the Government wishes pSPAs to be considered in the same way as if they had already been classified. Listed Ramsar sites should, also as a matter of policy, receive the same protection (paragraph 5.3.9)	Effects on offshore ornithology features of designated sites are fully considered in sections 5.11.1 (construction phase), 5.11.2 (operation and maintenance phase) and 5.11.3 (decommissioning phase). These effects have also been assessed within the Report to Inform Appropriate Assessment (Ørsted, 2017a) for Natura 2000 sites.
Many Sites of Special Scientific Interest (SSSI) are also designated as sites of international importance; those that are not, should be given a high degree of protection (paragraph 5.3.10 of NPS EN-1). Where a proposed development within or outside a SSSI is likely to have an adverse effect on a SSSI (either individually or together with other developments), development consent should not normally be granted. Where an adverse effect, after mitigation, on the site's notified special interest features is likely, an exception should only be made where the benefits (including need) of the development at this site clearly outweigh both the impacts on site features and on the broader network of SSSIs. The Secretary of State should use requirements and/or planning obligations to mitigate the harmful aspects of the development, and where possible, ensure the conservation and enhancement of the site's biodiversity or geological interest (paragraph 5.3.11 of NPS EN-1).	For SSSIs, where these are within European sites, the SSSI has been considered as part of that site in this environmental assessment. Where SSSIs are not within European sites these would be considered individually within this chapter, although no such SSSIs with offshore ornithology features were identified (see section 5.7.1).
Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the IPC should maximise such opportunities in and around developments, using requirements or planning obligations where appropriate. (paragraph 5.3.15)	Designed-in measures to be adopted as part of the Hornsea Three project are presented in section 5.10.

Summary of NPS EN-1 policy relevant to the assessment of offshore ornithology	How and where considered within the Hornsea Three assessment
Many individual wildlife species receive statutory protection under a range of legislative provisions. (paragraph 5.3.16) Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The IPC should ensure that these species and habitats are protected from the adverse effects of development by using requirements or planning obligations. (paragraph 5.3.17)	The valuation of all species recorded in baseline surveys in the context of their conservation importance is presented in volume 5, annex 5.1: Baseline Characterisation Report,
The applicant should include appropriate mitigation measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: • During construction, they will seek to ensure that activities will be confined to the minimum areas required for the works; • During construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements; • Habitats will, where practicable, be restored after construction works have finished; and • opportunities will be taken to enhance existing habitats and, where practicable, to create new habitats of value within the site landscaping proposals. (paragraph 5.3.18)	Mitigation measures proposed for Hornsea Three are presented in section 5.10.

Table 5.2: Summary of NPS EN-3 provisions relevant to this chapter.

Summary of [NPS EN-3] provision	How and where considered in this chapter
Biodiversity	
Applicants should assess the effects on the offshore ecology and biodiversity for all stages of the lifespan of the proposed offshore wind farm (paragraph 2.6.64 of NPS EN-3).	Construction, operation and decommissioning phases of Hornsea Three are assessed (paragraph 5.11.1.1 *et seq.,* paragraph 5.11.2.1 *et seq.* and paragraph 5.11.3.1 *et seq.*).
Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate (paragraph 2.6.65 of NPS EN-3).	Consultation on the assessment methodologies with relevant statutory and non-statutory stakeholders has been carried out from the early stages of Hornsea Three (paragraph 5.6.1.2). An Expert Working Group (EWG) has been established since March 2016 and the survey methods, scope, collision risk modelling (CRM) and displacement have been wholly or largely agreed to the extent set out in Table 5.5 below.
Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational offshore wind farms should be referred to where appropriate (paragraph 2.6.66 of NPS EN-3).	Relevant data collected as part of post-construction monitoring from other offshore wind farm developments has informed the assessment of Hornsea Three (e.g. see section 5.9.2).
Applicants should assess the potential for the scheme to have both positive and negative effects on marine ecology and biodiversity (paragraph 2.6.67 of NPS EN-3).	Both the positive and negative effects have been assessed for Hornsea Three (section 5.11).
Offshore Ornithology	
Offshore wind farms have the potential to impact on birds through: • collisions with rotating blades; • direct habitat loss; • disturbance from construction activities such as the movement of construction/ decommissioning vessels and piling; • displacement during the operational phase, resulting in loss of foraging/ roosting area; and • impacts on bird flight lines (i.e. barrier effect) and associated increased energy use by birds for commuting flights between roosting and foraging areas (paragraph 2.6.101 of NPS EN-3).	The Hornsea Three assessment has considered all impacts during each phase of development on key ornithological species in the vicinity of the development (paragraph 5.8.1.1 *et seq.*, Table 5.8) i.e. the former Hornsea Zone plus 10 km buffer, The Hornsea Three offshore ornithology study area and The Hornsea Three offshore cable corridor.
The scope, effort and methods required for ornithological surveys should have been discussed with the relevant statutory advisor (paragraph 2.6.102 of NPS EN-3).	The Hornsea Three application process has included full consultation with statutory advisors (the Joint Nature Conservation Committee (JNCC) and Natural England) on ornithological survey methods and scope (paragraphs 5.6.1.1 *et seq*,).
Relevant data from operational offshore wind farms should be referred to in the applicant's assessment (paragraph 2.6.103 of NPS EN-3).	Hornsea Three has considered relevant information on offshore birds in relation to published studies on operational offshore wind farms as part of the Environmental Impact Assessment process (e.g. see section 5.9.2).
It may be appropriate for assessment to include CRM for certain species of birds. Where necessary, the assessments carried out by applicants should assess collision risk using survey data collected from the site at the pre-application EIA stage. The Secretary of State will want to be satisfied that the collision risk assessment has been conducted to a satisfactory standard having had regard to the advice from the relevant statutory advisor (paragraph 2.6.104 of NPS EN-3).	Hornsea Three has conducted CRM primarily utilising data obtained from baseline surveys of the Hornsea Three offshore ornithology study area (see Section 5.9.3)
Applicants are expected to adhere to requirements in respect of FEPA licence requirements (now Marine Licence). A FEPA licence may be deemed to be given by a provision in a development consent given by the Secretary of State (paragraph 2.6.105 of NPS EN-3).	Hornsea Three has considered the need to protect the environment and human health, and to prevent interference with legitimate uses of the sea, as required by a Marine Licence. In relation to ornithological interests, this has been considered as part of the design of the project (Table 5.16), as well as determination of a maximum design scenario in Table 5.8, and subsequent impact assessments.

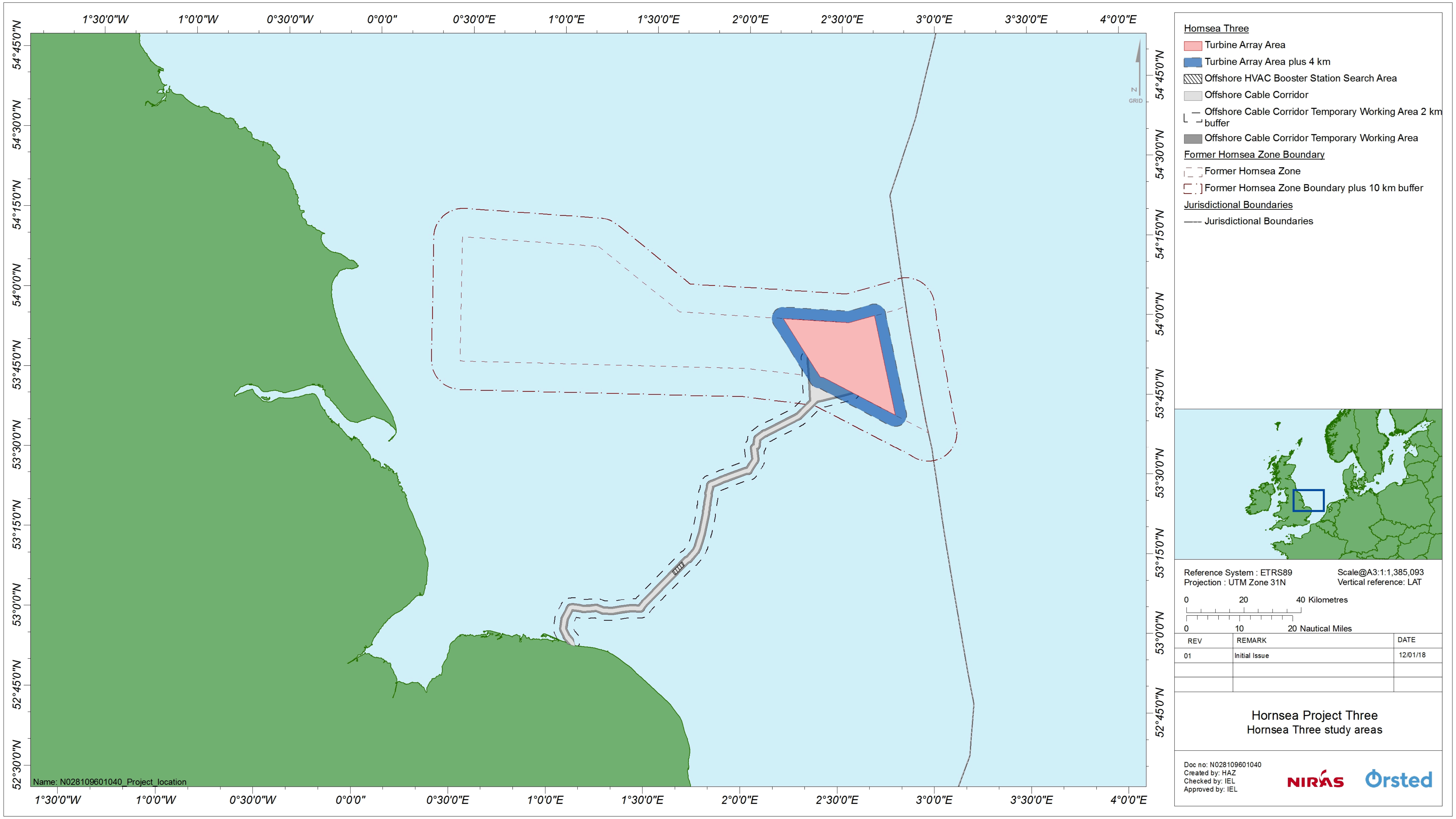

Figure 5.1: Hornsea Three array area and export cable route and associated buffer areas

5.4.1.3 NPS EN-3 also highlights a number of factors relating to the determination of an application and in relation to mitigation. These are summarised in Table 5.3 below.

Table 5.3: Summary of NPS EN-3 policy on decision making relevant to this chapter.

Summary of NPS EN-3 policy on decision making (and mitigation)	How and where considered in this chapter
Biodiversity	
The Secretary of State should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it (paragraph 2.6.68 of NPS EN-3).	The effect of the proposal on biodiversity has been described and considered as part of the Hornsea Three assessment process.
The designation of an area as Natura 2000 site does not necessarily restrict the construction or operation of offshore wind farms in or near that area (paragraph 2.6.69 of NPS EN-3).	Natura 2000 sites have been considered during the Hornsea Three assessment process (section 5.7.1).
Mitigation may be possible in the form of careful design of the development itself and the construction techniques employed (paragraph 2.6.70 of NPS EN-3).	Mitigation has been considered during the Hornsea Three assessment (Table 5.15). It should be noted that as part of the project design process, a number of designed-in measures have been proposed to reduce the potential for impacts (section 5.10).
Ecological monitoring is likely to be appropriate during the construction and operational phases to identify the actual impact so that, where appropriate, adverse effects can then be mitigated and to enable further useful information to be published relevant to future projects (paragraph 2.6.71 of NPS EN-3).	Future monitoring has been considered within the Hornsea Three assessment.
Ornithology	
In addition to section 5.3 of NPS EN-1 the offshore wind-specific biodiversity considerations set out in paragraphs 2.6.58 to 2.6.71 should inform Secretary of State decision-making (paragraph 2.6.106 of NPS EN-3).	The effect of the proposal on offshore ornithology has been described and considered as part of the Hornsea Three assessment process.
Aviation and navigation lighting should be minimised to avoid attracting birds, taking into account impacts on safety (paragraph 2.6.107 of NPS EN-3).	Lighting effects on birds have been considered within the Hornsea Three assessment process (see paragraphs 5.11.2.220 to 5.11.2.233)
Subject to other constraints, wind turbines should be laid out within a site, in a way that minimises collision risk, where the collision risk assessment shows there is a significant risk of collision (paragraph 2.6.108 of NPS EN-3).	Mitigation relating to turbine layout and birds has been considered within the Hornsea Three assessment process (see Table 5.16). It should be noted that as part of the project design process, a number of designed-in measures have been proposed to reduce the potential for collision mortality (section 5.10). Hornsea Three has committed to a significantly increased lower blade tip (34.97 m MSL) height than previous applications for offshore wind farms in the UK (which have often used 22 m HAT), in an effort to mitigate impacts of collision risk.
Construction vessels associated with offshore wind farms should, where practicable and compatible with operational requirements and navigational safety, avoid rafting seabirds during sensitive periods (paragraph 2.6.109 of NPS EN-3).	Mitigation measures for offshore ornithological interests have been considered within the Hornsea Three assessment process (Table 5.16).
The exact timing of peak migration events is inherently uncertain. Therefore, shutting down turbines within migration routes during estimated peak migration periods is unlikely to offer suitable mitigation (paragraph 2.6.110 of NPS EN-3).	Mitigation measures for offshore ornithological interests have been considered within the Hornsea Three assessment process (Table 5.16).

5.4.2 Other relevant policies

5.4.2.1 A number of other policies are relevant to the offshore ornithology assessment. The Marine Policy Statement (MPS) notes that marine planning authorities should be mindful of the high-level marine objectives set out by the UK in order to ensure due consideration of marine ecology and biodiversity interests. It also recognises the role of conservation of ecologically sensitive areas throughout the planning process and mitigation or compensatory actions where significant harm cannot be avoided (paragraph 2.6.1 of the MPS).

5.4.2.2 The assessment of potential changes to benthic ecology and the corresponding impacts on fish and shellfish ecology (which may result in indirect impacts on offshore ornithology receptors) has also been made with consideration to the specific policies set out in the East Inshore and East Offshore Marine Plans (MMO, 2014). Key provisions are set out in Table 3.4 of volume 2, chapter 3: Fish and Shellfish Ecology along with details as to how these have been addressed within the assessment.

5.4.2.3 Guidance provided within the Marine Strategy Framework Directive (MSFD), which was implemented in the UK by the Marine Strategy Regulations 2010/1627, has also been considered in the Hornsea Three assessment for offshore ornithology. The relevance of the MSFD to Hornsea Three is described in full in volume 1, chapter 2: Policy and Legislation.

5.4.2.4 The overarching goal of the MSFD is to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment. To this end, Annex I of the Directive identifies 11 high level qualitative descriptors for determining GES. Those descriptors relevant to the offshore ornithology assessment for Hornsea Three are listed in Table 5.4 including a brief description of how and where these have been addressed in the assessment.

5.4.2.5 Further advice in relation specifically to the Hornsea Three development has been sought through consultation with the statutory authorities and from the Secretary of State's scoping opinion (PINS, 2016) (section 5.5 and Table 5.5).

Table 5.4: Summary of the Marine Strategy Framework Directive's (MSFD) high level descriptors of Good Environmental Status (GES) relevant to offshore ornithology and consideration in the Hornsea Three assessment.

Summary of MSFD high level descriptors of GES relevant to fish and shellfish ecology	How and where considered within the Environmental Statement
Descriptor 1: Biological diversity: Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.	The effects on biological diversity have been described and considered within the assessment for Hornsea Three alone and in the CEA (see sections 5.11 and 5.13 respectively).
Descriptor 4: Elements of marine food webs: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long term abundance of the species and the retention of their full reproductive capacity.	The effects on offshore ornithology have been described and considered within the assessment for Hornsea Three alone and in the CEA (see sections 5.11 and 5.13 respectively).
Descriptor 6: Sea floor integrity: Seafloor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.	The indirect effects as a result of impacts on benthic ecology and on fish and shellfish ecology that may affect offshore ornithological receptors have been described and considered within the assessment for Hornsea Three alone and in the CEA (see sections 5.11 and 5.13 respectively).
Descriptor 8: Contaminants: Concentrations of contaminants are at levels not giving rise to pollution effects.	The effects of contaminants on offshore ornithology and populations have been assessed in section 5.11
Descriptor 10: Marine litter: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	A Code of Construction Practice (CoCP) will be developed and implemented to cover the construction phase and an appropriate Project Environmental Management and Monitoring Plan (PEMMP) will be produced and followed to cover the operation and maintenance phase of Hornsea Three. The latter will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details (e.g. the Environmental Agency (EA), Natural England and Maritime and Coastguard Agency (MCA)). A Decommissioning Programme will be developed to cover the decommissioning phase (see section 5.11).
Descriptor 11: Energy incl. Underwater Noise Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	The effects of underwater noise on offshore ornithology have been assessed see section 5.11

5.5 Consultation

5.5.1.1 A summary of the key issues raised during consultation specific to offshore ornithology is outlined below, together with how these issues have been considered in the production of this Environmental Statement chapter.

5.5.2 Hornsea Project One and Hornsea Project Two consultation

5.5.2.1 Hornsea Three has similarities, both in terms of the nature of the development and its location, to Hornsea Project One and Hornsea Project Two. The matters relevant to Hornsea Three, which were raised by consultees during the pre-application and examination phases of Hornsea Project One and Hornsea Project Two, on offshore ornithology, are set out in volume 4, annex 1.1: Hornsea Project One and Hornsea Project Two Consultation of Relevance to Hornsea Three.

5.5.3 Hornsea Three consultation

5.5.3.1 Table 5.5 below summarises the issues raised relevant to offshore ornithology, which have been identified during consultation activities undertaken to date. Table 5.5 also indicates either how these issues have been addressed within this chapter or how the Applicant has had regard to them. Further information on the consultation activities undertaken for Hornsea Three can be found in the Consultation Report (document reference number A5.1) that accompanies the application for Development Consent.

5.5.4 Evidence Plan

5.5.4.1 An evidence plan is a formal mechanism to agree upfront what information the applicant needs to supply as part of a Development Consent Order (DCO) application. This will help to ensure compliance with the Habitats Regulations. The Evidence Plan process for Hornsea Three is set out in Consultation Report (document reference number A5.1), annex 1: Evidence Plan.

5.5.4.2 As part of the Evidence Plan process, the Offshore Ornithology Expert Working Group (EWG) was established with representatives from the key regulatory bodies and their advisors and statutory nature conservation bodies, including the MMO, Natural England and the RSPB. Between April 2016 and publication of this chapter, a number of Offshore Ornithology EWG meetings were held that included discussion of key issues with regard to the offshore ornithology elements of Hornsea Three, including characterisation of the baseline environment and the impacts to be considered within the impact assessment. The identification of key issues was informed by consultation on Hornsea Project One and Hornsea Project Two, where appropriate. Matters raised during Offshore Ornithology EWG meetings have been included in Table 5.5 below.

Table 5.5: Summary of key consultation issues raised during consultation activities undertaken for Hornsea Three relevant to offshore ornithology

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
10 March 2016	Offshore Ornithology Expert Working Group (EWG) meeting	Introduction to the Evidence Plan: Aims, principles and approach. Identification of key issues and discussion around baseline data collection requirements and methodology.	The following key issues were discussed/agreed: • Agreement on the scope of the Offshore Ornithology EWG. • Initial discussions were held on the use of a meta-analysis of existing former Hornsea Zone data (paragraph 5.6.4.6 *et seq.*). • Agreement that digital aerial surveys would be the preferred survey methodology (paragraph 5.6.4.1). Natural England advised that two years or more of relevant baseline survey data for each species is required to adequately characterise the baseline environment. • It was agreed that the requirement for an intertidal EWG would be determined following determination of the export cable landfall
13 April 2016	Offshore Ornithology Expert Working Group (EWG) meeting	Discussion around the aerial survey methodology and meta-analysis scope of works	The following key issues were discussed/agreed: • It was agreed the meta-analysis Scope of Works (SoWs) would be updated to include the requirement to investigate points i) will 12-months of data be sufficient to inform the Hornsea Three assessment ii) if not how can we integrate the existing dataset into the data collected for Hornsea Three; and variability in flight height data collected for the former Hornsea Zone, Hornsea Project One and Hornsea Project Two and then circulated to Natural England and RSPB week commencing 18 April 2016. • It was agreed that the proposed aerial survey methodology for Hornsea Three was appropriate, noting the risk of collecting less than two years of site-specific survey data (paragraph 5.6.4.1)
27 July 2016	Offshore Ornithology Expert Working Group (EWG) meeting	Introduction to the export cable scoping corridor and potential landfall locations.	The following key issues were discussed/agreed: • Agreement that no further intertidal surveys were required and the intertidal assessment would be incorporated into the Offshore Ornithology (this chapter) and Ecology and Nature Conservation (volume 3, chapter 3) chapters as required. • The Offshore Ornithology EWG agreed that intertidal ornithology would be assessed within the terrestrial and offshore ornithology chapters (volume 3, chapter 6: Ecology and Nature Conservation) as appropriate rather than in a separate Environmental Statement Chapter. • The Offshore Ornithology EWG agreed that the little tern data collected was anticipated to be sufficient to inform the EIA, with the addition of supporting fisheries data. A final position on little tern at Zone 4 will be made once the final survey report has been reviewed. • The Offshore Ornithology EWG agreed that all the relevant designated conservation sites have been considered in relation to the export cable corridor, with the additional inclusion of the Outer Thames Estuary SPA. • The Offshore Ornithology EWG agreed that relevant construction/decommissioning impacts and operation and maintenance impacts, their applicability to Hornsea Three, the data gaps identified and the approach to filling the data gaps had been considered in relation to the export cable corridor. Potential habitat modification of foraging habitats was included as an impact. • The Offshore Ornithology EWG agreed that all key assessment issues from Hornsea Project One/Hornsea Project Two, relevant to Hornsea Three, had been considered and all the Hornsea Three specific issues had been highlighted in relation to the Hornsea Three offshore cable corridor.'
November 2016	PINS/ Natural England (Hornsea Three Scoping Opinion, 25/11/2016)	**Impact scoped in/out** Secretary of State/Natural England did not agree with the Applicant's proposal to scope out "Accidental Pollution" and "Disturbance from Lighting" as potential impacts on ornithological receptors	The impact of indirect effects such as changes in habitat or prey availability has been assessed for the operation and maintenance phase (see paragraph 5.11.2.84 *et seq.*). Accidental pollution and disturbance from lighting has been assessed (see section 5.11.2).
November 2016	Natural England (Hornsea Three Scoping Opinion, 25/11/2016)	**Baseline Surveys** Survey methodologies should be appropriate and enable collection of data (or use of existing data) that will enable quantification of the variability and uncertainty in key data parameters	The Offshore Ornithology EWG agreed that monthly aerial surveys from April 2016 to September 2017, considering the timescales of Hornsea Three, was the most appropriate approach to providing enough site specific data to characterise the baseline environment. Noting the Offshore Ornithology EWGs advice on the requirement for two years of site specific data, these data would then be supplemented by the meta-analysis, pending the suitability of existing ornithological data from across the former Hornsea Zone to inform the EIA, specifically regarding the Hornsea Three array area.
		Appropriate spatial scales Natural England advised that the appropriate spatial scale for an ornithological receptor would depend on the species being considered as well as the time of year when the impact is predicted.	The approach to defining Biological Defined Minimum Population Scale (BDMPS) has been agreed with the Offshore Ornithology EWG, see section 1.2.5 of volume 5, annex 5.1: Baseline Characterisation Report.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		Breeding seasons Natural England advised that the breeding season months as defined by the median return date for UK colonies from Furness *et al.* (2015) should be the starting point when defining the breeding season for each ornithological receptor. For some species there will then be an overlap between months defined as breeding season and some of the non-breeding season months. Further, for individual colonies of interest there may be colony specific data on occupancy in the breeding season that will be relevant to the assessment and should be considered.	Impact on bird populations from effects individuals may sustain as a consequence of Hornsea Three has been assessed in relation to relevant biological seasons and the appropriate reference populations as derived from Furness (2015) refined with existing data from the former Hornsea Zone and expert opinion (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA).
		Foraging ranges Natural England advised that assessments should always be based upon the best and most up to date evidence available.	It was agreed with the Offshore Ornithology EWG that where there is foraging data specific to an SPA that this would be used over Thaxter *et al.*, (2012) and any additional data supplied would be reviewed and considered. Otherwise the foraging range data presented in Thaxter *et al.*, (2012) would be deemed appropriate (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). Full logic for the screening of SPAs and establishment of connectivity was outlined within the HRA Screening Report. The approach was based upon the application of mean-maximum foraging ranges as reported by Thaxter *et al.* (2012). In some cases more specific information was available from GPS/satellite tracking studies, such as, for example, the FAME/STAR initiatives for kittiwake and gannet colonies associated with the FFC pSPA.
		Disturbance/displacement impacts Natural England advised that there was the potential for disturbance/displacement in the offshore project and cable route areas and also in the near-shore and coastal areas along the offshore cable route and not just specifically the cable landfall site. There is the potential for connectivity between these components of the project and a number of species including in near shore areas, common scoter, red-throated diver, common tern, Sandwich tern and little tern (i.e. not just little tern).	The approach to assessment of displacement has been agreed with stakeholders. The assessment has covered the Hornsea Three array area and the Hornsea Three offshore cable corridor (see section 5.6.4.10 and paragraphs 5.11.2.3 *et seq.*).
		Collision Risk Modelling Natural England advised that it would be important to reflect the variability and uncertainty around the various input parameters used for collision risk assessment. Band (2012) recommends that uncertainty around these need to be reflected in the outputs, but the model does not provide a mechanism to statistically model the combined effects of uncertainty across a range of input parameters. A recent update to the Band (2012) model by Masden (2015) has included a simulation approach that allows the incorporation of variability and uncertainty in the collision modelling outputs, Natural England recommended the use of Masden (2015)	It was agreed with stakeholders that the Masden (2015) update would be used where possible. Where it would not be appropriate to use Masden (2015), the Band (2012) model was to be utilised with both the basic and extended versions presented. However, it has recently come to light through advice from Natural England (Offshore Ornithology EWG 29th March 2017) that further evaluation of the Masden (2015) variant of the collision risk model is required. As a result, Masden (2015) has not been used to calculate collision risk estimates for Hornsea Three. See section 5.9.3.
21 November 2016	Offshore Ornithology Expert Working Group (EWG) meeting	Discussion around the Scoping Report and HRA Screening Report, and further discussions relating to the Hornsea Three offshore cable corridor boundary and aerial surveys.	The following key issues were discussed/agreed: • Hornsea Three confirmed that 18 months of survey data would be included within the assessment, including two breeding seasons. • Agreement on the apportioning approach for gannet and fulmar (all birds present during the breeding season will be assumed to be breeding adults), while puffin and kittiwake remained under discussion.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
29 March 2017	Offshore Ornithology Expert Working Group (EWG) meeting	Discussion around EIA Scoping responses, HRA Screening response, baseline data collection and key assessment methodologies.	The following key issues were discussed/agreed: • Agreement on impacts to be included within the assessment as outlined in section 5.8. • Agreement on use of Masden (2015) within the CRM where applicable. (This agreement was later retracted, after issues were found with the model, the Offshore Ornithology EWG advised that Band (2012) is run, presenting collision figures using upper and lower confidence intervals for key parameters that impact upon the CRM) (see section 5.11). • Agreement that 18 months of aerial surveys will be completed, covering two breeding seasons, with the meta-analysis providing additional information for the characterisation of the non-breeding season. • Agreement on approach to defining BDMPS, see section 1.2.5 of volume 5, annex 5.1: Baseline Characterisation Report. • Agreement as to the approach used to establish connectivity between an SPA breeding colony and Hornsea Three array area for fulmar and gannet, see volume 5, annex 5.1: Baseline Characterisation Report. • Agreement on approach to assessing operational displacement and mortality rates following SNCB guidance, see section 5.9.2. • Agreement that a range of avoidance rates will be presented, see section 5.9.3. • Agreement on a tier approach to the cumulative assessment, as outlined in paragraph 5.12.1.2 *et seq*.
5 June 2017	Offshore Ornithology Expert Working Group meeting	Discussion around the initial results of the meta-analysis and the approach to incorporating the data into the ES.	The following key issues were discussed/agreed: • Comments were raised on the meta-analysis report which were discussed during the Offshore Ornithology EWG meeting. The meta-analysis has been finalised in line with the comments received (see volume 5, annex 5.4: Data Hierarchy Report. • Natural England advised the use of the Band (2012) collision risk model, as an issue had been identified with the Masden (2015) modelling approach. It was also advised to consider the variability around key parameters by present collision figures using upper and lower confidence intervals (same approach as utilised for Hornsea Project Two).
20 September 2017	Natural England Section 42 consultation	**Incomplete baseline dataset to inform assessment** Natural England highlighted the limited spatial extent of baseline data incorporated into the PEIR (April 2016 to February 2017). Natural England queried the methodology for determining LSE and therefore which species require an AA, as well as the methodology for identifying Valued Ornithological Receptors (VORs) for EIA, there may be additional species that need to be included in the CRM assessment (e.g. herring gull).	Site specific digital aerial survey data has been collected across 20 months having been extended from the survey timeframe that was originally suggested during EWG meetings. Volume 5, annex 5.4: Data Hierarchy Report provides additional data across the months where two years of survey data has not been collected. Uncertainty surrounding the baseline characterisation has been accounted for within the assessments conducted throughout the Offshore Ornithology EIA. Twenty months of survey data has been collected and no further species have been identified for inclusion within assessment, other than those previously presented at Preliminary Environmental Information Report stage.
		Collision risk modelling: avoidance rates and Band model options Natural England highlighted that the assessments presented incorporated the use of collision risk estimates calculated using Band model options and avoidance rates that they did not agree with (e.g. use of the Extended model for gannet and kittiwake and the use of a 99.2% avoidance rate for kittiwake). Although Natural England do note that collision estimates based on a range of avoidance rates and Band model options are presented in annex 5.3.	A range of avoidance rates and Band model options are presented in annex 5.3: Collision Risk Modelling and these, alongside the variability associated with density data and flight height data, have been considered within the assessment presented in the Offshore Ornithology EIA. The assessment is based on the Project's understanding of the most appropriate situation to base the impact assessment upon.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		Displacement Natural England advised that a range of values are taken through to assessment of population impacts stage as this reflects the range of uncertainty around the predicted impact. Natural England advised that displacement impacts calculated for individual seasons should be summed across seasons to allow assessment of the annual impact on the population. Natural England advised that displacement effects on fulmar should be included in the RIAA	The guidance provided in JNCC *et al.* (2017) has been followed in the displacement assessments presented in the Offshore Ornithology EIA. A literature review has also been undertaken which attempts to refine the broad displacement and mortality rate ranges suggested for use in JNCC *et al.* (2017) (see section 5.9.2). Assessments are based on the Project's understanding of the most appropriate situation to base the impact assessment upon. Fulmar has been included within the displacement assessments in the RIAA (Ørsted, 2018).
		The need to present data and predicted impacts in a way that allows the full range of uncertainty (e.g. around input data, analysis, methodology) to be understood and evaluated Natural England advised that the assessments of displacement and collision mortality should both incorporate information on uncertainty and variability in the input parameters (e.g. bird densities, flight heights, avoidance rates) to allow consideration of the range of values predicted impacts may fall within, and to allow an assessment of confidence in the conclusions made regarding adverse effects on site integrity and significance of impacts for populations.	The uncertainty associated with input parameters for assessments has been considered, where appropriate in the relevant sections of the Offshore Ornithology EIA (see section 5.11). Mean estimate/maximum likelihood values are considered to be the basis of any assessment with discussion in relation to the likely variability/uncertainty associated with these estimates also provided (see section 5.11.2).
		Missing/incomplete elements to PEIr Natural England noted that due to the incomplete baseline survey data there were a number of aspects of the assessments that are not presented in the PEIr documents and which need to be addressed in the Environmental Statement. These include: • Flight height information for birds in project areas, including consideration of variability in flight heights and comparison with the generic flight height data; • Population modelling of impacts to determine significance; • Details of how the meta-analysis will be used to inform the characterisation of the baseline environment; and • Details of how predicted impacts on species present in the Hornsea Three project area during the breeding season will be apportioned to SPA populations, including in particular FFC pSPA.	Throughout the PEIR it was stated that the baseline characterisation of the Hornsea Three ornithological study area was ongoing and therefore the conclusions drawn throughout the PEIR were potentially subject to change. Baseline surveys, consisting of 20 months of digital aerial survey, have been completed and the survey data incorporated into the ornithology assessments. Volume 5, annex 5.4: Data Hierarchy Report provides additional consideration of existing ornithological data from across the former Hornsea Zone and explains how this has been used to inform the characterisation of the baseline environment.
23 November 2017	Offshore Ornithology Expert Working Group meeting	Discussion around the meta-analysis addendum and assessment methodology progression, as well as Section 42 consultation.	The following key issues were discussed: • The hierarchical approach for selecting which density or population estimate of birds should be used for assessing the potential impact of the proposed Hornsea Three OWF. Discussion revolved around the ranking of data sources, the incorporation of data, confidence limits and displacement/CRM approaches; and • The updates made to the draft ornithological assessments and the progress made on the assessment methodologies following previous Offshore Ornithology EWG meetings and Section 42 consultation.
15 December 2017	Natural England draft ornithological assessment responses (DAS)	**Hornsea Three approach to incomplete baseline data for the project area** Natural England provided comments on the approach to be taken to account for variability in those months where only one year of aerial survey data were available.	The populations and densities calculated for use in assessments are considered to be appropriately precautionary especially considering that site-specific surveys have been conducted for 20 months. The four months for which only one year of data are available are within the non-breeding period for the majority of species. This period is that during which impacts are likely to be much lower (as many birds will have moved to wintering areas outside of the North Sea) and will not disproportionately affect local breeding colonies.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
		Phenology,(for features of FFC pSPA) Natural England advised that for those species with potential connectivity in the breeding season, the "breeding season" months presented in Furness (2015) should be used, except in cases where colony or site specific information suggests that a different set of months is appropriate for defining colony attendance.	The analyses presented in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA provide supporting evidence for the seasonal extents defined for relevant species.
		Connectivity,(for features of FFC pSPA) Natural England welcomed the consideration of a range of evidence sources to attribute connectivity. Natural England agreed with the conclusions of connectivity between the project site and FFC pSPA breeding birds for gannet, kittiwake and puffin. Natural England further agreed that based on the available evidence, it is unlikely that breeding razorbill or guillemot from FFC pSPA will utilise the Hornsea Three site, birds present at the Hornsea Three project site in the breeding season may still be associated with the breeding colony, and constitute an important component of the population.	It is noted that Natural England broadly agree with the conclusions made in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA in relation to connectivity between Hornsea Three and features of FFC pSPA. Assessments for relevant features of FFC pSPA are presented in the RIAA (Ørsted, 2018).
		Apportioning (for features of FFC pSPA) Natural England provided comments on the approaches used to apportioning impacts to the breeding populations of gannet, kittiwake, puffin, razorbill and guillemot at FFC pSPA. For gannet, Natural England requested further data be presented and if provided that they considered the use of age class data to be useful in informing the proportion of adult birds using the project site. For puffin and kittiwake, Natural England did not consider that the approach taken was warranted given the level of uncertainty parameters used in the analysis. Natural England also requested that age class data from digital aerial surveys were presented	The additional information requested by Natural England in relation to the age class data has been included in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA. The apportioning values calculated for all features of FFC pSPA are considered precautionary with the reasons for this outlined in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA.
		Displacement Natural England did not consider that there is sufficient evidence to suggest that a single level of displacement or mortality can be selected for any species and that the mortality predicted using a range of rates should be considered in population modelling Natural England also advised that the application of the same range of displacement and mortality rates should be used across all seasons in the assessment	A literature review has been undertaken with the aim of identifying appropriate displacement and mortality rates to inform the displacement assessments presented in 5.11.2 and 5.13.3 based on empirical data. This review is presented in section 5.9.2.
		Proposed approach to assessing impacts on populations Natural England requested additional metrics relating to PVA modelling be produced in particular whether it is possible to extract confidence intervals around the metrics presented (e.g. counterfactual of growth rate) based on the distribution of values derived from calculating the metrics from the multiple simulations of the matched runs (impacted versus unimpacted).	It is proposed that the population models to be used in the RIAA are those produced to support the assessments undertaken at Hornsea Project Two. These population models have also been used to inform the assessments undertaken for the East Anglia Three offshore wind farm.

Date	Consultee and type of response	Issues raised	Response to issue raised and/or where considered in this chapter
16 February 2018	Additional Natural England draft ornithological assessment responses (DAS)	**Collision Risk Modelling** Natural England queried the process used to identify species for inclusion in collision risk modelling with specific reference made to herring gull, Sandwich tern, little tern and a number of waterbird species	The processes used to identify species as VORs and then for inclusion in collision risk modelling are fully explained and applied in Annex 5.1: Baseline Characterisation Report and Annex 5.3: Collision Risk Modelling References are included in Annex 5.3: Collision Risk Modelling to where agreement has been reached on the suite of species to include in collision risk modelling either as part of this application or as part of applications for other offshore wind farms where the ecology of such species would be no different to that that would occur at Hornsea Three (e.g. Hornsea Project Two).
		Collision Risk Modelling Natural England did not agree that there is a sufficient body of empirical evidence from which to define nocturnal activity factors for gannet and kittiwake	A review of the empirical evidence available for gannet and kittiwake in relation to nocturnal activity is presented in Appendix D of Annex 5.3: Collision Risk Modelling. There is considered to be sufficient evidence to define empirically derived nocturnal activity factors for both gannet and kittiwake

5.6 Methodology to inform the baseline

5.6.1 Evidence-based approach

5.6.1.1 The Evidence Plan process has included seeking agreement on the methodological approach to inform the baseline. The Evidence Plan seeks to ensure compliance with the EIA and Habitat Regulations.

5.6.1.2 As part of the Evidence Plan process, an Offshore Ornithology EWG was established with representatives from the key regulatory bodies, statutory nature conservation bodies (SNCBs), including the MMO and Natural England, and non-statutory parties, including the RSPB. A number of meetings have been held in order to discuss and agree key elements of the Offshore Ornithology EIA. Meetings with key stakeholders commenced in March 2016 and have continued throughout 2016 and 2017 and into 2018.

5.6.1.3 The approach proposed by Hornsea Three for the purposes of characterising the baseline within the four offshore ornithology study areas defined in paragraph 5.3.1.1, was an evidence based approach to the EIA, which includes utilising existing data and information from sufficiently similar or analogous studies to inform the baseline understanding and/or impact assessments for a new proposed development. The Hornsea Three array area is located within the former Hornsea Zone, for which extensive data and knowledge regarding offshore ornithology is already available. This data/knowledge has been acquired through zonal studies in addition to the surveys and characterisations undertaken for Hornsea Project One and Hornsea Project Two. The suitability of existing ornithological data from across the former Hornsea Zone to inform the EIA for Hornsea Three, specifically regarding the Hornsea Three array area, has been examined by means of a meta-analysis and presented to and reviewed by the Offshore Ornithology EWG (further detailed below).

5.6.1.4 The baseline characterisation of the Hornsea Three offshore ornithology study area within this chapter has also drawn upon the site-specific surveys that have also been undertaken (further detailed below). The survey methodologies have been discussed with the Offshore Ornithology EWG through the Evidence Plan process and, supplemented by existing data, have been agreed as appropriate to enable the characterisation of the baseline environment. The Offshore Ornithology EWG have agreed that monthly aerial surveys from April 2016 to September 2017, considering the timescales of Hornsea Three, supplemented with a meta-analysis of historical data is the most appropriate approach to providing enough site specific data to characterise the baseline environment. It should be noted, however, that 20 months of site specific survey data (April 2016 to November 2017) are presented in this assessment, supplemented with the meta-analysis of historical data (Annex 5.4: Data Hierarchy Report).

5.6.1.5 The evidence based approach described above does not however apply to the Hornsea Three offshore cable corridor as it follows a completely different route to that of Hornsea Project One and Hornsea Project Two. As such, the existing data and knowledge of the baseline environment along the Hornsea Three offshore cable corridor for Hornsea Project One and Hornsea Project Two is relevant only in part to the Hornsea Three offshore cable corridor and the evidence-based approach described above cannot be applied. Therefore, the baseline characterisation of the Hornsea Three offshore cable corridor within this chapter has primarily drawn upon extensive available information, which include surveys targeting areas within and in close proximity to areas designated for nature conservation (primarily Lawson *et al.* (2015)).

5.6.1.6 An initial desk based appraisal and site walkover in July 2016 at the Hornsea Three intertidal area established this area as being of minimal importance for intertidal birds (DONG Energy, 2016a). The Offshore Ornithology EWG have agreed that no further intertidal surveys are required and the intertidal bird assessment has been incorporated into volume 2, chapter 5: Offshore Ornithology and volume 3, chapter 3: Ecology and Nature Conservation chapters where required.

5.6.2 Desktop study

5.6.2.1 A literature review was undertaken to provide information on the bird interest of the former Hornsea Zone and its importance in a regional, national and international context. This review included general seabird ecology, migration behaviour, population sizes and conservation status, particularly on the east coast of Britain, the southern North Sea, and Britain as a whole. Information sources used are summarised in Table 5.6.

5.6.3 Designated sites and legislative context

Legislative context

5.6.3.1 The key international conventions promoting the conservation of birds are the Convention on Wetlands of International Importance especially as Waterfowl Habitat (the ‘Ramsar Convention’), the Convention on the Conservation of Migratory Species of Wild Animals (the ‘Bonn Convention’) and the Convention on the Conservation of European Wildlife and Natural Habitats (the ‘Bern Convention’).

5.6.3.2 The Ramsar Convention allows contracting parties to the convention to designate suitable wetlands within their own territory for inclusion in the ‘List of Wetlands of International Importance’ (the List). Contracting parties are required to incorporate into their planning the conservation of the areas included in the List. In addition, the Ramsar Convention states that “*where a Contracting Party in its urgent national interest, deletes or restricts the boundaries of a wetland included in the List, it should as far as possible compensate for any loss of wetland resources, and in particular it should create additional nature reserves for waterfowl and for the protection, either in the same area or elsewhere, of an adequate portion of the original habitat.*”

5.6.3.3 The Bonn Convention provides for contracting parties to work together to conserve migratory species and their habitats by providing strict protection for endangered migratory species (listed in Appendix I of the Convention), by concluding multilateral agreements for the conservation and management of migratory species which require or would benefit from international cooperation (listed in Appendix II), and by undertaking cooperative research activities.

5.6.3.4 The Bern Convention aims to ensure conservation and protection of wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention). It also aims to increase cooperation between contracting parties and regulate the exploitation of those species (including migratory species) listed in Appendix III.

5.6.3.5 Within the European Union, the key legislative measures providing for the protection of birds are Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (the 'Birds Directive') and Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (the 'Habitats Directive').

5.6.3.6 The Birds Directive aims to maintain the populations of wild bird species across their natural range and allows for the designation of SPAs for rare and vulnerable species listed in Annex I of the Directive and regularly occurring migratory birds.

5.6.3.7 The Habitats Directive promotes the maintenance of biodiversity by requiring Member States to maintain or restore natural habitats and wild species listed in the Annexes to the Directive and by introducing protection for habitats and species of European importance. The Habitats Directive contributes to a coherent European ecological network of protected sites by designating Special Areas of Conservation (SACs) for habitats listed on Annex I and for species listed on Annex II of the Directive. Together, SACs and SPAs create a Europe-wide network of designated sites known as Natura 2000.

5.6.3.8 The Habitats Directive and Birds Directives have been transposed into UK legislation through the Conservation of Habitats and Species Regulations 2010 (as amended) (the 'Habitats Regulations') and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended) (the 'Offshore Habitats Regulations'). These Regulations allow for the designation of SACs and SPAs and set out a mechanism for the protection of those sites.

5.6.3.9 Birds are further protected in the UK under the Wildlife and Countryside Act 1981 (as amended) which provides protection for wild birds by making it an offence to kill, injure, or take any wild bird or take, damage or destroy the nest or eggs of a wild bird. The Act also provides for the designation of SSSIs which are sites designated by Natural England as areas of land of special interest by reason of any of their flora, fauna, or geological or physiographical features.

5.6.3.10 Further advice in relation specifically to the Hornsea Three development has been sought through consultation with the statutory authorities and from the Secretary of State's scoping opinion (Table 5.5).

5.6.3.11 No regional or local policies or guidance have been identified that are relevant to this assessment.

Designated sites

5.6.3.12 All designated sites that could be affected by the construction, operation and maintenance, and decommissioning of Hornsea Three, have been identified as part of the HRA process as summarised in the HRA Screening Report (DONG Energy, 2016b) and the Report to Inform Appropriate Assessment for Hornsea Three.

5.6.3.13 There may be the potential for impacts on bird features of sites located further afield, where qualifying features of these sites forage and/or migrate through the Hornsea Three array area and/or Hornsea Three offshore cable corridor. These features include:

- Breeding birds;
- Migratory seabirds; and
- Waterbirds (waders and wildfowl).

Table 5.6: Summary of key desktop reports.

Title	Source	Year	Author
Data from aerial surveys carried out between 2004 and 2008 collated in reports produced by the Department of Energy and Climate Change (DECC, formerly BERR and now BEIS) and the Department for Trade and Industry (DTI)	DTI, 2006; BERR, 2007; DECC, 2009b	Multiple	-
JNCC Online SPA standard data forms for Natura 2000 sites	http://jncc.defra.gov.uk/page-1400	Multiple	
Existing offshore wind farm Environmental Statements and Monitoring Reports	Multiple	Multiple	Multiple
Reports, guidance and advice notes	Scoping Response from Natural England	Multiple	Multiple
Wetland Bird Survey (WeBS) Annual Reports and Report Online interface	Wetland Bird Survey partnership	Multiple	Multiple
British Trust for Ornithology (BTO) online profiles of birds occurring in Britain and Ireland, BirdFacts	British Trust for Ornithology	2016	Robinson
Biologically appropriate, species-specific, geographically non-breeding season population estimates for seabirds	Natural England	2015	Furness
Population estimates of birds in Great Britain and the UK	British Birds journal	2013	Musgrove *et al.*
Seabird sensitivity mapping for English territorial waters	Natural England	2013	WWT Consulting and MacArthur Green Ltd

Title	Source	Year	Author
Survey data relating to the former Hornsea Zone, including Hornsea Project One and Hornsea Project Two boat based surveys	SMart Wind	2010-2013	
Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas	British Trust for Ornithology	2012	Thaxter *et al.*
Assessing the risk of offshore wind farm development to migratory birds designated as features of UK SPAs	Strategic Ornithological Support Services	2012	Wright *et al.*
An analysis of the numbers and distribution of seabirds within the British Fishery Limit aimed at identifying areas that qualify as possible marine SPAs	JNCC	2010	Kober *et al.*
A review of assessment methodologies for offshore wind farms	British Trust for Ornithology	2009	Maclean *et al.*
The Migration Atlas	British Trust for Ornithology	2002	Wernham *et al.*
Atlas of seabird distribution in northwest European waters	JNCC	1995	Stone *et al.*

5.6.3.14 During the breeding season foraging birds may travel some distance from their breeding colonies. The information available on the distances that breeding birds will forage depends on the species. Thaxter *et al.* (2012) provide data on recorded foraging ranges for a wide range of species, including the mean-maximum and maximum distances travelled. Typically the mean-maximum range (i.e. the mean average of the maximum foraging trips recorded and therefore a precautionary approach) has been used as a criterion for establishing whether there is likely to be connectivity (and hence risk of an impact) between an SPA breeding colony and a proposed wind farm array area. In some cases site-specific information is available from GPS/satellite tracking studies, such as, for example, the FAME/STAR initiatives for kittiwake and gannet colonies associated with the FFC pSPA.

5.6.3.15 For the identification of SPAs relevant to Hornsea Three, mean-maximum foraging ranges (± 1 SD) as reported by Thaxter *et al.* (2012) have been used to determine potential connectivity with Hornsea Three, unless specific relevant tracking data are available (where the latter is deemed to have priority).

5.6.3.16 During the non-breeding period, birds from colonies further afield may also be present within Hornsea Three, although there is uncertainty regarding how many individuals from each of the colonies will be affected by Hornsea Three. Details of how potential impacts are apportioned across colonies from within the region are given in the supporting documents associated with the Report to Inform Appropriate Assessment for Hornsea Three.

5.6.4 Site specific surveys

Site-specific aerial surveys

5.6.4.1 For Hornsea Three, digital aerial surveys have been undertaken monthly since April 2016 until November 2017. These aerial surveys covered the Hornsea Three offshore ornithology study area. A strip-transect method was employed with transects arranged approximately perpendicular to depth contours and 2.5 km apart. Further information on the aerial digital survey methodology and how data are processed are described in sections 1.2.1 and 1.2.2 of volume 5, annex 5.1: Baseline Characterisation Report, respectively.

5.6.4.2 Data collected during aerial surveys were analysed by trained reviewers. The abundance of each species observed during surveys was estimated separately using a design-based strip transect analysis with variance and confidence intervals ("CI") derived using a bootstrapping methodology. A more detailed explanation of the data processing approach and calculation of abundance metrics is provided in section 1.2.3 of volume 5, annex 5.1: Baseline Characterisation Report.

5.6.4.3 It was agreed through the Offshore Ornithology EWG that surveys of the Hornsea Three offshore cable corridor are not required (Consultation Report (document reference number A5.1), annex 1: Evidence Plan).

Former Hornsea Zone boat-based surveys

5.6.4.4 A series of monthly boat-based surveys of seabirds across the former Hornsea Zone commenced in March 2010 and were completed in February 2013, encompassing three breeding, migratory and winter periods.

5.6.4.5 JNCC was consulted in January 2010, on the proposed survey methodology for ornithology surveys across the former Hornsea Zone. This methodology was formally approved, as part of the 2008 Act process, in the Scoping Opinions for Hornsea Project One (IPC, 2010) and Hornsea Project Two (The Planning Inspectorate, 2012). Full details of these surveys and the methodology employed are included in the Hornsea Project Two Ornithology Technical Report Part 1, Section 2 (see PINS Document Reference 7.5.5.1 available from https://infrastructure.planninginspectorate.gov.uk).

Meta-analysis of baseline ornithological data sets

5.6.4.6 The site-specific surveys for Hornsea Three have obtained data for twenty months, including two breeding seasons for the majority of species. For the largely non-breeding period of December to March, there are site-specific digital aerial survey data for one year. This is considered to be of relatively minor consequence to impact assessment as for example, the coverage actually obtained is comparable to that achieved in most two year survey campaigns in offshore settings). It is also considered that reduced site-specific survey coverage in these months is of lesser importance as many species of birds have migrated to wintering areas outside of the regional Offshore Ornithology study area or are less constrained in terms of area usage than would have been the case, say, for the breeding season. For those species that do not exhibit migratory behaviour, the populations present in biogeographic regions during non-breeding seasons are composed of birds associated with a much wider range of breeding colonies as there is far less affinity to breeding colonies exhibited by birds at this time of year. The site-specific survey data, including for the period December to March, are also supplemented with a detailed analysis of historical data obtained for the former Hornsea Zone, including the area occupied by Hornsea Three.

5.6.4.7 As part of the preparation of data for use in an EIA for Hornsea Three, a detailed analysis of the boat-based and digital aerial data has been conducted in order to understand the inherent variability in the boat-based survey data and how this affects the compatibility of these historical boat-based data with digital aerial data (see volume 5, annex 5.4: Data Hierarchy Report).

5.6.4.8 This analysis has produced the following outputs:

- Seasonal density estimates for the Hornsea Three area (plus relevant buffers) for key species and seasons;
- Identification of the seasonal and annual variability in population density for key species for each analysis area;
- Investigation of suitable co-variates (such as sea temperature, bathymetry, distance from shore, chlorophyll a) that might explain observed variability in densities and flight heights; and
- Detailed analyses including statistical analysis and, where possible, predictive modelling.

5.6.4.9 The production of these outputs allowed for the following analyses to be conducted which in turn inform discussions in relation to Hornsea Three:

- Identification of the extent of boat-based ornithological records across the Hornsea Three area;
- Characterisation of the uncertainty in population estimates and density distribution;
- Comparison of population estimates for ten key species for Hornsea Three with those derived for the Hornsea Project One and Hornsea Project Two sites;
- Analysis of the variability in patterns of observed flight heights across the former Hornsea Zone by season and year;
- Comparison of results of the boat-based and aerial surveys; and
- Discussion in relation to the implications of the above for CRM and displacement analysis.

5.6.4.10 The results of the above analyses are used to inform the assessments undertaken for Hornsea Three by identifying whether in those months where only one survey was completed as part of the aerial survey programme for Hornsea Three, the data from aerial surveys captures the variability inherent in seabird populations. For months where two surveys have been conducted the aerial survey data are assumed to adequately capture this variability. The process by which population estimates or densities are identified is presented in volume 5, annex 5.4: Data Hierarchy Report. The abundance metrics used for displacement analyses and CRM are identified in volume 5, annex 5.2: Analysis of Displacement Impacts on Seabirds and volume 5, annex 5.3: Collision Risk Modelling.

5.7 Baseline environment

5.7.1 Designated sites

5.7.1.1 Designated sites within close proximity to Hornsea Three and therefore most likely to be potentially affected by activities associated with it, are described here and discussed in full in annex 5.1: Baseline Characterisation Report.

5.7.1.2 There is only one designated site that potentially directly overlaps with elements of Hornsea Three, the Greater Wash pSPA, which is located within the Hornsea Three offshore cable corridor.

5.7.1.3 In addition, the potential for birds from breeding colonies to interact offshore with Hornsea Three has been identified based on foraging distances from the following sites:

- Flamborough and Filey Coast pSPA;
- Flamborough Head and Bempton Cliffs SPA;
- Farne Islands pSPA;
- Coquet Island pSPA;
- Forth Islands SPA;
- Outer Firth of Forth pSPA; and
- Alde-Ore Estuary SPA.

5.7.1.4 The rationale for the identification of these sites and the specific features potentially affected are described in section 1.5 of annex 5.1: Baseline Characterisation Report.

5.7.1.5 It was concluded following consultation on the HRA Screening Report and discussion with the Offshore Ornithology EWG, that a Likely Significant Effect (LSE) on three of the pSPA/SPAs above (Greater Wash pSPA, FFC pSPA, and Flamborough Head and Bempton Cliffs SPA) could not be ruled out during the screening exercise and these sites have therefore be taken forward to the RIAA for Hornsea Three (Ørsted, 2018).

5.7.2 Valued Ornithological Receptors

5.7.2.1 The species that are considered to be VORs for this assessment are identified in the individual species accounts below and in Table 5.7. The main premise behind the identification of a VOR is where the numbers present at Hornsea Three plus a 4 km buffer exceed the 1% threshold of the regional population in any season. In general, it therefore follows that any impacts on species occurring in numbers of less than 1% of the relevant regional population will not be significant. This assumption is not however, deemed to be definitive across all species with expert judgement also applied to identify species for which this threshold may not be applicable (e.g. species whose populations are not accurately quantified by traditional survey methods) and therefore ensure that a robust and precautionary suite of VORs is identified for further assessment.

5.7.2.2 The next stage of the assessment involves the determination of the importance or value of each VOR, taking into account conservation status and the importance of populations estimated within the Hornsea Three ornithological study area (see annex 5.1: Baseline Characterisation Report). These criteria were informed by ecological impact assessment guidance (CIEEM, 2010).

5.7.2.3 Annex 5.1: Baseline Characterisation Report presents a range of populations at various geographical scales which were used to identify the importance of populations estimated in the Hornsea Three ornithological study area. Thresholds for international importance have been sourced from Wetlands International (2017), Mitchell *et al.* (2004), del Hoyo *et al.* (1996) or Birdlife International (2017) with national population thresholds derived from Musgrove *et al.* (2013), Furness (2015) or Burton *et al.* (2013). Regional populations were either calculated based on the population predicted to have connectivity with Hornsea Three using population data from JNCC's Seabird Monitoring Programme (SMP) database[1] or sourced from Furness (2015) which non-breeding season populations for seabirds in UK waters using BDMPS. BDMPS combines both a spatial scale and a population scale within which the number and origin of the birds present in a particular season are defined.

5.7.2.4 Details of the information used to evaluate species against these criteria are included in annex 5.1: Baseline Characterisation Report.

Species accounts

5.7.2.5 The following species accounts summarise information on the identified VORs recorded within Hornsea Three offshore ornithology study area between April 2016 and November 2017. This includes estimated populations and spatial distribution information including contextual information from the former Hornsea Zone, and a summary of each species' conservation status. Full details for each species are provided in annex 5.1: Baseline Characterisation Report.

[1] ttp://jncc.defra.gov.uk/smp/Default.aspx

Common scoter

5.7.2.6 Common scoter is listed on Schedule 1 of the Wildlife and Countryside Act (1981, as amended) and is currently red-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

5.7.2.7 An estimated 52 pairs of common scoter breed in the UK, with the majority of pairs found in the north and west of Scotland (Musgrove *et al.*, 2013; Balmer *et al.*, 2013). The wintering population around Britain has been estimated at 100,000 individuals (Musgrove *et al.*, 2013) and the 1% threshold for national importance is 1,000 birds (Musgrove *et al.*, 2011).

5.7.2.8 Common scoter is listed as a qualifying interest species in the non-breeding season for four SPAs and one potential SPA on the UK east coast: Firth of Forth SPA; Firth of Tay and Eden Estuary SPA; Lindisfarne SPA; The Wash SPA; and Greater Wash pSPA. The Greater Wash pSPA supports a discrete population of approximately 3,463 individuals or nearly 3.5% of the British wintering population, making the site the fifth most important site for non-breeding common scoter in the UK.

5.7.2.9 No common scoter were recorded in aerial surveys undertaken across Hornsea Three offshore ornithology study area. The absence of common scoter in offshore areas is also evident in the results presented in Stone *et al.* (1995) with high densities of common scoter in inshore areas.

5.7.2.10 The Hornsea Three offshore cable corridor runs through the Greater Wash Area of Search making landfall at Weybourne on the North Norfolk coast, approximately 35 km east of the highest densities of common scoter which are located in the mouth of The Wash. The average density of common scoter within the Hornsea Three offshore cable corridor, derived from Lawson *et al*. (2015), is considerably less than 0.01 birds/km^2.

5.7.2.11 The population of common scoter recorded at Hornsea Three during aerial surveys did not exceed any 1% threshold. The Hornsea Three offshore cable corridor passes through the Greater Wash pSPA for which common scoter is a proposed qualifying feature and, hence, this species is considered to be of International conservation value in relation to the proposed export cable only.

Red-throated diver

5.7.2.12 Red-throated diver is listed on Annex I of the EU Birds Directive (2009/147/EEC) and Schedule 1 of the Wildlife and Countryside Act (1981, as amended) and is currently green-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

5.7.2.13 An estimated 1,300 pairs of red-throated diver breed in Britain, with the majority of pairs found in the north and west of Scotland (Musgrove *et al.*, 2013; Balmer *et al.*, 2013). The wintering population around Britain has been estimated at 17,000 individuals (O'Brien *et al.*, 2008) and the 1% threshold for national importance is 170 birds (Musgrove *et al.*, 2011). Several important areas for the species off the east coast of England have recently been identified; in particular, the outer Thames Estuary and the Greater Wash (O'Brien *et al.*, 2008).

5.7.2.14 Red-throated diver is listed as a qualifying interest species in the non-breeding season for two SPAs and one potential SPA on the UK east coast: the Outer Thames Estuary SPA; Firth of Forth SPA; and Greater Wash pSPA. The Outer Thames Estuary SPA regularly supports wintering red-throated diver in numbers of European importance (6,466 individuals – wintering 1989–2006/07) (Natural England and JNCC, 2010), which is around 38% of the British wintering population.

5.7.2.15 The Greater Wash pSPA regularly supports 1,511 red-throated diver, or nearly 9% of the British wintering population, making this the second most important area for red-throated diver around the coast of the UK after the Outer Thames Estuary (Natural England, 2016). The highest densities of divers within the Greater Wash pSPA occur close inshore (up to 3.38 birds/km^2), particularly in the area outside The Wash SPA, north of the Humber Estuary and along the eastern part of North Norfolk Coast (Lawson *et al*, 2015).

5.7.2.16 Red-throated diver is also included as a potential qualifying feature of a number of Scottish pSPAs in the non-breeding season.

5.7.2.17 Available evidence from ringing studies suggests that red-throated divers may move considerable distances from their breeding grounds in the non-breeding season. Birds ringed in Greenland and Scandinavia have been recovered in the UK, indicating that not all birds recorded in the former Hornsea Zone may breed in the UK (Wernham *et al.*, 2002).

5.7.2.18 Red-throated diver were recorded in two of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. A total of six birds were recorded during May 2016 translating to a peak population estimate of 66 birds. Although this population occurred during the defined breeding season for red-throated diver these birds are not considered to be breeding birds. There is considered to be no connectivity between Hornsea Three and red-throated diver breeding areas with the closest breeding areas to Hornsea Three in northern Scotland (Cramp & Perrins 1997 – 1994; Forrester *et al.* 2007; Thaxter *et al.* 2012; Wernham *et al.,* 2002). Birds recorded at Hornsea Three during the defined breeding season for red-throated diver are therefore considered to be non-breeding birds or birds on passage. In addition to the birds recorded in May 2016 a further two birds were recorded in April 2017, translating to population estimate of 30 birds. These populations do not surpass the 1% regional threshold of the population of red-throated diver that occurs in the south-west North Sea during migration (133 individuals).

5.7.2.19 It is therefore considered unlikely that significant impacts will occur on red-throated diver at the Hornsea Three array area. However, the Hornsea Three offshore cable corridor passes through the Greater Wash pSPA for which red-throated diver is a proposed qualifying feature and, hence, this species is considered to be of International conservation value in relation to the proposed export cable only.

Fulmar

5.7.2.20 Fulmar is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). Fulmar is however currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015). The species is one of the most common seabirds in Britain, with an estimated breeding population of 499,081 pairs (Mitchell *et al.*, 2004). The largest breeding colonies are located off the north and west coasts of Scotland with birds often present at these colonies outside of the breeding season.

5.7.2.21 Between March and July, fulmars are distributed widely across the southern North Sea, although numbers are relatively low compared to further north along Scottish coasts, where the majority of British colonies occur (Stone *et al.*, 1995). From August to November, distribution extends southwards from the main breeding colonies. Through the rest of the winter this species is very widely distributed across the whole North Sea, although it is evident that the continental shelf edge is important for fulmar at most times of the year, with the closest area of high concentrations to Hornsea Three being at Dogger Bank (Stone *et al.*, 1995).

5.7.2.22 Historical survey data suggests that the Hornsea Three array area supports relatively low to moderate densities of fulmar (1.23-2.32 birds/km^2). The highest predicted densities in the North Sea in the summer (April to September) occur to the north-west of Hornsea Three off the Northumberland coast (see Figure 1.40 in annex 5.1: Baseline Characterisation Report). From August to November, distribution extends southwards from the main breeding colonies (Stone *et al.,* 1995). Through the rest of the winter this species is very widely distributed across the whole North Sea, although it is evident that the continental shelf edge is important for fulmar at most times of the year, with the closest area of high concentrations (up to 5 birds/km^2) to Hornsea Three being at Dogger Bank (Stone *et al.,* 1995). Moderate densities (0.59 – 0.9 birds/km^2) of fulmar occur at Hornsea Three during winter months (October to March), although these densities are lower than those predicted in the summer. The highest predicted densities in the winter (up to 2.14 birds/km^2) again occur to the north-west of Hornsea Three approximately 40 km from the Yorkshire coast.

5.7.2.23 Hornsea Three lies within the mean maximum foraging range of fulmar (400 ± 245.8 km; Thaxter *et al.,* 2012) from two SPA and three pSPAs, Northumberland Marine SPA, Flamborough and Filey Coast pSPA, Forth Islands SPA, Farne Islands pSPA and Coquet Island pSPA. Fulmar is not a qualifying feature in its own right but is listed as a main component of the seabird assemblage at the Flamborough and Filey Coast pSPA and the Forth Islands SPA and is a non-listed assemblage feature at the Northumberland Marine SPA, Farne Islands pSPA and Coquet Island pSPA.

5.7.2.24 Fulmars were recorded in all of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. In the breeding season (April to August) a peak population of 1,554 birds occurred in August 2017. This population and those estimated in April, May and June of both 2016 and 2017 and July 2017 exceed the 1% threshold of the regional breeding population (117 individuals). However, none of these populations exceed the 1% threshold of the national breeding population.

5.7.2.25 In surveys undertaken in the post-breeding season (September to October), a peak population estimate of 1,347 birds occurred in September 2016. This population does not exceed the 1% threshold of the post-breeding BDMPS population for fulmar. Similarly, for surveys undertaken in the pre-breeding season (December to March), the peak population of 997 birds that occurred in December was also not of regional importance.

5.7.2.26 The non-breeding season for fulmar is defined as November. A peak population of 450 fulmars were estimated to be present within Hornsea Three offshore ornithology study area during the aerial survey undertaken during November 2017. This population does not exceed the 1% threshold of the regional BDMPS population for fulmar (5,687 individuals).

5.7.2.27 Fulmar is considered to be of International conservation value due to the potential for interaction between birds from a number of SPA breeding colonies and the Hornsea Three area based on the mean-maximum foraging range of fulmar (Thaxter *et al.*, 2012). In addition to this, population estimates of fulmar in Hornsea Three plus a 4 km buffer in the breeding season for April, May and June of both survey years and July 2016 and August 2017exceed the 1% threshold of the regional population. The 1% thresholds of the national and international populations for fulmar are not surpassed in any month.

Gannet

5.7.2.28 Gannet is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). Gannet is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

5.7.2.29 Gannet is a widely dispersed species throughout the southern North Sea with an estimated flyway population of 892,000 individuals (Stienen *et al.*, 2007). Of this population, it is estimated that 40-60,000 birds pass through the southern North Sea en route to the Strait of Dover, with 10,000 birds remaining in the area through winter (Stienen *et al.*, 2007). From March to August gannets are present in low densities (up to 0.99 birds/km^2) in the southern North Sea with populations concentrated on the shelf edge or, in the breeding season, around the major colonies (Stone *et al.*, 1995). Historical survey data suggests that densities of the species are relatively low (<0.01-0.91 birds/km^2) at Hornsea Three during the summer (April to September) (see Figure 1.41 in annex 5.1: Baseline Characterisation Report). However, the population of gannet at Bempton Cliffs is now much larger than throughout the majority of the period during which historical survey data were collected (JNCC, 2017). In the winter (October to March), predicted densities of gannet at Hornsea Three are again relatively low (<0.01-0.92 birds/km^2) (see Figure 1.41 in annex 5.1: Baseline Characterisation Report).

5.7.2.30 The UK breeding population of gannet has been estimated at 220,000 pairs (Musgrove *et al.*, 2013). The species breeds at 26 large colonies around the UK, the nearest to the former Hornsea Zone being at Bempton Cliffs within the FFC pSPA (Balmer *et al.*, 2013). This colony was estimated at 7,859 nests in 2009 (JNCC, 2017) and increased to an estimated 11,061 pairs in 2012 and 12,494 pairs in 2015. Breeding birds have been shown by satellite-tagging to range widely across the North Sea, at times as far as the Norwegian coast (Hamer *et al.*, 2007). However, an analysis of tracking data by Wakefield *et al.* (2013) suggested that in the North Sea there was limited overlap between the foraging areas of gannets from the Bempton Cliffs breeding colony and the breeding colony at Bass Rock.

5.7.2.31 Gannet is listed as a qualifying interest species in the breeding season for four SPAs and two pSPAs on the UK east coast. These SPAs were designated for 54,495 pairs at time of designation, representing nearly 25% of the current national population of gannet (Wanless *et al.*, 2005). Hornsea Three lies within the mean-maximum forging range of gannet (229.4 km) (Thaxter *et al.*, 2012) from only the FFC pSPA although the Firth of Forth Islands SPA is within the estimated maximum foraging range of 590 km. However, Wakefield *et al.* (2013) indicates that the foraging areas of gannets from these two colonies show little overlap.

5.7.2.32 Gannets were recorded in all of the aerial surveys conducted across the Hornsea Three offshore ornithology study area. The peak population during the breeding season (April to August) was recorded in August 2017 when an estimated 2,207 birds occurred. This population and those recorded in April, May, June and July 2016 and July 2017 exceed the 1% threshold of the regional breeding population (250 individuals). However, none of these populations exceed the 1% threshold of the national breeding population (4,400 individuals).

5.7.2.33 In aerial surveys undertaken in the post-breeding season as defined for gannet (September to November) a peak population of 2,638 birds was estimated during October 2017. This population does not exceed the 1% threshold of the post-breeding BDMPS population for gannet (4,563 individuals). Similarly, during surveys undertaken in the pre-breeding season (December to March) the peak population of 1,099 birds that occurred in December was also not of regional importance (1% threshold of 2,484 individuals).

5.7.2.34 Gannet is considered to be of International conservation value as there is the potential for connectivity between the FFC pSPA breeding colony and Hornsea Three based on the mean-maximum foraging range of gannet (229.4 km). In addition, population estimates of gannet in Hornsea Three offshore ornithology study area in the breeding season for all months between April and July 2016 and July and August 2017 exceed the 1% threshold of the regional breeding population. The 1% thresholds of the national and international populations for gannet are not surpassed in any month.

Arctic skua

5.7.2.35 Arctic skua is currently red-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015) due to its significant recent decline with the UK breeding population showing declines of 37% between 1985/88 and 1998/2002 and 64% between 1998/2002 and 2015 (JNCC, 2016).

5.7.2.36 Arctic skua is a passage migrant in spring and autumn in the North Sea, and a scarce UK breeding species, restricted to Shetland, Orkney, north Scotland and the Western Isles (Forrester *et al.*, 2007). Seabird 2000 estimated the Scottish breeding population at 2,136 pairs (Mitchell *et al.*, 2004).

5.7.2.37 Predicted densities of Arctic skua in the North Sea during the summer (April to September), derived from historical survey data, suggest Hornsea Three does not support high densities of the species (<0.01-0.01 birds/km^2) (see Figure 1.42 in annex 5.1: Baseline Characterisation Report). It is worth noting that the highest predicted densities of Arctic skua in the North Sea were between 0.05 and 0.08 birds/km^2 with these occurring inshore of Hornsea Three. However, passage movements of Arctic skua are not considered to be adequately captured by traditional survey methods.

5.7.2.38 Arctic skua is listed as a qualifying interest species in the breeding season for seven SPAs on the UK east coast. These SPAs are designated for 790 breeding pairs representing approximately 37% of the UK breeding population as recorded during Seabird 2000 (Mitchell *et al.* 2004). Hornsea Three does not lie within the maximum known foraging range of this species (75 km; Thaxter *et al.*, 2012) from these SPAs.

5.7.2.39 Arctic skuas were recorded in six of the aerial surveys conducted across the Hornsea Three offshore ornithology study area. Hornsea Three is not considered to be within foraging range of Arctic skua from any UK colonies with the closest located in northern Scotland beyond the maximum foraging range reported for this species (Thaxter *et al.* 2012). As such, all records of Arctic skua at Hornsea Three are considered to be non-breeding or migrating birds with population estimates compared to the relevant regional and national post-breeding season population thresholds.

5.7.2.40 The peak population of Arctic skua estimated in the Hornsea Three offshore ornithology study area was 56 birds in September 2016, based on 5 observations This population does not surpass the 1% threshold of the regional post-breeding population of Arctic skua that migrates through the North Sea (64 individuals). However, traditional boat-based and aerial surveys are considered unlikely to accurately quantify the migratory movements of this species that may pass through Hornsea Three. On a precautionary basis, Arctic skua is assigned an International conservation value as the population that interacts with Hornsea Three is unknown and may consist of a large proportion of birds breeding at UK SPA colonies.

Great skua

5.7.2.41 Great skua is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). Great skua is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

5.7.2.42 Great skua regularly occur in the North Sea on spring and autumn passage, with some birds remaining for the winter months (Stone *et al.*, 1995). Great skuas breed on Shetland, Orkney and the Western Isles (Balmer *et al.*, 2013), with an estimated population of 9,634 pairs during Seabird 2000 (Mitchell *et al.*, 2004).

5.7.2.43 Predicted densities of great skua in the North Sea during the summer, derived from historical survey data (WWT Consulting and MacArthur Green, 2014), suggest the species is relatively abundant closer to the eastern coast of England with lower densities in the vicinity of Hornsea Three ornithological study area (0.01-0.03 birds/km^2) (see Figure 1.43 in annex 5.1: Baseline Characterisation Report). However, passage movements of great skua are not adequately captured by traditional survey methods. In the winter predicted densities of the species are relatively low throughout the North Sea only reaching 0.04 birds/km^2 at Hornsea Three.

5.7.2.44 Great skua is listed as a qualifying interest species in the breeding season for seven SPAs on the UK east coast (Shetland to Kent). These SPAs are designated for 6,126 breeding pairs representing approximately 64% of the UK population as recorded during Seabird 2000 (Mitchell *et al.* 2004). None of these SPA colonies lie within the maximum known foraging range of this species (219 km) (Thaxter *et al.*, 2012) from Hornsea Three.

5.7.2.45 Great skuas were recorded in six of the aerial surveys undertaken across Hornsea Three offshore ornithology study area. These records occurred during the September, December and March 2016 and August, September and October 2017 surveys. The peak population estimated during the post-breeding season (August to October) (17 individuals in September 2017) does not surpass the 1% threshold of the post-breeding BDMPS population for great skua (196 birds). Similarly, the estimated population in the non-breeding season does not surpass the 1% threshold of the non-breeding BDMPS population (50 birds) for great skua.

5.7.2.46 The peak population of great skua estimated in the Hornsea Three offshore ornithology study area was 22 birds in December. However, traditional boat-based and aerial surveys are considered unlikely to accurately quantify the migratory movements of this species that may pass through Hornsea Three. As such, on a precautionary basis great skua is considered to be of International conservation value as the population that interacts with Hornsea Three is unknown and may consist of a large proportion of birds breeding at UK SPA colonies.

Puffin

5.7.2.47 Puffin is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act. The species is however currently red-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

5.7.2.48 Puffins are one of the most common seabird species in Britain, breeding in coastal colonies. Seabird 2000 recorded 579,500 pairs at breeding colonies around Britain (Mitchell *et al.*, 2004).

5.7.2.49 During the breeding season puffin are aggregated around their colonies along the east coast and high densities are found in the Flamborough Head area. During post-breeding, however, the birds disperse towards the north-western North Sea before spreading out more widely throughout the winter months (Stone *et al.*, 1995).

5.7.2.50 Between April and July, the Flamborough Head area has densities of up to five birds/km^2 due to the high numbers of birds foraging in the area local to the breeding colony. This continues into the non-breeding season months of August to September as puffins are leaving the colony (Stone *et al.*, 1995). Predicted densities of puffin in the summer (April to September) as derived from historical survey data suggest high densities (up to 5.58 birds/km^2) of the species occur in inshore areas along the eastern coast of England between the two main breeding colonies on this coast at Flamborough and the Farne Islands (see Figure 1.44 in annex 5.1: Baseline Characterisation Report). Predicted densities in the summer at Hornsea Three are relatively low (0.00-0.24 birds/km^2). In the winter, predicted densities of puffin are relatively low at Hornsea Three (0.00-0.02 birds/km^2) with the highest predicted densities associated with the Dogger Bank area approximately 100 km to the north of Hornsea Three (up to 0.83 birds/km^2).

5.7.2.51 Puffin is listed as a qualifying interest species in the breeding season for eleven SPAs and two pSPAs on the UK east coast. The distance between Hornsea Three and the nearest designated site (FFC pSPA) is within the mean-maximum foraging range ± 1 standard deviation of puffin (105.4 ±46 km) (Thaxter *et al.*, 2012). Puffin is a non-listed assemblage feature at FFC pSPA. No other SPAs are within the mean-maximum or maximum foraging range (200 km; Thaxter *et al.*, 2012) of puffin from Hornsea Three.

5.7.2.52 Puffins were recorded in twelve of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. Two seasons are defined for puffin, a breeding season from May to July and a non-breeding season from August to April. The peak population recorded in the breeding season occurred in May 2016 when a population of 352 birds was estimated. This surpasses the 1% threshold of regional importance for puffin (50 birds) with the population estimated in May and July 2017 also surpassing the threshold for regional importance.

5.7.2.53 In surveys undertaken in the non-breeding season, puffins were recorded in seven surveys with an estimated peak population estimate of 266 birds in April 2016. This population does not exceed the 1% threshold of the regional non-breeding BDMPS population for puffin (2,320 individuals).

5.7.2.54 On a precautionary basis, puffin is considered to be of International conservation value because there is potential connectivity between Hornsea Three and the breeding colony at the FFC pSPA. Population estimates of puffin in the Hornsea Three offshore ornithology study area exceed the 1% thresholds of relevant regional populations in May 2016 and May and July 2017. The 1% thresholds of the national and international populations for puffin are not surpassed in any month.

Razorbill

5.7.2.55 Razorbill is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). The species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

5.7.2.56 Seabird 2000 recorded 164,557 individuals at breeding colonies around Britain (Mitchell *et al.*, 2004). The closest large colony to Hornsea Three is at FFC pSPA which held an estimated 10,570 pairs in 2008-12. However, Hornsea Three is outside of the mean-maximum (48.5 km) and maximum (95 km) foraging ranges of razorbill as reported by Thaxter *et al.* (2012).

5.7.2.57 High densities of razorbills (up to 5 birds/km^2) have been recorded in the north-western North Sea with lower densities (generally up to 1.99 birds/km^2) recorded overwintering in the southern North Sea (Stone *et al.*, 1995). With a flyway population of some 482,000 birds in the southern North Sea, between 1.3 and 2.0% of the biogeographic population are estimated to move through this area (Stienen *et al.*, 2007).

5.7.2.58 From April to August during the incubating and chick-rearing season, razorbills are generally confined to coastal areas from Flamborough Head northwards along the east coast. Predicted densities of razorbill during the summer (April to September), derived from historical surveys, are highest (3.62-5.55 birds/km^2) in inshore areas along the eastern coast of England between Yorkshire and Northumberland, extending into offshore areas from the breeding colony at Flamborough, although not as far as Hornsea Three (see Figure 1.45 in annex 5.1: Baseline Characterisation Report). From August to September densities of more than five birds/km^2 can be found in the Flamborough area, as young birds disperse from the colony with their parents. Very few birds were reported in the vicinity of Hornsea Three by Stone *et al.* (1995). Between October and March there are low to moderate densities (0.05-0.18 birds/km^2) in the southern North Sea with low densities along the east coast of up to one bird/km^2 (Stone *et al.*, 1995).

5.7.2.59 Razorbill is listed as a qualifying interest species in the breeding season for ten SPAs and two pSPAs on the UK east coast. These SPAs are designated for 41,821 pairs representing approximately 38% of the most UK population as counted during Seabird 2000 (Mitchell *et al.* 2004).

5.7.2.60 Razorbills were recorded in all of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area with the exception of the August 2016 survey. In surveys undertaken during the breeding season defined for razorbill (April to July) a peak population of 736 birds was estimated in April 2017. This population estimate does not exceed the 1% threshold for national importance (2,600 individuals).

5.7.2.61 In the post-breeding season (August to October), the peak population of razorbill was estimated in October 2017 (4,022 birds). This population does not surpass the 1% threshold of regional importance (5,912 individuals). Similarly in the pre-breeding season (January to March), the peak population of 2,972 birds estimated in March does not exceed the 1% threshold of regional importance (5,912 individuals).

5.7.2.62 The largest populations of razorbill estimated from aerial survey data were in the non-breeding season (November to December). In the three surveys undertaken in this season populations of 4,976 (November 2016), 3,648 (December) and 4,352 (November 2017) birds were estimated. These populations all exceed the 1% threshold of regional importance (2,186 individuals) but do not exceed the 1% threshold of the national non-breeding population of razorbill (5,600 individuals).

5.7.2.63 Population estimates of razorbill in the Hornsea Three offshore ornithology study area surpass the 1% threshold of the regional population in all non-breeding season months (November and December), therefore razorbill is assigned a Regional conservation value.

Guillemot

5.7.2.64 Guillemot is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). The species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

5.7.2.65 Seabird 2000 recorded 1,322,830 individuals at breeding colonies in Britain (Mitchell *et al.*, 2004). The closest large colonies to Hornsea Three are at the Farne Islands and Bempton Cliffs (including Flamborough Head).

5.7.2.66 The southern North Sea is important for guillemots throughout the year with high densities in all months. With a total flyway population of 1,990,000 birds, 1.5 to 3.0% of the biogeographic population resides in or flies over the southern North Sea (Stienen *et al.*, 2007).

5.7.2.67 From March to June, guillemot densities are high in the southern North Sea, notably in the Dogger Bank area. These densities of between two and five birds/km^2 reflect both high levels of pre-breeding activity (when birds from further afield are foraging more widely) and also that local colonies are showing more concentrated foraging activity at the start of the breeding season. This is evident in the Flamborough Head area (Stone *et al.*, 1995). During July and August, chicks and adults depart the colonies resulting in high densities (more than five birds/km^2) being found in both these months around Flamborough Head and Dogger Bank. These high densities remain throughout the winter months from October to February (Stone *et al.*, 1995).

5.7.2.68 A similar distribution is evident from historical survey data with the highest densities of guillemot (up to 22.68 birds/km^2) in the summer (April to September) associated with inshore areas between the Northumberland coast and Flamborough with densities extending offshore from the Flamborough breeding colony in a north-easterly direction (see Figure 1.46 in annex 5.1: Baseline Characterisation Report). In the winter (October to March) densities are lower (up to 16.3 birds/km^2) throughout the North Sea with the main concentration of guillemot associated with the Dogger Bank area.

5.7.2.69 Guillemot is listed as a qualifying interest species in the breeding season for 18 SPAs and 3 pSPAs on the UK east coast. These SPAs are designated for 487,801 breeding pairs representing approximately 37% of the UK breeding population as recorded during Seabird 2000 (Mitchell *et al.* 2004).

5.7.2.70 The closest colony to Hornsea Three is FFC pSPA which supported 41,607 pairs in 2008-12. The distance between Hornsea Three and FFC pSPA is approximately 149 km, further than the maximum foraging range of guillemot (135 km; Thaxter *et al.*, 2012).

5.7.2.71 Guillemots were recorded in all of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. During surveys undertaken in the breeding season defined for guillemot (March to July), a peak population of 19,360 birds was estimated in June 2016 with this population surpassing the threshold for national importance.

5.7.2.72 In the non-breeding season a peak population of 26,561 birds was estimated from aerial survey data collected in November 2017. This population and those estimated in August, September, November and December 2016 and September and October 2017 exceed the 1% threshold of regional importance (16,173 individuals) but are not considered to be of national significance (27,565 individuals).

5.7.2.73 Population estimates of guillemot in the Hornsea Three offshore ornithology study area exceed the 1% thresholds of the relevant national breeding population in August 2016. The 1% threshold of the international population for guillemot is not surpassed in any month. Guillemot is therefore considered to be of National conservation value.

Sandwich tern

5.7.2.74 Sandwich tern is listed on Annex I of the EU Birds Directive (2009/147/EEC), and the species is currently amber-listed on the UK Birds of Conservation Concern (Eaton *et al.*, 2015).

5.7.2.75 Sandwich terns are summer visitors to Britain, breeding in coastal colonies. Seabird 2000 recorded 10,536 pairs in Britain (Mitchell *et al*., 2004). The closest colonies to Hornsea Three are on the north Norfolk Coast at Blakeney Point and Scolt Head which form part of the North Norfolk Coast SPA. After the breeding season, Sandwich terns migrate south to the west coast of Africa, returning the following spring (Wernham *et al.,* 2002). Sandwich terns feed on a variety of small, surface-feeding fish including sandeels but also cephalopods and crustaceans that they catch by plunge-diving (Brown and Grice, 2005).

5.7.2.76 Predicted densities of Sandwich tern in the summer (April to September) shown in Figure 1.45 (WWT Consulting and MacArthur Green, 2014), indicate that the species is abundant off the north Norfolk coast with relatively low densities present at Hornsea Three and in surrounding sea areas.

5.7.2.77 Sandwich tern is listed as a qualifying interest species in the breeding season for six SPAs and four pSPAs on the UK east coast (Table 1.28). These SPAs held 8,943 pairs at the time of designation. The distance between all these sites and Hornsea Three is beyond the maximum foraging range of Sandwich terns (54 km) (Thaxter *et al*., 2012).

5.7.2.78 Sandwich terns were recorded in two of the aerial surveys conducted across Hornsea Three plus a 4 km buffer. A total of three birds were recorded during the August 2017 survey with four recorded in the September 2017 survey. These counts translate to population estimates (see annex 5.1: Baseline Characterisation Report for methodology) of 35 and 162 birds respectively (Table 1.29, Figure 1.21). These birds are migratory individuals, with these population estimates not surpassing the 1% threshold for regional importance (1% threshold = 381 individuals).

5.7.2.79 It is therefore considered unlikely that significant impacts will occur on Sandwich tern at the Hornsea Three array area. However, the Hornsea Three offshore cable corridor passes through the Greater Wash pSPA for which Sandwich tern is a proposed qualifying feature. The predicted usage of the area in which the Hornsea Three offshore cable corridor is located by Sandwich tern is notably low (see Figure 1.22 in annex 5.1: Baseline Characterisation Report). However, on a precautionary basis the species is included as a VOR for further assessment for impacts associated with the Hornsea Three offshore cable corridor only.

<u>Common tern</u>

5.7.2.80 Common tern is listed on Annex I of the EU Birds Directive and the species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al*., 2015).

5.7.2.81 Common terns are summer visitors to Britain, breeding in colonies at coastal sites and also inland. Seabird 2000 recorded 10,308 pairs in Britain (Mitchell *et al.*, 2004). The closest large colonies to Hornsea Three are Coquet Island, the Farne Islands and Scolt Head. In autumn, common terns migrate south to the west coast of Africa, returning the following spring (Wernham *et al*., 2002). Predicted densities of the species in the North Sea during the summer (April to September), derived from historical survey data, indicate that the highest densities (up to 0.25 birds/km^2) occur in inshore areas, extending offshore of Flamborough Head (see Figure 1.48 in annex 5.1: Baseline Characterisation Report). However, passage movements of common tern are not adequately captured by traditional survey methods.

5.7.2.82 Hornsea Three lies beyond the maximum foraging range of common tern from these SPAs (30 km) (Thaxter *et al*., 2012) and therefore common tern occurs only on passage (particularly in autumn) through Hornsea Three with no apparent connectivity to SPAs where they are a breeding feature. Common tern is listed as a qualifying interest species in the breeding season for nine SPAs and six pSPAs on the UK east coast. These SPAs are designated for 4,136 breeding pairs representing approximately 40% of the national breeding population as recorded during Seabird 2000 (Mitchell *et al*., 2004).

5.7.2.83 Common terns were recorded in only two of the aerial surveys conducted across the Hornsea Three offshore ornithology study area. A total of three birds were recorded during the September survey with thirty recorded in the May 2017 survey. These counts translate to population estimates of 314 and 1,184 birds respectively when individuals not identified to species level are taken into account. These birds are migratory individuals with this population not surpassing the 1% threshold for regional importance (1,449 individuals).

5.7.2.84 Traditional boat-based and aerial surveys are considered unlikely to accurately quantify the migratory movements of this species that may pass through Hornsea Three. Common tern is listed on Annex I of the EU Birds Directive, and as the population that interacts with Hornsea Three is unknown and may include birds from breeding UK SPA colonies, on a precautionary basis, common tern is considered to be of International conservation value.

<u>Arctic tern</u>

5.7.2.85 Arctic tern is listed on Annex I of the EU Birds Directive and the species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al*., 2015).

5.7.2.86 Arctic terns are summer visitors to Britain, breeding in coastal colonies predominantly in the north. Seabird 2000 recorded 52,621 pairs in Britain (Mitchell *et al.*, 2004). In autumn, Arctic terns migrate down the west coast of Europe and Africa to the Antarctic seas for the winter, returning the following spring (Wernham *et al.*, 2002). The closest large colonies to Hornsea Three are the Farne Islands, Coquet Island and Long Nanny (all Northumberland). The highest predicted densities of the species (up to 3.1 birds/km^2) in the summer (April to September), derived from historical survey data, correlate with the location of breeding colonies (see Figure 1.49 in annex 5.1: Baseline Characterisation Report).

5.7.2.87 Arctic tern is listed as a qualifying interest species in the breeding season for 13 SPAs and 3 pSPAs on the UK east coast. These SPAs are designated for 15,398 breeding pairs representing approximately 29% of the national breeding population as recorded during Seabird 2000 (Mitchell *et al.*, 2004). Hornsea Three lies beyond the maximum known foraging range of Arctic terns from these SPAs (30 km) (Thaxter *et al.*, 2012).

5.7.2.88 Arctic terns were recorded in only two of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. A total of seven birds were recorded during the May 2016 survey with a further 44 recorded in the May 2017 survey. These counts translate to population estimates of 399 and 1,578 birds, respectively when birds not identified to species level are taken into account. These birds are migratory individuals with these populations not surpassing the 1% threshold for regional importance (1,639 individuals).

5.7.2.89 Traditional boat-based and aerial surveys are considered unlikely to accurately quantify the migratory movements of this species that may pass through Hornsea Three. As a species listed on Annex I of the EU Birds Directive, on a precautionary basis Arctic tern is considered to be of International conservation value. In addition, the source population of birds that interact with Hornsea Three is unknown and may include birds breeding at UK SPA colonies.

<u>Kittiwake</u>

5.7.2.90 Kittiwake is currently red-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015). The species is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended).

5.7.2.91 Kittiwake is one of the commonest seabirds in the UK, breeding in large colonies on coastal cliff habitat. Seabird 2000 recorded 366,835 pairs in the UK, with the largest numbers on the east coast (Mitchell *et al.*, 2004). The nearest large colony to Hornsea Three is at FFC pSPA.

5.7.2.92 Between April and July, kittiwakes are dispersed widely around the coast of Britain, with only moderate densities (generally up to 4.99 birds/km^2) throughout the southern North Sea, compared to more northerly areas, where the main breeding colonies are located (Stone *et al.*, 1995). In eastern England, particularly south of Flamborough Head, there are few kittiwake colonies, due to the lack of suitable cliff-face breeding habitats. However, predicted densities, derived from historical survey data, are high (up to 19.8 birds/km^2) in offshore areas to the east of the colony at Flamborough Head, however such high densities do not extend as far as Hornsea Three (see Figure 1.50 in annex 5.1: Baseline Characterisation Report).

5.7.2.93 From August to October, kittiwakes begin to disperse across the North Sea, although the predominant concentrations in this distribution still reflect the location of breeding colonies. From November to March, birds are dispersed over much larger areas of the North Sea, and in the southern parts, numbers peak during this period. This reflects kittiwakes preference for pelagic habitats in winter. The highest predicted densities (up to 11.9 birds/km^2) in the winter (October to March) occur offshore of the Yorkshire and Lincolnshire coast and also in the Dogger Bank area. At Hornsea Three during this period, predicted densities are relatively low.

5.7.2.94 Kittiwake is listed as a qualifying interest species in the breeding season for 20 SPAs and 3 pSPAs on the UK east coast. These SPAs are designated for 256,160 breeding pairs representing nearly 70% of the national breeding population as recorded during Seabird 2000 (Mitchell *et al.*, 2004).

5.7.2.95 FFC pSPA is the closest SPA/pSPA to Hornsea Three. However, Hornsea Three is outside of the maximum foraging range of 120 km of kittiwake from the pSPA as reported by Thaxter *et al.* (2012). Preliminary results from the FAME project which has tracked breeding kittiwake from the FFC pSPA colony does however suggest possible (albeit limited) connectivity between the FFC pSPA and Hornsea Three (see Figure 1.38 in annex 5.1: Baseline Characterisation Report). Of the 93 breeding adults tracked for a few days each within a 3-4 week period of the breeding season of a single year (between 2010 - 2013), no more than two individuals visited Hornsea Three.

5.7.2.96 Kittiwakes were recorded in all of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. Population estimates derived from aerial survey data during all breeding months surpass the 1% threshold for regional importance. The population estimates calculated for April (8,451 birds) and July 2016 (12,551 birds) also exceed the 1% threshold for national importance. A marked reduction in the abundance of kittiwake at Hornsea Three array area between April (8,451 birds) and May (4,842 birds), and particularly thereafter in June (1,152 birds) coincides with chick provisioning by breeding adults when this 'central place forager' is most constrained by distance from their nesting site. Combined with the preliminary results of the FAME project, the evidence suggests that the kittiwake population in Hornsea Three during June and to a lesser extent May, comprises non-breeders, with the likely arrival of further immatures into the area explaining the 10-fold increase in abundance in July. Further discussion regarding the trends in kittiwake abundance observed at Hornsea Three is provided in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA.

5.7.2.97 Populations estimated during the post-breeding season (August to December) did not surpass the 1% threshold of the post-breeding regional BDMPS population for kittiwake (8,299 individuals) The peak population during the post-breeding season was in December with 3,591 birds estimated to be present. Populations estimated during the surveys undertaken in the pre-breeding season (January to March) also did not surpass the 1% threshold for regional importance (6,278 individuals) with the peak population occurring in the March survey (2,812 birds).

5.7.2.98 Kittiwake is considered to be of International conservation value as although the foraging ranges reported by Thaxter *et al.* (2012) suggest no connectivity between Hornsea Three and any breeding colony, preliminary evidence from tracking studies (FAME project) do suggest limited connectivity with FFC pSPA. Population estimates of kittiwake in the Hornsea Three offshore ornithology study area exceed the 1% threshold of the regional population (1,020 individuals) in all breeding season months with the populations estimated in April and July also surpassing the 1% threshold for national importance (7,600 individuals).

<u>Little gull</u>

5.7.2.99 Little gull is listed on Annex I of the EU Birds Directive and Schedule 1 of the Wildlife and Countryside Act (1981, as amended). It is currently green-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

5.7.2.100 Little gull occurs on passage in the North Sea, where it is fairly common off the Flamborough coast with the highest numbers occurring in autumn (Thomas, 2011; Stone *et al.*, 1995). Data from the 2004 to 2008 reports, Aerial Surveys of Waterbirds in the UK (DECC, 2009), show that almost no little gulls were recorded during aerial surveys of the Greater Wash survey blocks GW2, GW9 and GW10, with only three birds recorded during November.

5.7.2.101 Large numbers of little gull occur at Hornsea Mere on the East Yorkshire coast, in late summer, with up to 21,500 birds known to be present in 2007 for example, although in recent years numbers have been lower (five year average = 3,312 birds) (Frost *et al.*, 2017). There are no terrestrial UK SPAs for little gull although the species was considered for marine SPAs in a recent JNCC report (Kober *et al.*, 2010) and is included as a qualifying feature for two pSPAs on the east coast of the UK: the Greater Wash pSPA (1,303 individuals) and the Outer Firth of Forth and St Andrews Bay Complex pSPA (126 individuals).

5.7.2.102 Little gulls were recorded during five of the aerial surveys conducted across the Hornsea Three offshore ornithology study area. These birds were recorded during the April 2016, September 2016, October 2016 February 2017 and October 2017 surveys with populations of 34, 13, 24, 12 and 78 birds estimated for each month respectively. These population estimates do not surpass the 1% threshold for regional importance (720 – 1,740 individuals).

5.7.2.103 Traditional boat-based and aerial surveys are considered unlikely to accurately quantify the migratory movements of this species that may pass through Hornsea Three. As a species listed on Annex I of the EU Birds Directive and as the source population that interacts with Hornsea Three is unknown, little gull is considered to be of International conservation value on a precautionary basis.

<u>Lesser black-backed gull</u>

5.7.2.104 Lesser black-backed gull is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). The species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al.*, 2015).

5.7.2.105 Lesser black-backed gulls are common and widespread in the UK in summer, and breed in colonies in coastal and inland locations. Seabird 2000 recorded 111,835 pairs in Britain (Mitchell *et al.*, 2004). In winter, many birds leave northern areas between November and March, although some remain all year, particularly in the south-west (Forrester *et al.*, 2007). The UK wintering population of lesser black-backed gull has been estimated at over 125,000 individuals (Burton *et al.*, 2013). Lesser black-backed gull is listed as a qualifying interest species in the breeding season for three SPAs on the UK east coast: Northumberland Marine SPA, Forth Islands SPA and Alde-Ore Estuary SPA. The species is also included as a non-listed assemblage feature at two further pSPAs. These SPAs are designated for 24,626 breeding pairs representing approximately 22% of the national breeding population as recorded during Seabird 2000 (Mitchell *et al.*, 2004). The distance between Hornsea Three and these two SPAs is beyond the maximum known foraging range of lesser black-backed gull (181 km) (Thaxter *et al.*, 2012). There is also a large breeding colony at Outer Trial Bank within The Wash SPA (1,457 pairs in 2009) (JNCC, 2017), which is within the maximum foraging range for this species, though they are not a qualifying feature of the SPA.

5.7.2.106 Historical survey data suggest that lesser black-backed gull is not abundant in the North Sea in either the summer (April to September) or winter (October to March) with densities of less than 0.6 birds/km^2 (see Figure 1.53 in annex 5.1: Baseline Characterisation Report). The highest predicted densities (up to 6 birds/km^2) in the summer occur to the south of Hornsea Three associated with breeding colonies on the Suffolk and Norfolk coasts.

5.7.2.107 Lesser black-backed gulls were recorded in twelve of the aerial surveys conducted across the Hornsea Three offshore ornithology study area. The peak population in the breeding season (May to July) was recorded in June 2016 when 1,002 birds occurred. This population and those estimated in July 2016 and 2017 and June 2017 exceed the 1% threshold for regional importance (50 birds). However, none of these populations exceed the 1% threshold of the national breeding population (2,200 individuals).

5.7.2.108 In the post-breeding season (August to October) lesser black-backed gulls were recorded in September and October with a peak population of 343 birds estimated in August 2017. In the pre-breeding season (March to April), the peak population occurred in April 2016 (133 birds). The population estimates calculated in the post-breeding and pre-breeding seasons do not surpass the respective 1% thresholds for regional importance (2,090 and 1,975 individuals respectively). No birds were recorded in the non-breeding season as defined for lesser black-backed gull (November to February).

5.7.2.109 The peak population estimate (June 2016) along with the population estimated in July 2016 and 2017 and June 2017 exceeds the 1% threshold of the regional breeding population of lesser black-backed gull. The 1% thresholds of the national and international populations for lesser black-backed gull are not surpassed in any month. Therefore based on the conservation status of lesser black-backed gull and the populations present at Hornsea Three, lesser black-backed gull is considered to be of Regional conservation value.

Great black-backed gull

5.7.2.110 Great black-backed gull is not listed under Annex I of the EU Birds Directive (2009/147/EEC) or Schedule 1 of the Wildlife and Countryside Act (1981, as amended). The species is currently amber-listed on the UK Birds of Conservation Concern list (Eaton *et al*., 2015).

5.7.2.111 Great black-backed gull is a common resident species in the UK, occurring in coastal areas. Seabird 2000 recorded 17,394 pairs in Britain, with largest numbers on western coasts (Mitchell *et al*., 2004). Great black-backed gull is a relatively common breeding species in Great Britain. During the pre-breeding and breeding season their distribution tends to be limited to coastal areas. In winter they are a much more widely dispersed species and often travel long distances in pursuit of discards from fishing vessels (Stone *et al*., 1995). The UK wintering population of great black-backed gull has been estimated at over 76,000 individuals (Burton *et al*., 2013). The flyway population in the North Sea is estimated at 480,000 birds with 5.2% of the biogeographic population flying over the southernmost part of this area (Stienen *et al*., 2007).

5.7.2.112 During March and April the highest densities (up to 5 birds/km^2) within the UK are found in the northern isles of Scotland with overwintering birds in UK waters returning to breeding grounds in Fennoscandia and Iceland during this time (Furness, 2015), leaving low densities (up to 1.99 birds/km^2) along the east coast. Predicted densities of great black-backed gull in the English North Sea during the summer (April to September), derived from historical survey data, are highest (up to 2.07 birds/km^2) in inshore areas between Northumberland and East Yorkshire. At Hornsea Three densities of the species are relatively low (<0.01-0.4 birds/km^2).

5.7.2.113 During the post-breeding period of August to October, distribution is more widespread along the east coast with densities of five birds/km^2 recorded to the north of the Humber estuary (Stone *et al*., 1995). In November to February great black-backed gulls are widespread over much of the North Sea with high densities (up to 5 birds/km^2) near the Dogger Bank and the southern North Sea. Predicted densities in winter (October to March) are highest (up to 0.9 birds/km^2) off the East Yorkshire coast at Flamborough, off the eastern Norfolk coast and in the north-eastern part of Hornsea Three, extending outside of UK territorial waters (see Figure 1.55 in annex 5.1: Baseline Characterisation Report).

5.7.2.114 Great black-backed gull is listed as a qualifying interest species in the breeding season for five SPAs and one pSPA on the east coast of the UK. These SPAs held 2,812 pairs at time of designation representing approximately 16% of the national breeding population as recorded during Seabird 2000 (Mitchell *et al*., 2004). However, Hornsea Three is well outside of foraging range (60 km; Seys *et al.*, 2001) of great black-backed gull from these colonies.

5.7.2.115 Great black-backed gulls were recorded in nineteen of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area. Great black-backed gulls were recorded in all surveys covering the breeding season defined for the species (May to July) with the peak population of 399 birds recorded during the July 2017 survey. There is not considered to be any connectivity between great black-backed gull breeding colonies and Hornsea Three and therefore any birds recorded at Hornsea Three are considered to be non-breeding or immature birds.

5.7.2.116 In the non-breeding season (August to March) the peak population was recorded during February (1,455 birds). This population, and those estimated in the November and December 2016 and October 2017 surveys surpass the 1% threshold for regional importance (914 individuals) with the population in February also considered to be of national importance (766 individuals).

5.7.2.117 The peak population estimate (February) exceeds the 1% threshold of national importance with the populations estimated in November and December surpassing the threshold for regional importance. Therefore based on the conservation status of great black-backed gull and the national importance of great black-backed gull populations present at Hornsea Three, great black-backed gull is considered to be of National conservation importance.

5.7.3 Future baseline scenario

5.7.3.1 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 require that "an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge" is included within the Environmental Statement.

5.7.3.2 In the event that Hornsea Three does not come forward, an assessment of the future baseline conditions has been carried out and is described within this section.

5.7.3.3 A projection of the likely evolution of the baseline for species relevant to Hornsea Three is best assessed from the latest population trends. These, are published by JNCC, as part of the SMP (JNCC, 2017), as annual updates on seabird population trends. A summary of these trends are presented in annex 5.1: Baseline Characterisation Report (in Table 1.2).

5.7.4 Data limitations

5.7.4.1 The baseline characterisation of Hornsea Three and resulting assessments include data from twenty months of aerial surveys (April 2016 to November 2017). Two years of data are available for April to November covering all or the majority of the breeding season for all VORs. Only one year of data is available for December to March. These months form part of non-breeding seasons for all species included in this assessment (with the exception of guillemot for which March is a breeding season month), with this period generally representing a period of reduced abundance for the majority of species. As such, the magnitude of impacts is likely to be lower during this period and potential impacts should not disproportionally affect local breeding populations based on large BDMPS population sizes and low apportioning values (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). A process has been undertaken to reduce the uncertainty associated with having only one year of data for certain months. This process is described in volume 5, annex 5.4: Data Hierarchy Report and incorporated into the assessments for all relevant species.

As detailed below in Section 5.9.3, the flight height data collected as part of the digital aerial survey programme was not found to be adequate. To inform collision risk modelling Option 1 of Band (2012) incorporates site-specific flight height data (from the boat-based survey programmes of Hornsea One and Two), while collision risk estimates calculated using Options 2 and 3 of Band (2012) make use of aggregated flight height data contained in Johnston *et al*. (2014).

Table 5.7: Summary of the conservation importance and peak populations of all seabird species identified for consideration as part of the Hornsea Three assessment in relation to national and regional thresholds[a].

Species	Conservation status	SPA connectivity	Breeding season		Post-breeding/Pre-breeding season		Non-breeding season		Conservation value
			Peak population estimate at Hornsea Three	Population importance	Peak population estimate at Hornsea Three	Population importance	Peak population estimate at Hornsea Three	Population importance	
Common scoter	Schedule 1	Yes	Not recorded during aerial surveys of the Hornsea Three array area but may occur along the export cable route						International
Red-throated diver	Annex I	Yes	66 (May 2016)	Local	Not recorded during aerial surveys of the Hornsea Three array area but may occur along the export cable route				International
Fulmar	Amber list	Yes	1,554 (August 2017)	Regional	1,347 (September 2016)	Local	450 (November 2017)	Local	International
Gannet	Amber list	Yes	2,207 (August 2017)	Regional	2,638 (October 2017)	Local			International
Arctic skua	Red list	No	11 (July 2016 and July 2017)	Local	55 (September 2016)	Local	0	-	International
Great skua	Amber list	No	0	-	17 (September 2017)	Local	22 (December)	Local	International
Puffin	Red list	Yes	352 (May 2016)	Regional			266 (April 2016)	Local	International
Razorbill	Amber list	No	736 (April 2017)	Local	4,021 (October 2017)	Local	4,976 (November 2016)	Regional	Regional
Guillemot	Amber list	No	19,360 (June 2016)	National			26,561 (November 2017)	Regional	National
Little tern	Annex 1	Yes	Not recorded during aerial surveys of the Hornsea Three array area						International
Sandwich tern	Annex 1	Yes	0	-	162 (September 2017)	Local	0	-	International
Common tern	Annex I	No	0	-	1,184 (May 2017)	Local	0	-	International
Arctic tern	Annex I	No	0	-	1,578 (May 2017)	Local	0	-	International
Kittiwake	Red list	Yes	12,551 (July 2016)	National	3,592 (December)	Local			International
Little gull	Annex I	No					78 (October 2017)	Local	National
Lesser black-backed gull	Amber list	Yes	1,002 (June 2016)	Regional	343 (August 2017)	Local	0	-	Regional
Great black-backed gull	Amber list	No	399 (July 2017)	Local			1,455 (February)	National	National
[a] Grey cells indicate seasons which are not applicable to the relevant species									

5.8 Key parameters for assessment

5.8.1 Maximum design scenario

5.8.1.1 The maximum design scenarios identified in Table 5.8 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. These scenarios have been selected from the details provided in the project description (volume 1, chapter 3: Project Description). Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (volume 1, chapter 3: Project Description), to that assessed here be taken forward in the final design scheme.

5.8.2 Impacts scoped out of the assessment

5.8.2.1 On the basis of the baseline environment and the project description outlined in volume 1, chapter 3: Project Description, no known impacts are proposed to be scoped out of the assessment for offshore ornithology.

Table 5.8: Maximum design scenario considered for the assessment of potential impacts on offshore ornithology

Potential impact	Maximum design scenario	Justification
Construction phase		
The impact of construction activities such as increased vessel activity and underwater noise, may result in direct disturbance or displacement from important foraging and habitat areas of birds.	<u>**Maximum design scenario: Construction vessels**</u> Up to 10,474 vessel movements during construction, comprised of: • Up to 3,900 vessel movements over construction period based on gravity base foundations (self-installing concept); • Up to 3,000 vessel movements, over construction period for Wind Turbine Generator (WTG) installation; • Up to 304 vessel movements over construction period for substations; • Up to 2,520 vessel movements over construction period for array cables; • Up to 750 vessel movements over construction period for export cable; and • Up to 8 vessels in a 5 km² area at any one time. The installation of the offshore components of Hornsea Three will occur over a maximum duration of eight years, assuming a two phase construction scenario. A gap of three years may occur between the same activity in different phases. Up to 3,785 helicopter flights per year comprising of: • 225 return trips associated with wind turbine installation; • 600 return trips associated with monopile installation; • 532 return trips associated with substation foundation construction • 1,828 return trips associated with export cable installation; and • 600 return trips associated with inter-array cable installation <u>**Maximum design scenario: Construction activity**</u> The potential for disturbance / displacement impacts due to construction activity are considered for two different scenarios – maximum level of construction activity and maximum duration of construction activity. <u>**Maximum construction activity level (magnitude)**</u> Foundations when using monopiles with concurrent piling • Piling of up to 300 monopile foundations of 15 m diameter; • Piling of up to 19 monopile foundations, 15 m diameter, for substations and platforms including: o Three offshore accommodation platforms; o Twelve offshore transformer substations; and o Four offshore HVAC booster stations (located within the offshore HVAC booster station search area. • Total number of monopiles 319 (300 + 19); • Absolute maximum hammer energy of up to 5,000 kJ, although typically the maximum hammer energy will be considerably less than this and the absolute maximum hammer energy (i.e. up to 5,000 kJ) would not be required at all locations; • Average maximum of 3,500 kJ (highest energy likely to be reached during piling events); and • Average hammer energy of 2,000 kJ (average hammer energy likely to be reached during piling). • Maximum 4 hours piling duration per monopile (including 30 minute soft start); • Maximum total duration of actual piling 1,276 hours (4 x 319); • Piling within Hornsea Three array area singly or concurrently (a maximum of two vessels piling at opposite ends of the site) with the maximum design spatial scenario being for concurrent piling. Concurrent piling will occur only for infrastructure located within the Hornsea Three array area and not for infrastructure located within the offshore HVAC booster station search area in which only a single vessel scenario is possible; • Assumed that one monopile could be installed in each 24 hours period for single piling or up to two monopiles installed for	<u>**Maximum design scenario: Construction vessels**</u> Maximum design scenario provides for the greatest number of potential vessels associated with the construction phase and hence the highest likelihood of potential disturbance/displacement to bird species, as a result of multiple activities taking place over an eight year offshore construction period. Maximum design scenario also reflects season and location with respect to a species abundance and vulnerability to an impact in the zone of influence i.e. seasonality distribution is considered as part of the sensitivity rating. <u>**Maximum design scenario: Construction activity**</u> Maximum Design Scenario provides for the greatest disturbance/displacement effects to bird species due to construction activities (magnitude and duration). **Maximum magnitude of piling** provides for the maximum increase in background noise levels generated over the largest area. Maximum diameter of pile and maximum number of simultaneous piling events provides for the maximum construction activity generated. Maximum separation distance provides the maximum spatial extent of construction activity impact (construction activity footprint area). All other foundation scenarios considered for WTGs (GBS, piled jackets and suction caisson jackets) would result in reduced levels of construction activity. **Maximum piling duration** provides for the maximum duration of disturbance / displacement to bird species. Maximum piling duration assumes active piling over 2.5 years over a six years construction period with piling being intermittent when using a two phase partially-parallel construction programme. All other foundation scenarios considered for WTGs (GBS, monopiles and suction caisson jackets) would result in reduced pile duration.

Potential impact	Maximum design scenario	Justification

	concurrent piling, plus a 20% contingency allowance.
	• Therefore, maximum design spatial scenario (concurrent piling scenario for infrastructure located within the Hornsea Three array area and single piling scenario for infrastructure located within the offshore HVAC booster station search area) is 193.8 days which consists of:
	• Hornsea Three array area: 189 days = (157.5 days piling for 300 turbines + three accommodation platforms + 12 offshore transformer substations) plus 20% contingency; and
	• Hornsea Three offshore cable corridor: 4.8 days = (four days piling for four offshore HVAC booster stations) plus 20% contingency.
	• Foundation installation could occur over 2.5 years in up to two phases with a gap of up to three years between phases. This includes foundation installation for the offshore HVAC booster substations within the Hornsea Three offshore cable corridor which is expected to occur within an eight month piling phase.
	Offshore cables:
	• Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Individual elements of construction will be over shorter durations as follows: Installation of 1,146 km of export cables (six cable trenches 191 km in length) within the Hornsea Three offshore cable corridor and array area. 30 m width of disturbance per cable where sandwave clearance, 25 m for boulder clearance (15 m for array cables) and 15 m elsewhere with the exception of within the MCZ where clearance will be 10 m is necessary, elsewhere 10 m width of disturbance per cable.
	• Installation of up to 830 km of array cables, 225 km of platform inter-connector cables. Up to 30 m width of disturbance per cable where sandwave clearance is necessary
	Maximum design temporal: jacket foundations with single piling
	Up to 1,848 pin piles (1,200 for turbine foundations and 648 for other infrastructure and platform foundations)
	• Piling of up to 300 jacket foundations (four legs per foundation, each pin pile 4 m diameter) for turbines, with up to 1,200 piles (300 x 4) in total;
	• Piling of up to 19 jacket foundations, up to 4 m diameter, for substations and platforms including:
	  ○ Three offshore accommodation platforms (six legs), with up to 72 piles (three x 24) in total;
	  ○ Twelve offshore transformer substations (six legs), with up to 288 piles (12 x 24) in total; and
	  ○ Four offshore HVDC converter substations located in the Hornsea Three array area (72 piles per foundation) with up to 288 piles (four x 72) in total (HVDC transmission option only).
	• Maximum hammer energy of up to 2,500 kJ, although typically the maximum hammer energy will be considerably less than this, with only a proportion of the piles requiring the maximum hammer energy (i.e. up to 2,500 kJ);
	• Maximum four hours piling duration per pile (including 30 minute soft start);
	• Maximum total piling duration 7,392 hours of piling (four x 1,848);
	• Piling could occur as single vessel scenario or two concurrent vessels (at opposite ends of the site) although maximum design temporal scenario is for single piling;
	• Assumed that four pin piles could be installed in each 24 hour period for single piling, or up to eight pin piles installed for concurrent piling, plus a 20% contingency;
	• Therefore maximum design temporal scenario (single piling scenario for infrastructure located within the Hornsea Three array area only) is 554.4 days comprising:
	  ○ 300 days piling for turbines (1,200 pin piles)
	  ○ 18 days piling for accommodation platforms (72 pin piles)
	  ○ 72 days for offshore transformer substations (288 pin piles)
	  ○ 72 days for + for offshore HVDC converter substations (288 pin piles)
	  ○ Total = 462 days plus 20% contingency.
	• Foundation installation could occur over 2.5 years in up to two phases (i.e. of ~1.25 years each phase) with a gap of up to three years between phases.
	Offshore cables:	

Potential impact	Maximum design scenario	Justification
	• Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Individual elements of construction will be over shorter durations as follows: Installation of 1,146 km of export cables (six cable trenches 191 km in length) within the cable route corridor. 30 m width of disturbance per cable where sandwave clearance is necessary, elsewhere 10 m width of disturbance per cable. • Installation of up to 830 km of array cables, 225 km of platform inter-connector cables. 30 m width of disturbance per cable where sandwave clearance is necessary, elsewhere 10 m width of disturbance per cable.	

Indirect effects, such as changes in habitat or abundance and distribution of prey.	<u>**Temporary habitat loss:**</u>
	Total subtidal temporary habitat loss of up to 68,645,736 m^2 and total intertidal temporary habitat loss of up to 271,914 m^2 comprising the following:
	Hornsea Three array area - Foundations
	1,301,520 m^2 temporary loss due to jack-up barge deployments for foundations for up to 319 structures (maximum design scenario assumes up to 300 turbines, up to 12 offshore transformer substations, up to four offshore HVDC substations and up to three offshore accommodation platforms) assuming six spud cans per barge, 170 m^2 seabed area affected per spud can and four jack up operations per turbine (319 foundations x 6 spud cans x 170 m^2 per spud can x 4 jack ups);
	Up to a total of 4,235,774 m^2 of spoil from placement of coarse dredged material to a uniform thickness of 0.5 m (see justification, right) as a result of seabed preparation works prior to the installation of all GBFs. Comprising:
	• Up to a total of 1,225,800 m^3 of material from seabed clearance due to the installation of up to 300 turbines with GBFs (each with a seabed clearance volume of up to 4,086 m^3) affecting up to 2,451,600 m^2;
	• Up to a total of 735,000 m^3 of material from seabed clearance due to the installation of up to 12 offshore transformer substations with box GBFs (each with a seabed clearance volume of up to 61,250 m^3) affecting up to 1,470,000 m^2;
	• Up to a total of 139,552 m^3 of material from seabed clearance for up to four offshore HVDC convertor substations with box GBFs (each with a seabed clearance volume of up to 34,888 m^3) affecting up to 279,104 m^2; and
	• Up to a total of 17,535 m^3 of material from seabed clearance for up to three offshore accommodation platforms (each with a seabed clearance volume of up to 5,845 m^3) affecting up to 35,070 m^2.
	Up to a total of 1,560,000 m^2 of temporary loss from the clearance of sandwaves prior to turbine installations.
	Hornsea Three array area - Cables
	• Up to a total of 19,920,000 m^2 from burial of up to 830 km of array cables as follows:
	  ○ Up to a total of 14,490,000 m^2 due to 498 km of the array cable requiring sandwave clearance (up to 30 m wide corridor); and
	  ○ Up to a total of 4,980,000 m^2 due to boulder clearance and laying of up to 332 km of array cables by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor).
	• Up to a total of 6,300,000 m^2 from burial of up to 225 km of interconnector cables as follows:
	  ○ Up to a total of 4,050,000 m^2 due to 135 km of the interconnector cable requiring sandwave clearance (up to 30 m wide corridor); and
	  ○ Up to a total of 2,250,000 m^2 due to boulder clearance and laying of up to 90 km of interconnector cables by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor).
	• Up to a total of 4,704,000 m^2 from burial of up to 168 km of export cables (up to six trenches of 28 km length) within the array as follows:
	  ○ Up to a total of 3,024,000 m^2 due to 100.8 km of the export cables within the array requiring sandwave clearance (up to 30 m wide corridor); and
		The maximum design scenario is represented by the largest footprint from the foundation structures (and associated scour protection) under consideration and hence greatest influence on habitat and physical processes, created by greatest number of turbines etc.
		<u>**Temporary habitat loss:**</u>
		The maximum design scenario presented is associated with HVDC transmission due to the larger foundation sizes associated with the offshore HVDC substations compared to the HVAC booster substations.
		Seabed preparation works prior to gravity base installation represents the maximum design scenario, with respect to spatial extent, for temporary habitat loss, compared to the temporary habitat loss associated with drill arisings resulting from jacket foundation installation.
		The area affected by the placement of material as a result of seabed preparation and sandwave clearance has been calculated based on the maximum volume of sediment placed across the entire Hornsea Three array area, assuming all this sediment is coarse material and therefore is placed on the seabed (i.e. is not dispersed through tidal currents; see "Temporary increases in suspended sediment concentrations" impact assessment below). The total area of seabed affected was calculated assuming a mound of uniform thickness of 0.5 m height. As detailed in volume 5, annex 1.1: Marine Processes Technical Report, the area of seabed affected by this scenario broadly aligns with the scenario of a cone shaped mound of 1.7 m maximum height (see Table 4.24 of volume 5, annex 1.1). Temporary loss of benthic habitat is assumed beneath this within the Hornsea Three array area.
		The maximum design scenario for temporary habitat loss has considered the burial of all subtidal cables, except where the necessary burial depth cannot be achieved.
		Temporary habitat loss within the entire Hornsea Three offshore cable corridor and temporary working area at the landfall has been considered as the maximum design scenario (including anchor placements), though direct impacts (i.e. excavation) will only occur within a proportion of these areas.
		Drilling operations for foundation installation: Greatest sediment disturbance from a single foundation location
		Drilling of individual turbine monopile foundations results in the release of relatively larger volumes of relatively fine sediment, at relatively lower rates (e.g. potentially leading to SSC effects over a wider area or longer duration), than similar potential impacts for bed preparation via dredging for individual gravity base foundations (which are separately assessed).
		The greatest volume of sediment disturbance by drilling, for both individual foundations and for the array as a whole, is associated with the largest diameter monopile and piled jacket foundations for substations in the array area.
		The volume of sediment released through drilling of other turbine and offshore accommodation platform foundation types (e.g. piled jackets) is smaller than for monopiles.
		The HVDC transmission system option (up to12 offshore transformer substations and up to four

Potential impact	Maximum design scenario	Justification
	○ Up to a total of 1,680,000 m² due to boulder clearance and laying of up to 67.2 km of interconnector cables by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor). • Up to a total of 142,300 m² from placement of coarse dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance within the Hornsea Three array, assuming a volume of up to 71,150 m³, placed on the seabed within the Hornsea Three array area. • Up to a total of 244,600 m² from cable barge anchor placement associated with array, interconnector and export cable laying within the Hornsea Three array area assuming: one anchor (footprint 100 m²) repositioned every 500 m ((830,000 m + 225,000 m + 168,000 m) x one x 100 m² / 500 m =244,600 m²). ***Hornsea Three offshore cable corridor - Subtidal*** • Up to a total of 27,492,030 m² from burial of up to 978 km of export cable (up to six trenches of 163 km length) as follows: ○ Up to a total of 18,396,180 m² due to 613.2 km of the export cable requiring sandwave clearance (up to 30 m wide corridor); ○ Up to a total of 9,095,850 m² due to boulder clearance and cable laying of up to 363.8 km of export cable by trenching, jetting, mass flow excavator, ploughing or vertical injection and similar tools currently under development augmented by cable protection installation (up to 25 m wide corridor for boulder clearance and 15 m wide corridor for cable installation). • Up to a total of 2,405,912 m² from placement of coarse, dredged material to a uniform thickness of 0.5 m as a result of sandwave clearance on the offshore cable corridor, assuming a volume of up to 1,202,946 m³, placed on the seabed within the Hornsea Three offshore cable corridor. • Up to 339,600 m² from cable barge anchor placement associated with cable laying for subtidal export cables within the Hornsea Three offshore cable corridor broken down as follows: ○ First 20 km of the offshore cable corridor: Up to seven anchors (footprint of 100 m² each) repositioned every 500 m for up to six export cables (20,000 m x seven x 100 m² x six / 500 m = 168,000 m²); and ○ Export cables beyond 20 km: one anchor (footprint of 100 m²) repositioned every 500 m for up to six export cables ((163,000 m – 20,000 m) x one x 100 m² x six / 500 m = 171,600 m²). ***Hornsea Three offshore cable corridor - Intertidal*** • Up to 12,642 m² from works to bury up to 500 m of cable length (from MHWS to MLWS) with up to six cable circuits (i.e. up to 3 km of export cable in the intertidal) by trenching (assuming habitat loss/disturbance within the entire corridor width). ***Drilling operations for foundation installation: Greatest sediment disturbance from a single foundation location*** Total sediment volume of up to 581,611 m³ comprising: • Up to 113,104 m³ total spoil volume, from largest turbine monopile foundations (up to 160 monopiles), associated diameter 15 m, drilling to 40 m penetration depth, spoil volume per foundation 7,069 m³, up to 10% of foundations may be drilled (160 x 10% x 7,069 m³ = 113,104 m³). • Up to 253,338 m³ total spoil volume from largest offshore transformer substation piled jacket foundations (up to 12 foundations), 24 piles per foundation (six legs), 4 m diameter, drilling to 70 m penetration depth, spoil volume per foundation 21,112 m³, up to 100% of foundations may be drilled (12 x 21,112 m³ = 253,338 m³). • Up to 193,962 m³ total spoil volume from the largest offshore HVDC converter substation piled jacket foundations (up to four foundations), 72 piles per foundation (18 legs), 3.5 m diameter, drilling to 70m penetration depth, spoil volume per foundation 48,490 m³, up to 100% of foundations may be drilled (four x 48,490 m³ = 193,962 m³). • Up to 21,207 m³ total spoil volume from the largest offshore accommodation platform monopile foundations (up to three monopiles), associated diameter 15 m, drilling to 40 m penetration depth, spoil volume per foundation 7,069 m³, up to 100% of foundations may be drilled (three x 7,069 m³ = 21,207 m³).	offshore HVDC converter substations) results in the largest number of offshore HVDC substation foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option. ***Dredging for seabed preparation for foundation installation: Greatest sediment disturbance from a single foundation location*** Dredging as part of seabed preparation for individual gravity base foundation foundations results in the release of relatively smaller overall volumes of relatively coarser sediment, at relatively higher rates (e.g. leading to higher concentrations over a more restricted area), than similar potential impacts for drilling of individual monopile or piled jacket foundations (which are separately assessed above). The greatest sediment disturbance from a single gravity base foundation location is associated with the largest diameter or dimension gravity base foundation, which results in the greatest volume of spoil from a single foundation. Due to differences in both scale and number, gravity base foundations for turbines, electrical substations and offshore accommodation platforms are separately considered. The HVDC transmission system option (up to12 offshore transformer substations and up to four offshore HVDC converter substations) results in the largest number of offshore HVDC substation foundations and the largest total volume of associated sediment disturbance in the array area compared to the HVAC transmission system option. **Cable Installation** Cable installation may involve ploughing, trenching, jetting, rock-cutting, surface laying with post lay burial, and/or surface laying installation techniques. Of these, mass flow excavation will most energetically disturb the greatest volume of sediment in the trench profile and as such is considered to be the maximum design scenario for sediment dispersion. Sandwave clearance may involve dredging or mass flow excavation tools. Of these, mass flow excavation will most energetically disturb sediment in the clearance profile and as such is considered to be the maximum design scenario for sediment dispersion causing elevated SSC over more than a very short period of time. Dredging will result in a potentially greater instantaneous local effect in terms of SSC and potentially a greater local thickness of sediment deposition, but likely of a shorter duration and smaller extent, respectively.

Potential impact	Maximum design scenario	Justification

	Up to two foundations may be simultaneously drilled with a minimum spacing of 1,000 m.
	
	Disposal of drill arisings at the water surface.
	
	Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Foundation installation over up to 2.5 years within this time.
	
	Dredging for seabed preparation for foundation installation: Greatest sediment disturbance from a single foundation location
	
	Total sediment volume of 1,827,287 m^3, comprising:
	• 935,000 m^3 total spoil volume from largest turbine GBF (up to 160 GBFs), associated base diameter 53 m, associated bed preparation area diameter 61 m, average depth 2 m), spoil volume per foundation 5,845 m^3 (160 x 5,845 = 935,000 m^3).
	• 735,000 m^3 total spoil volume from largest offshore transformer substation GBF (up to 12 GBFs), associated base dimensions 75 m, associated bed preparation area dimensions 175 m, average depth 2 m, spoil volume per foundation 61,250 m^3 (12 x 61,250 m^3 = 735,000 m^3).
	• 139,552 m^3 total spoil volume from largest offshore transformer substation GBFs (up to four GBFs), associated base dimensions 90 x 170 m, associated bed preparation area dimensions 98 x 178 m, average depth 2 m, spoil volume per foundation 34,888 m^3 (four x 34,888 m^3 = 139,552 m^3).
	• 17,535 m^3 total spoil volume from largest offshore accommodation platform GBF (up to three GBFs), associated base diameter 53 m, associated bed preparation area diameter 61 m, average depth 2 m), spoil volume per foundation 5,845 m^3 (three x 5,845 m^3 = 17,535 m^3).
	
	Disposal of material on the seabed within Hornsea Three.
	
	Dredging carried out using a representative trailer suction hopper dredger (11,000 m^3 hopper capacity with split bottom for spoil disposal). Up to two dredgers to be working simultaneously, minimum spacing 1,000 m.
	
	Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Foundation installation over up to 2.5 years within this time.
	
	<u>Cable Installation</u>
	
	Total sediment volume of 14,256,240 m^3, comprising:
	• Array cables
	  ○ Installation method: mass flow excavator;
	  ○ Total length 830 km;
	  ○ 4,980,000 m^3 total spoil volume from installation of up to 830 km cables in a V-shape trench of width = 6 m and depth =2 m (830 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 4,980,000 m^3); and
	  ○ 71,150 m^3 total spoil volume from sand wave clearance by dredging or mass flow excavation within the Hornsea Three array area (based on the Hornsea Three array area geophysical survey data combined with cable installation design specifications).
	• Interconnector cables
	  ○ Installation method: mass flow excavator;
	  ○ 15 in-project cables, total length 225 km; and
	  ○ 1,350,000 m^3 total spoil volume from installation of up to 225 km cables in a V-shape trench of width = 6 m and depth =2 m (225 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 1,350,000 m^3).
	• Export cables
	  ○ Up to six cable trenches; each 191 km in length (1,146 km in total);
	  ○ Installation method: mass flow excavator;
	  ○ 6,876,000 m^3 total spoil volume from installation of up to 1,146 km cables in a V-shape trench of width = 6 m and depth =2 m (6 x 191 km x 6 m x 2 m x 0.5 (i.e. to account for V-shape of trench) = 6,876,000 m^3); and
	  ○ 979,090 m^3 total spoil volume from sandwave clearance via either a dredger or mass flow excavator within the Hornsea Three offshore cable corridor (based on the Hornsea Three offshore cable corridor geophysical survey data	

Potential impact	Maximum design scenario	Justification
	combined with cable installation design specifications). Construction phase lasting up to eight years over two phases. A gap of up to three years will occur between an activity finishing in the first phase and starting in the second phase of construction. Individual elements of construction will be over shorter durations as follows: • Array cable installation over up to six months to 2.5 years; and • Export cable installation over up to four months to 3 years.	
The impact of pollution including accidental spills and contaminant releases which may affect species' survival rates or foraging activity.	Synthetic compound (e.g. from antifouling biocides), heavy metal and hydrocarbon contamination resulting from offshore infrastructure installation and up to 10,474 return trips during the construction phase: • Up to four installation vessels (300 movements), up to 24 support vessels (1,800 movements) and up to 12 transport vessels (900 movements) for wind turbine installation; • Up to 13 support vessels (1,500 movements), up to 12 dredging vessels (1,200 movements) and up to four transport vessels (tugs) (1,200 movements) for wind turbine GBF installation; • Up to two installation vessels (38 movements), up to 12 support vessels (228 movements) and up to four transport vessels (38 movements) for offshore substation foundations installation; and • Up to three main cable laying vessels (315 movements), up to three main cable burial vessels (315 movements), support vessels comprising up to four crew boats or SOVs, up to two service vessels, up to two diver vessels, up to two PLGR vessels, and up to two dredging vessels (1,890 movements for support vessels) for array cable installation. • Up to three main cable laying vessels (180 movements), up to three main cable jointing vessels (120 movements), up to three main cable burial vessels (180 movements), support vessels comprising four crew boat or SOVs, up to two service vessels, up to two diver vessels, up to two PLGR vessels, up to three dredging vessels and up to two survey vessels (270 movements) for export cable installation Water-based drilling muds associated with drilling to install foundations, should this be required; A typical wind turbine is likely to contain up to 25,000 litres (l) of lubricants (hydraulic oil, gear oil and grease), up to 80,000 l of nitrogen, up to 7,000 l of transformer silicon/ester oil, up to 13,000 l of coolants, up to 2,000 l of diesel fuel and up to 6 kg of SF6; A typical offshore accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates; Offshore fuel storage tanks: • One tank on each of the up to three offshore accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across the entire wind farm; and • One on each of the up to three offshore accommodation platforms for crew transfer vessel (CTV) fuel and each with a capacity of 210,000 l. • Potential contamination of nearshore/intertidal habitats from drilling mud (bentonite) used to facilitate the installation of export cables in the intertidal via HDD.	Parameters that create the greatest use of fuel, chemicals and hazardous waste offshore in the project area at any one time, that have the potential to spill into the marine environment. The accidental release of contaminants may directly affect birds or indirectly via their prey. Maximum vessel traffic movements will be associated with greatest turbine numbers (and associated infrastructure) and will cause highest risk of a pollution incident.
Operation phase		
The impact of physical displacement from an area around turbines (300) and other ancillary structures (up to twelve offshore transformer substations, up to three offshore accommodation platforms and four offshore transformer substations) during the operational phase of the development may result in effective habitat loss and reduction in survival or fitness rates.	Operation of maximum number of turbines (up to 300 WTGs), within the total wind farm array area of 696 km^2, with a minimum of 1,000 m spacing. Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore transformer substations and four offshore HVAC booster stations (located within the offshore HVAC booster station search area) and up to three offshore accommodation platforms. Infrastructure placed up to the edge of Hornsea Three.	Provides for the maximum amount (spatial extent) of habitat loss due to physical displacement effects. For sensitive species, the wind farm as a whole will be avoided, whereas for others only individual turbines will be avoided while within the wind farm. Edge-weighted layout will potentially maximise area of sea rendered unavailable to birds.

Potential impact	Maximum design scenario	Justification
The impact of indirect effects such as changes in habitat or abundance and distribution of prey.	Operation of maximum number of turbines (up to 300 WTGs). Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore transformer substations, and four offshore HVAC booster stations (located within the offshore HVAC booster station search area) and up to three offshore accommodation platforms.	Provides for the greatest area of habitat loss or creates the greatest area of habitat e.g. artificial reef.
Mortality from collision with rotating turbine blades	Operation of maximum number of turbines (up to 300 WTGs). Rotor swept diameter up to a maximum of 185 m when the maximum number of turbines is used i.e. total rotor swept area for the project of 9.19 km^2, with the lowest rotor tip height of 34.97 m above the Lowest Astronomical Tide. Irregular distribution of the positioning of the foundations within the total wind farm array area of 696 km^2, with a minimum of 1,000 m spacing.	Greatest rotor swept area plus parameters that maximise collision risk and therefore mortality rates for all species as the surface area available for collision increases. This is the turbine layout with the largest combined rotor swept area and collision probability, the latter at its highest when turbines are at maximum rotor speed and at the lowest tip height.
The impact of barrier effects caused by the physical presence of turbines and ancillary structures may prevent clear transit of birds between foraging and breeding sites, or on migration.	Operation of maximum number of turbines (up to 300 WTGs). Rotor swept diameter up to a maximum of 185 m. when the maximum of turbines is used. Irregular distribution of the positioning of the foundations within the total wind farm array area of 696 km^2, with a minimum of 1,000 m spacing. Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore transformer substations, and four offshore HVAC booster stations (located within the offshore HVAC booster station search area) and up to three offshore accommodation platforms,	Provides the maximum number of structures in the wind farm across the broadest front in relation to bird trajectory, to increase likelihood that birds will avoid individual turbines or the wind farm as a whole.
The impact of attraction to lit structures by migrating birds in particular may cause disorientation, reduction in fitness and possible mortality.	Operation of maximum number of turbines (up to 300 WTGs). Rotor swept diameter up to a maximum of 185 m when the maximum number of turbines is used. Randomised distribution of the positioning of the foundations within the total wind farm array area of 696 km^2, with a minimum 1,000 m spacing. Operation of associated offshore HVAC transmission infrastructure (up to twelve offshore transformer substations, and four offshore HVAC booster stations (located within the offshore HVAC booster station search area) and up to three offshore accommodation platforms. Lighting outward and not directional on all structures, maximised intensity and range to provide best visibility for aviation and shipping purposes. Red and white lighting, which has been shown to be more disorienting for migrating birds.	Provides the maximum number of structures in the wind farm, with maximum intensity and extent of red and white light sources to increase likelihood that birds will be attracted to structures and become disoriented or more susceptible to collision risk.
The impact of disturbance as a result of activities associated with maintenance of operational turbines, cables and other infrastructure may result in disturbance or displacement of bird species.	Up to 2,822 vessel return trips per year during operation and maintenance, including crew vessels wind turbine visits (2,433 return trips per year), supply vessels accommodation platform visits (312 return trips per year) and jack-up vessels (77 return trips per year) over the operational design life of the project (i.e. 35 years). Up to 4,671 helicopter flights per year.	Option provides for the largest possible source of direct and indirect (prey species) disturbance from noise, vessel movements and other maintenance related activity over the longest time period.

Potential impact	Maximum design scenario	Justification
The impact of pollution including accidental spills and contaminant releases associated with maintenance or supply/service vessels which may affect species' survival rates or foraging activity.	Synthetic compound (e.g. from antifouling biocides), heavy metal and hydrocarbon contamination resulting from up to 300 turbines, up to 12 offshore transformer substations, up to four offshore HVDC substations (or up to four offshore HVAC booster substations on the offshore cable corridor) and up to three offshore accommodation platforms. Accidental pollution may also result from offshore refuelling for crew vessels and helicopters: i.e. up to 2,822 round trips to port by operational and maintenance vessels (including supply/crew vessels and jack-up vessels) and up to 4,671 round trips by helicopter per year over the 35 year design life; A typical turbine is likely to contain approximately up to 25,000 l of lubricants (hydraulic oil, gear oil and grease), 80,000 l of liquid nitrogen and 7,000 kg of transformer silicon/ester oil, 2,000 l of diesel, 13,000 l of coolant and up to 6 kg of SF6; A typical offshore transformer substation is likely to contain up to 50,000 l of diesel, up to 200,000 l of transformer oil and up to 1,500 kg of SF6; A typical offshore HVDC substation is likely to contain up to 200,000 l of diesel; A typical offshore accommodation platform is likely to contain up to 10,000 l of coolant, up to 10,000 l of hydraulic oil and up to 3,500 kg of lubricates; Offshore fuel storage tanks: One tank on each of the up to three offshore accommodation platforms for helicopter fuel and with a total capacity of up to 255,000 l across the entire wind farm; and One on each of the up to three offshore accommodation platforms for crew transfer vessel fuel and each with a capacity of 210,000 l. Potential leachate from zinc or aluminium anodes used to provide cathodic protection to the turbines. • The anticipated design life of Hornsea Three is 35 years. It may be desirable to 'repower' Hornsea Three at or near the end of the design life of Hornsea Three to the end of the 50 year Crown Lease period. If the specifications and designs of the new turbines and/or foundations fell outside of the Maximum design scenario or the impacts of constructing, operation and maintenance, and decommissioning them were to fall outside those considered by this EIA, repowering would require further consent (and EIA) and is therefore outside of the scope of this document.	Parameters that create the greatest use of fuel usage, chemicals and hazardous waste offshore in the project area at any one time, that have the potential to spill into the marine environment. The release of contaminants may directly affect birds or indirectly via their prey. Maximum vessel traffic movements will be associated with greatest turbine numbers (and associated infrastructure) and will cause highest risk of a pollution incident.
Decommissioning phase		
The impact of direct disturbance and displacement due to underwater noise and vessel traffic may stop birds from accessing important foraging and habitat areas. The impact of indirect disturbance and displacement due to underwater noise and vessel traffic may stop prey species accessing important foraging and habitat areas.	Decommissioning of: • Up to 300 WTGs, 12 offshore transformer substations, three offshore accommodation platforms, four offshore HVDC substations or four offshore HVAC booster stations (located within the offshore HVAC booster substation search area; • Up to 1,146 km of export cable and 830 km array cables; and • Up to 10,474 vessel movements during the decommissioning phase. • Up to 3,785 helicopter return trips during the decommissioning phase	Provides for the largest possible noise over the greatest spatial extent of the Project Three site, over the largest temporal scale. The maximum number of vessel movements and helicopter round trips during the construction phase which may affect the available airspace for other users.
The impact of indirect effects such as changes in habitat or abundance and distribution of prey.	Decommissioning of: • Up to 300 WTGs, 12 offshore transformer substations, three offshore accommodation platforms, four offshore HVDC substations or four offshore HVAC booster substations (located within the offshore HVAC booster substation search area; • Up to 1,146 km of export cable and 830 km array cables; and • Up to 10,474 return vessel trips over the decommissioning phase.	Maximum footprint and hence greatest influence on physical processes, created by removal of greatest number of turbines. Impacts may be either positive or negative depending on habitat types created for prey species. The maximum number of vessel movements during the construction phase which may affect the available airspace for other users.
The impact of pollution including accidental spills and contaminant releases associated with removal of infrastructure and supply/service vessels may lead to direct mortality of birds or a reduction in foraging capacity.	Maximum design scenario is identical to that of the construction phase.	Maximum design scenario as per construction phase

5.9 Impact assessment methodology

5.9.1 Overview

5.9.1.1 The Offshore Ornithology EIA has followed the methodology set out in volume 1, chapter 5: Environmental Impact Assessment Methodology. These criteria have been adapted in order to implement a specific methodology for offshore ornithology. The general principle of determining impact significance from levels of sensitivity of the receptors and magnitude of effect is however consistent with Design Manual for Roads and Bridges (DMRB). In this respect, the methodology used also follows the approach outlined by CIEEM (2010).

5.9.1.2 In addition, the Offshore Ornithology EIA has considered relevant legislation with this detailed in Section 5.4. Also considered in this section are methodologies specific to certain impacts that may affect those VORs identified in section 5.7.2.

5.9.2 Displacement analysis

Overview

5.9.2.1 The presence of wind turbines has the potential to directly disturb and displace birds from within and around Hornsea Three. This indirect habitat loss would reduce the area available for feeding, loafing and moulting for seabird species that may occur at Hornsea Three. In addition there is the potential for seabird species to be affected by disturbance impacts resulting from construction, decommissioning and operation and maintenance activities associated with the Hornsea Three offshore cable corridor.

5.9.2.2 Seabird species vary in their reactions to the presence of operational infrastructure (e.g. wind turbines, substations and met mast) and to the maintenance activities that are associated with it (particularly vessel and helicopter traffic). Wade *et al.* (2016) presents a scoring system for such disturbance factors, which is used widely in offshore wind farm EIAs.

5.9.2.3 Following recently published joint SNCB interim guidance JNCC *et al.* (2017), displacement impacts for each relevant species are presented using a wide range of potential displacement and mortality rates. These have been presented as separate matrix tables, one for each of the seasons being assessed as applicable (e.g. ‘breeding’, ‘post-breeding’, ‘non-breeding’ and ‘pre-breeding’) in annex 5.2: Analysis of Displacement Impacts on Seabirds. The matrices and assessments presented in this chapter take into consideration three species-specific factors: (i) intensity of displacement within a given area (i.e. what proportion of the population is displaced); (ii) spatial extent – to what distance from turbines any individuals within the population will be displaced; and (iii) seasonality – what magnitude of impact there will be within a population (taken as percentage mortality), based on the species’ particular sensitivity during a particular stage in the life cycle.

5.9.2.4 It is recognised that for many species, limited information is available to predict the magnitude of displacement or, should it occur, its resultant effects on populations. For most species there has been little evidence of total or near-total displacement from constructed offshore wind farms (e.g. Krijgsveld *et al.*, 2011). For some species, such as auks, the reported levels of displacement have been variable.

Species for consideration

5.9.2.5 Annex 5.2: Analysis of Displacement Impacts on Seabirds presents information to inform the assessments presented in this chapter relating to the significance of displacement impacts. These analyses have been informed by recent guidance published jointly by the UK SNCBs (JNCC *et al.*, 2017).

5.9.2.6 The full process applied to VORs is documented in the Baseline Characterisation Report (annex 5.1: Offshore Ornithology Baseline Characterisation Report) with those considered for displacement analyses identified in annex 5.2: Analysis of Displacement Impacts on Seabirds.

5.9.2.7 The following species were identified for inclusion in the displacement assessment for potential displacement impacts associated with the Hornsea Three array area:

- Fulmar;
- Gannet;
- Puffin
- Razorbill; and
- Guillemot.

5.9.2.8 In addition, potential disturbance/displacement impacts associated with the Hornsea Three offshore cable corridor have been considered for three Valued Ornithological Receptors (VORs), red-throated diver, common scoter and Sandwich tern (see annex 5.1: Baseline Characterisation Report).

Spatial scales

5.9.2.9 JNCC *et al.* (2017) interim guidance recommends that for the species of highest sensitivity (divers and sea ducks), the Hornsea Three array area plus 4 km buffer should be used when assessing displacement, whereas a 2 km buffer should be used for all other species. In both cases JNCC *et al.* (2017) recommended that no gradient of impact of displacement level should be applied to the buffer zone, as there is not sufficient evidence to underpin any such gradient application on a species-by-species basis. This is a precautionary approach that doesn’t represent the reality that some degree of gradient will occur in respect to how close individual birds will approach a source of disturbance influenced by, for example, past exposure to the event (habituation), need to feed chicks and ability to forage as successfully elsewhere.

5.9.2.10 For all species included in the displacement analysis for impacts associated with the Hornsea Three array area, a 2 km buffer around the Hornsea Three array area is used with no gradient of impact of displacement level applied to the buffer zone. Species deemed particularly sensitive to displacement, such as divers and seaduck did not qualify as VORs in this assessment for the Hornsea Three array area due to either being absent (e.g. common scoter) or recorded in only very small numbers (e.g. red-throated diver) during site-specific aerial surveys (annex 5.1: Baseline Characterisation Report). Red-throated diver and common scoter did however qualify as VORs for consideration in relation to impacts arising from the Hornsea Three offshore cable corridor temporary working area with a 2 km buffer which is considered to be an equally valid spatial extent to consider disturbance / displacement impacts due to low densities of birds and the nature of the potential impacts.

5.9.2.11 Seasonal mean-peak population estimates of birds at Hornsea Three plus a 2 km buffer have been applied in order to assess displacement effects. SNCB advice recommends the use of mean-peak population estimates for displacement analysis (JNCC *et al*., 2017).

5.9.2.12 Displacement effects associated with the Hornsea Three offshore cable corridor have been assessed using a seasonal mean population derived from existing datasets (Lawson *et al.,* 2015). This approach has in built elements of considerable precaution as the spatial extent of the data is limited to inshore areas where the highest density of relevant species is likely to occur. In addition, the nature of potential impacts, which are likely to be of a lesser magnitude when compared to displacement impacts associated with the Hornsea Three array area.

Displacement and mortality rates

Overview

5.9.2.13 The potential impact of displacement will vary depending on the season. Breeding seabirds are 'central place foragers', with the need to optimise their time spent away from the nest and energy expended in foraging. The range at which they can forage away from the nest site becomes constrained by distance from their nesting site, unlike birds that are not actively breeding, irrespective of season, that can forage more widely. Consequently, any displacement during the breeding season of breeding adults from foraging areas is predicted to have a greater magnitude of impact than at other times as birds may struggle to meet their energy requirements.

5.9.2.14 JNCC *et al.* (2017) indicates that SNCBs intend to use 'Disturbance Susceptibility' scores from Bradbury *et al.* (2014) (which have in fact been updated by Wade *et al.* (2016)) as a general guide to the appropriate displacement levels to apply for a species. JNCC *et al.* (2017) suggests that a displacement rate range of 90-100% should be used for species with a high vulnerability, 30-70% should be used for species with a moderate vulnerability and 10% should be used for species with a low vulnerability. In addition, where possible, attempts have been made to refine these rates using available published evidence. This has been brought together and summarised in the following section.

Review of displacement rates

5.9.2.15 Although concentrating on birds in flight, the study of the operational Egmond aan Zee wind farm by Krijgsveld *et al.* (2011) is one of the more in-depth studies determining the effect of the presence of operational turbines on birds. Based on radar and panorama scans, macro-avoidance rates (i.e. birds avoiding the wind farm as a whole) were assessed for the majority of species groups present, and this behaviour is likely to be indicative of displacement risks. Gulls were the main species present, and although in the cases of auks and divers too few observations were available to obtain a reliable macro-avoidance rate, from flight paths it was evident that their avoidance behaviour was similar to that of gannets and scoters, rather than that of gulls.

5.9.2.16 Construction period records from the Lincs offshore wind farm showed that at least 769 birds (198 observations) including large gulls, kittiwake and terns used turbine bases and monopiles to rest on. On several occasions gulls were clearly associated with the jack-up barge, the guard vessels and with the construction vessel while piling was in progress (RPS, 2012). Similarly, Vanermen *et al.* (2013) in their study of Belgian offshore wind farms, birds (mainly gulls) were attracted to physical structures e.g. turbines, as roost locations and did not show any signs of displacement. Construction disturbance to these species is therefore considered likely to be minimal.

Fulmar

5.9.2.17 Fulmar is considered to have a very low vulnerability to displacement from offshore wind farms, being assigned a score of 1 (out of 5) by Wade *et al.* (2016). JNCC *et al.* (2017) suggests that a 10% displacement rate would be assumed for species such as fulmar.

5.9.2.18 There was no significant effect on the abundance of fulmar at the Thortonbank offshore wind farm between the pre-construction and operational phases (Vanerman *et al.,* 2017). Leopold *et al.* (2011) was unable to draw conclusive results at Egmond aan Zee due to low numbers of birds although Krijgsveld *et al*. (2011), using data collected at the same project, identified fulmar as a lower sensitivity species with a displacement rate of 28%. Barton *et al.* (2009) noted "*highly significant*" declines in the abundance of fulmar at the Arklow Bank wind farm although declines appear to have occurred across the study area.

5.9.2.19 Available published evidence for fulmar is limited and as such it is considered appropriate to consider a range of displacement rates from 10-30%.

Gannet

5.9.2.20 Gannet is considered to have a high vulnerability to displacement from offshore wind farms, being assigned a score of 4 (out of 5) by Wade *et al.* (2016). JNCC et al. (2017) however quote Bradbury *et al* (2014) who score gannets susceptibility to disturbance as 2 (out of 5). Considering that JNCC et al. (2017) suggests that a 30-70% displacement rate range would be assumed for species such as gannet appropriate for guillemot and razorbill (rated 3 out of 5 for disturbance susceptibility) it is assumed here that a similar range would be appropriate (and precautionary) for gannet.

5.9.2.21 Krijgsveld *et al.* (2010; 2011) have shown that gannets in flight strongly avoid wind farms, albeit they do so relatively close to turbines (within 500 m) resulting in a macro-avoidance rate of 64%. At the Robin Rigg offshore wind farm there was potential avoidance of the wind farm during operation however, only small numbers of gannet were recorded increasing the uncertainty associated with the conclusions drawn (Nelson *et al.,* 2015).

5.9.2.22 Vanerman *et al.* (2017) found gannet showed significant avoidance of the Thorntonbank wind farm with numbers dropping 97% in the wind farm plus 500 m buffer area and a 70% reduction in the wind farm plus 3 km buffer. At the Blighbank wind farm plus a 500 m buffer, a 82% reduction was noted. When the effect in a 3 km buffer zone around Blighbank was considered a 26% reduction was noted, an effect which was not significant (Vanerman *et al.,* 2016). Significant avoidance of wind farms by gannet in Dutch waters has also been recorded with birds rarely entering the wind farm area but still observed flying around the wind farms (Leopold *et al.,* 2011). In German waters, the abundance of gannet at the Alpha Ventus wind farm decreased between pre-construction and operation (Mendel *et al.,* 2014) although information presented in Mendel *et al.* (2014) would suggest such decreases were a wider trend that was not limited to the wind farm area.

5.9.2.23 Although displacement rates for wind farm areas appear to be very high (nearly 100%), gannet are still observed within associated buffer areas. When including a 3 km buffer area, an overall 70% reduction was noted at Thortonbank and a 26% reduction at Blighbank wind farm. In addition, Krijgsveld *et al.* (2011) calculated a macro-avoidance rate of 64%. As such, a displacement rate range of 30-70% from the Hornsea Three array area plus 2 km buffer during the breeding and non-breeding seasons (post-breeding and pre-breeding seasons) is considered appropriate for the impact assessment for gannet.

Auks

5.9.2.24 Guillemot and razorbill are considered to have a high vulnerability to displacement from offshore wind farms, being assigned a score of 4 (out of 5) by Wade *et al.* (2016). JNCC *et al.* (2017) Puffin is assigned a score of 3 and considered to be moderately vulnerable to displacement. JNCC et al. (2017) suggests that a suggests that SNCBs would typically recommend a 30-70% displacement rate range would be assumed for species with moderate or high vulnerability for guillemot and razorbill based on disturbance susceptibility scores of 3 (out of 5). Puffin scores 2 (out of 5) for disturbance susceptibility, so the 30-70% range of displacement would apply in a precautionary sense to this species.

5.9.2.25 Krijgsveld *et al.* (2011) identified auks as higher sensitivity species to displacement, calculating a macro-avoidance rate of 68%, however, only relatively close to turbines (within 500 m). Dierschke and Garthe (2006) present evidence that also suggests guillemot and razorbill have a relatively high sensitivity to displacement from offshore wind farms. Danish studies at Horns Rev, whilst showing considerable variability, also suggest this, noting total absence from the wind farm footprint following construction (Petersen *et al.*, 2006).

5.9.2.26 Studies undertaken at Dutch wind farms have reported displacement effects of less than 50% (Leopold *et al.*, 2011). Leopold *et al.* (2010) found that at Egmond aan Zee, auks entered the wind farm area by swimming, and birds regularly recorded foraging within the site. However, a number of more recent studies have not shown a similar level of impact. Arklow Bank Offshore Wind Farm did not find any significant difference in the number of guillemots present pre- and post-construction with an increase in the abundance of razorbill suggesting no impact due to the presence of turbines (Barton *et al.*, 2009). Post construction monitoring at North Hoyle Offshore Wind Farm indicated an increase of up to 55% in the number of guillemots present compared to before the wind farm was constructed (nPower, 2008).

5.9.2.27 The density of razorbill at the Robin Rigg offshore wind farm was not significantly affected by the development phase of the wind farm, although densities of razorbill on the sea did increase within the wind farm area between the pre-construction and operational phases (Nelson *et al.,* 2015). The abundance of guillemot at the same wind farm was significantly affected by the development phase of the wind farm, increasing between pre-construction and operation.

5.9.2.28 The abundance of guillemot at the Thortonbank offshore wind farm was shown to have decreased considerably once the wind farm was operational (69% in the wind farm plus 500 m buffer area) with these decreases significant within the wind farm plus 500 m buffer area. Although decreases were also noted in the buffer area (500 m to 3 km) these were not statistically significant. The abundance of razorbill decreased within the wind farm area but increased in the surrounding buffer. When these two areas were combined there was no apparent effect on the abundance of razorbill due to the presence of the wind farm (Vanerman *et al.,* 2017). Similar results were found at the Alpha Ventus offshore wind farm with the abundance of guillemot significantly lower after the construction of the wind farm (Mendel *et al.,* 2014). At Blighbank offshore wind farm both guillemot and razorbill appeared to avoid the wind farm area with decreases of 75% and 67%, respectively however, decreases were lower (and not significant) in the buffer area (49 and 32%, respectively) (Vanerman *et al.,* 2016).

5.9.2.29 It is important to note that some of the high displacement rates reported in the studies summarised in here apply to the wind farm alone whereas the displacement analyses for Hornsea Three calculate the number birds displaced from Hornsea Three plus a 2 km buffer. A number of studies found no significant effect on the number of birds present in buffer areas around wind farms and therefore the likely displacement rate is not considered to be at the upper end of the range considered.

5.9.2.30 Monitoring studies have often recorded auks inside of wind farm areas and on the basis of the above information, a displacement value of 50% has been used for guillemots based on the conclusions of Vanerman *et al.,* (2016; 2017) and Nelson *et al.,* (2015), in particular. Based on the studies summarized above, razorbill appears to have a lower vulnerability to displacement impacts than guillemot, especially when considering the results obtained at Thortonbank (Vanerman *et al.,* 2017), Blighbank (Vanerman *et al.,* 2016) and Robin Rigg (Nelson *et al.,* 2015) which show lower displacement rates than those calculated for guillemot. As such, a displacement rate of 40% is considered appropriate for razorbill.

5.9.2.31 There have been few studies which have included puffin as a separate species to assess displacement rates, with the majority combining all auks together. For assessment purposes, a displacement value of 50% from the Hornsea Three array area plus 2 km buffer during the breeding and non-breeding seasons is considered appropriate for puffin, based on the rationale described for razorbill (paragraphs 5.9.2.24 - 5.9.2.30), but with an added degree of precaution due to a lower level of empirical evidence.

Review of mortality rates

5.9.2.32 There is limited evidence on what the extent of mortality may be, although a typical ceiling of 10% is often applied by SNCBs (e.g. see the assessments produced for Hornsea Project Two (Natural England, 2015a; 2015b; 2015c)). There are no directly appropriate studies of the effects of displacement on mortality of seabirds. It is however reasonable to consider as overly precautionary, the assumption of 100% of displaced birds will die. It follows that the density of birds within areas to which birds are displaced will increase as a result of the relocation of the displaced birds to where others may already be occupying. There is the possibility that there will be additional mortality experienced by these birds due to increased resource competition and that this “additional mortality” will be a function of density (i.e. the mortality rate increases as density increases).

5.9.2.33 When assessing the resultant effects of displacement on a population, previously a common starting default position has been the worst-case scenario of 100% mortality for displaced birds. However, this is now recognised throughout the offshore wind industry and SNCBs as being unrealistic and over-precautionary (for example see Natural England, 2015a; 2015b; 2015c; and Scottish Government, 2017).

5.9.2.34 Based on expert judgement on the sensitivity of each receptor, precautionary mortality rates of between 2 and 10% are applied in the breeding season to displaced species taken forward to impact assessment (Table 5.9) These rates are comparable to those previously used in offshore wind farms (e.g. Hornsea Project Two). However, recent advice provided by Scottish Natural Heritage (SNH) for projects in Scottish water has proposed mortality rates of 2% for puffin and 1% for guillemot and razorbill across all seasons. The RSPB have advised a 2% mortality rate for all species for all seasons.

5.9.2.35 The mortality rate varies between species, with actual assigned values dependent on that species' known behaviour (e.g. habitat and foraging flexibility as defined in Wade *et al.,* 2016). These rates are considered suitably precautionary for EIA requirements, although the matrices presented show rates of up to 100% for both displacement and mortality as recommended in interim guidance (JNCC *et al.*, 2017).

5.9.2.36 Fulmar and gannet have extensive foraging ranges during the breeding season (Thaxter *et al.* 2012) providing the species with sufficient alternative foraging opportunities. A mortality rate of 2% is therefore considered appropriate in the breeding season. For the three auk species, it is considered highly unlikely that any breeding adult birds will be present at Hornsea Three with the population present considered to be composed of immature and non-breeding birds. These birds are not constrained due to the necessity to provision young and therefore the application of a lower mortality rate in the breeding season for these species may be appropriate. In addition, Hornsea Three is located in an area of the North Sea that does not support high densities of the three auk species in any season (see annex 5.1: Baseline Characterisation Report). Therefore the application of a range of mortality rates (2-10%) is considered appropriate for the three auk species in the breeding season.

5.9.2.37 During the 'non-breeding' periods (defined here as all seasons outside of the breeding season), seabirds are generally less constrained in terms of the foraging areas they can use and are more capable of relocating to other areas. Birds that were breeding adults are not constrained by central place foraging from a colony and therefore have a greater degree of flexibility in utilising different resources free from providing food for young or breeding partners. The vast majority of individuals are therefore highly likely to find alternative foraging habitat if displaced. However, for the purposes of this assessment it is considered that in the non-breeding season, a significantly lower proportion of birds will be exposed to sufficient stress to suffer mortality. Therefore a mortality rate of 1% of displaced birds has been adopted and is considered suitably precautionary.

5.9.2.38 'Post-breeding', seabirds leave their colonies and disperse. For most species this period is little or no different from the 'non-breeding' period. However, razorbill, for example, leaving their colonies accompanied by chicks are constrained to some extent, by both the adults and young being flightless and therefore unable to travel large distances rapidly in search for food. Displaced birds away from suitable foraging areas may be at higher risk of increased mortality than birds during the 'non-breeding period'. Other post-breeding seabirds can, however, move further afield than breeding adults and therefore the potential effects from displacement are expected to be lower. Furthermore, the possible impacts from displacement are more transitory as the majority of birds are dispersing through the area. For the purposes of the assessment a 2% mortality rate for auks displaced in the post-breeding period is applied which reflects the lower restrictions than during the breeding season, but the slightly increased potential for mortality on these species due to the ongoing care required for young, as well as any stress incurred during the moult period when foraging range is more limited.

Summary

5.9.2.39 Table 5.9 summarises the proposed displacement and mortality rates to be considered in the assessment presented in section 5.11.2 based on the information presented above.

Table 5.9: Assessment criteria for displacement effects for the area Hornsea Three array area plus a 2 km buffer

Species	Season of relevance	Months	Displacement rate based on guidance interpreting Wade et al. (2016) sensitivity scores (%)	Evidence – based displacement rate (%)	Mortality rate (%)
Fulmar	Breeding	Apr – Aug	10	10-30	2
	Post-breeding	Sep-Oct			1
	Non-breeding	Dec			1
	Pre-breeding	Jan – Mar			1
Gannet	Breeding	Apr – Aug	30-70	30-70	2
	Post-breeding	Sep – Nov			1
	Pre-breeding	Dec- Mar			1
Puffin	Breeding	Apr – Jul	30-70	50	2-10
	Non-breeding	Aug – Mar			1
Razorbill	Breeding	Apr – Jul	30-70	40	2-10
	Post-breeding	Sep – Oct			2
	Non-breeding	Nov – Dec			1
	Pre-breeding	Jan – Mar			2
Guillemot	Breeding	Mar – Jul	30-70	50	2-10
	Non-breeding	Aug – Feb			1

5.9.3 Collision Risk Modelling

5.9.3.1 CRM was undertaken to quantify the potential risk of additional mortality through collisions with operational turbines above the current baseline for each species. The most frequently used collision risk model in the UK is commonly referred to as 'the Band model'. This model was originally devised in 1995 and has since been subject to a number of iterations, most recently to facilitate application in the offshore environment (Band, 2011) and to allow for the use of flight height distribution data and to include a methodology for considering birds on migration (Band, 2012).

5.9.3.2 Masden (2015) presents an update to Band (2012) which further develops the application of the Band model using a simulation modelling approach to incorporate variability and uncertainty. The update provides for an improved understanding of uncertainty by randomly sampling parameter values from distributions for each parameter, deriving average collision risk estimates with associated measures of variability. However, it has recently come to light through advice from Natural England (as part of EWG meetings) that further amendment of the Masden (2015) update of the collision risk model is required before they advise its use. These amendments are however expected to be included as part of ongoing work that aims to produce an improved stochastic collision risk model later in 2018. As a result, Masden (2015) has not been used to calculate collision risk estimates for Hornsea Three.

5.9.3.3 In order to express the variability associated with the collision risk estimates used in the assessment, modelling has been conducted incorporating upper and lower confidence intervals associated with species densities and flight height distributions and the standard deviations associated with avoidance rates. It should be noted that collision risk estimates calculated using the mean estimate (density) and maximum likelihood scenario of input parameters are those that best represent the likely number of collisions that will occur. However, throughout relevant sections, the variability associated with these estimates is presented and considered within assessments.

5.9.3.4 There are a number of other factors that influence the level of uncertainty/variability associated with a collision risk estimate with many listed in the Band (2012) guidance. These factors are associated with the input parameters used the CRM and also to the underlying assumptions in the Band (2012) collision risk model and have varying levels of uncertainty/variability associated with them. However, applying the upper or lower confidence metrics for all of the parameters within the CRM is incorrect and would provide unrealistic estimations of collision risk by either under-estimating or over-estimating collision risk. The collision risk estimate calculated using the mean estimate/maximum likelihood scenario for all parameters is therefore the estimate that best describes the likely magnitude of collision risk and is that used in the assessments presented in relevant sections.

5.9.3.5 The Band (2012) model incorporates two approaches to calculating the risk of collision referred to as the 'Basic' and 'Extended' versions of the model. A key difference between these versions is the extent to which they account for the flight height patterns of seabirds (Band, 2012). The distribution of seabird flights across the sea is generally skewed towards lower altitudes. As stated by Band (2012) there are three consequences of a skewed flight height distribution:

- "the proportion of birds flying at risk height decreases as the height of the rotor is increased;
- more birds miss the rotor, where flights lie close to the bottom of the circle presented by the rotor; and
- the collision risk, for birds passing through the lower parts of a rotor, is less than the average collision risk for the whole rotor."

5.9.3.6 The Basic model assumes a uniform distribution of flights across the rotor with a consistent risk of collision across the whole rotor swept area. The Extended model of Band (2012) takes into account the distribution of birds in addition to the differential risk across the rotor swept area. It should be noted that the use of the basic model is precautionary as it does not take into account the variability in risk of collision that occurs across a rotor swept area, with the risk of collision decreasing as the distance from the hub of the turbine increases. If this were to be taken into account (as when using Option 3) it is likely that collision risk estimates would be lower as the vertical distribution of birds flying across water is skewed towards lower heights (i.e. those associated with a lower risk of collision within a rotor swept area).

5.9.3.7 Both the Basic and Extended models of Band (2012) allow for the use of two 'Options' termed Options 1-4. Options 1 and 2 use the Basic model with Options 3 and 4 utilising the Extended model. The difference between the two Options under each model is linked to the use of flight height data. Options 2 and 3 use generic data from Johnston *et al.* (2014) whereas Options 1 and 4 use site-specific data derived from site-specific surveys.

5.9.3.8 The flight height data collected as part of site-specific digital aerial surveys at Hornsea Three have been thoroughly reviewed and are concluded to be of limited use in CRM (see Consultation Report (document reference number A5.1), annex 1: Evidence Plan for Offshore Ornithology EWG discussion in relation to this point). For the majority of species the number of records falls below a 100 record threshold which has been recommended as being required by Natural England in order to calculate a representative proportion of birds at potential collision height (PCH) value (Natural England, 2013). For those two species for which a representative PCH value is calculable the resulting value falls considerably outside of the confidence limits associated with generic flight height information (Johnston *et al*., 2014) with no valid ecological reason as to why this should occur.

5.9.3.9 Further to this, the majority of records in the dataset have associated wide confidence intervals and there are a significant number of records that are assigned a negative flight height. Of the 3,553 records of birds recorded in flight between April 2016 and September 2017 (flight heights were not calculated for birds recorded in the October or November 2017 surveys) a height value could be estimated for just over 39% (1,393 birds). Of these birds, a negative flight height was estimated for over 29%. For those birds for which a positive flight height was estimated (987 records) the lower confidence limit for 38% was also negative. This therefore leaves only 538 records that are unaffected by negative values which represents a limited dataset that could not robustly inform the assessment.

5.9.3.10 To populate analysis of collision risk, various options have been considered in the absence of adequate data from the digital aerial survey programme. It is considered that data that has direct relevance to Hornsea Three would be preferable and indeed there exists a considerable amount of flight height data that were collected during boat-based surveys conducted to support the application process for the Hornsea Project One and Hornsea Project Two offshore wind farms. Surveys were conducted between March 2010 and February 2013 covering the former Hornsea Zone and were based on standard survey methodologies (Camphuysen *et al*., 2004). A full description of the surveys conducted is presented in SMart Wind (2015a) and SMart Wind (2013). These data have been interrogated in order to identify those records that occur within Hornsea Three plus a 4 km buffer.

5.9.3.11 The boat-based surveys categorised flying birds into five metre height bands meaning that, for example, birds assigned to the 10 m flight height band were flying between 7.5 and 12.5 m. The lower rotor tip height at Hornsea Three is 33.17 (MSL), therefore the 35 metre flight height band (32.5 – 37.5 m) has been used to calculate the proportion of birds at PCH. Although likely to include a proportion of birds that are actually outside of the rotor swept area (i.e. those between 32.5 and 33.17 m), the use of a complete five metre band is considered precautionary and aligns with the approach to analysis requested by Natural England during the examination at Hornsea Project Two (see SMart Wind, 2015b). The PCH values calculated for each species are presented in annex 5.3: Collision Risk Modelling.

5.9.3.12 In addition to the use of Option 1 incorporating site-specific flight height data, collision risk estimates have been calculated using Options 2 and 3 of the Band (2012) model which make use of aggregated flight height data contained in Johnston *et al*. (2014). Collision risk estimates calculated using Options 2 and 3 are presented at the request of stakeholders during EWG meetings however, these Options are considered to over-estimate collision risk as they utilise flight height data that is not specific to Hornsea Three with this supported by the PCH values derived from boat-based data covering Hornsea Three used when modelling using Option 1. However, it is also important to note that Options 1 and 2, which use the Basic model of Band (2012) are also likely to over-estimate collision risk due to the simplistic assumptions associated with the Basic Band model.

5.9.3.13 CRM is undertaken for three species groups that occur at Hornsea Three:

- Regularly occurring seabirds;
- Migratory seabirds; and
- Migratory waterbirds.

5.9.3.14 A brief description of the methodology applied for each of these groups is provided in the following sections with full methodologies provided in annex 5.3: Collision Risk Modelling.

5.9.3.15 The maximum design scenario for collision risk in this modelling process is taken to be the development scenario comprising the maximum number of turbines (300) with parameters as defined in volume 1, chapter 3: Project Description. The parameters for this scenario are presented in annex 5.3: Collision Risk Modelling. The CRM assumed a wind turbine hub-height of 116.77 m (above LAT) will be used at Hornsea Three. This provides for a lower tip height clearance of 34.97 m LAT reducing the potential collision risk impacts to seabirds when compared to lower minimum lower tip heights.

Collision risk to regularly occurring seabirds

5.9.3.16 CRM was conducted for four regularly occurring seabird species at Hornsea Three with these species selected using the criteria applied in annex 5.1 Baseline Characterisation Report:

- Gannet;
- Kittiwake;
- Lesser black-backed gull; and
- Great black-backed gull.

5.9.3.17 CRM for these species has been conducted using the Band (2012) collision risk model, as agreed with the Offshore Ornithology EWG. Bird biometric parameters for each of these species is presented in annex 5.3: Collision Risk Modelling.

5.9.3.18 The avoidance rates applied for each species are also presented in annex 5.3: Collision Risk Modelling. The rates applied are taken from Cook *et al.* (2014) which presents avoidance rates for all four species included in the modelling for Hornsea Three. Cook *et al.* (2014) recommended avoidance rates for use with the Basic model for all four species and with the Extended model for lesser black-backed gull and great black-backed gull. Cook *et al.* (2014) were unable to recommend an avoidance rate for use in the Extended model for gannet and kittiwake and as such a default 98% avoidance rate is applied in the modelling conducted for Hornsea Three.

5.9.3.19 In a joint response, UK SNCBs supported the recommended avoidance rates of Cook *et al.* (2014) with the exception of kittiwake (JNCC *et al.*, 2014). The SNCBs did not agree with the application of avoidance rates calculated for the 'small gull' category used in Cook *et al.* (2014) to kittiwake and recommended that the avoidance rate calculated for the 'all gull' category should be applied instead. CRM for Hornsea Three is therefore conducted using the avoidance rates presented in Table 5.6 taking into account the recommendations in both Cook *et al.* (2014) and JNCC *et al.* (2014).

Table 5.10: Avoidance rates applied in CRM for regularly occurring seabirds at Hornsea Three

Band (2012) model	Gannet	Kittiwake	Lesser black-backed gull	Great black-backed gull
Basic	98.9 (±0.2)	98.9 (±0.2) 99.2 (±0.2)	99.5 (±0.1)	99.5 (±0.1)
Extended	98.0	98.0	98.9 (±0.2)	98.9 (±0.2)

5.9.3.20 Outputs from the CRM undertaken for the four regularly occurring seabird species are presented in annex 5.3: Collision Risk Modelling.

Collision risk to migratory seabirds

5.9.3.21 CRM has been conducted for five migratory seabird species with potential connectivity with Hornsea Three with these species selected by applying the criteria in annex 5.1: Baseline Characterisation Report:

- Arctic skua;
- Great skua;
- Little gull;
- Common tern; and
- Arctic tern.

5.9.3.22 These species migrate on a broad front through the North Sea to their wintering grounds. Hornsea Three may lie on the migratory route for a proportion of these species some of which may originate from SPA colonies although interaction is likely to be limited. However, as certain species have a significant proportion of their population in SPAs, they are carried forward for further consideration in relevant sections.

5.9.3.23 Unlike the modelling approach used for CRM for regularly occurring seabird species at Hornsea Three, density data collected during site-specific surveys is deemed to be unsuitable to estimate the impact of collision for migratory seabird species. This is due to the snapshot nature of site-specific surveys and consequential limitations in recording sporadic movements of migratory species. Therefore the CRM approach used for migratory seabirds incorporates species-specific information relating to population estimates and migratory behaviour. A generic 'migratory front' is then defined which is then used to calculate the number of birds that have the potential to interact with Hornsea Three during spring and autumn migration. A detailed methodology is provided in appendix C of annex 5.3: Collision Risk Modelling alongside the calculation of interacting populations and the peak migratory months used for modelling.

5.9.3.24 CRM for migratory seabirds has been undertaken using the Band (2012) collision risk model. Bird biometric parameters for each of the species selected for modelling is presented in appendix C of annex 5.3: Collision Risk Modelling. With the exception of little gull, there is limited published evidence relating to avoidance rates to be applied for migratory species as such for Arctic skua, great skua, common tern and Arctic tern, collision risk estimates calculated using a 98% avoidance rate are used in the assessment of LSE.

5.9.3.25 Cook *et al.* (2014) derived avoidance rates for small gull spp. and gull spp., two groups which included data relating to the avoidance behaviour of little gull. Avoidance rates of 99.2% and 98.9% were derived for the small gull spp. and gull spp. respectively. As such, avoidance rates of 98%, 98.9%, 99.2% and 99.5% will be presented in the CRM for little gull, with a 99.2% avoidance rate considered to be the most relevant for assessment purposes.

5.9.3.26 The results of the CRM conducted for migratory seabird species are presented in appendix C of annex 5.3: Collision Risk Modelling.

Collision risk to migratory waterbirds

5.9.3.27 Migratory waterbirds which move across offshore areas in large numbers predominantly do so over short temporal periods. These movements are poorly recorded by traditional boat-based or aerial surveys used to define the baseline environment for Environmental Impact Assessments of offshore wind farms. As such, the modelling approach described by Wright *et al.* (2012), is used to inform the assessment of collision risk at Hornsea Three on migratory waterbirds. This approach uses the Strategic Ornithological Support Services (SOSS) Migration Assessment Tool (MAT). A full description of the methodology applied is provided in appendix D of annex 5.3: Collision Risk Modelling.

5.9.3.28 Twelve species were selected based on a relatively high proportion of birds occurring at locations (e.g. SPAs) close to Hornsea Three:

- Bewick's swan;
- Taiga bean goose;
- Dark-bellied brent goose;
- Shelduck;
- Wigeon;
- Golden plover;
- Grey plover;
- Lapwing;
- Knot;
- Dunlin;
- Black-tailed godwit; and
- Bar-tailed godwit.

5.9.3.29 The suite of migratory waterbirds to be incorporated into CRM is consistent with those species considered in the assessments for the Hornsea Project One and Hornsea Project Two projects. The list represents those species recorded during boat-based surveys at Hornsea Project One in addition to migrant species considered to be representative of those that have the potential to cross the former Hornsea Zone. The latter species were selected through consultation with Natural England and JNCC based on observations where a relatively high proportion of birds occur within the SPAs close to the former Hornsea Zone.

5.9.3.30 CRM for migratory waterbirds has been undertaken using the Band (2012) collision risk model. The Band (2012) collision risk model includes two models (basic and extended) which both incorporate two 'Options'. Generic flight height distributions, used for Options 2 and 3 of Band (2012) are unavailable for migratory waterbirds and therefore it is not possible to use these model options. Therefore Option 1 is used incorporating the PCH values from Wright *et al.* (2012). Collision risk estimates are calculated using a default avoidance rate of 98%, as recommended by SNH guidance (SNH, 2010), which is applied for all species however, it is important to note that this rate is applied on a precautionary basis for taiga bean goose and dark-bellied brent goose for which it is considered appropriate to apply an avoidance rate of 99.8% (SNH, 2013).

5.9.3.31 The results of the CRM for migratory waterbirds are presented in appendix D of annex 5.3: Collision Risk Modelling.

5.9.4 Impact assessment criteria

5.9.4.1 The criteria for determining the significance of effects is a two stage process that involves defining the sensitivity of the receptors and the magnitude of the impacts. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts. The terms used to define sensitivity and magnitude are based on those used in the DMRB methodology, which is described in further detail in volume 1, chapter 5: Environmental Impact Assessment Methodology. These criteria have been adapted in order to implement a specific methodology for offshore ornithology. The general principle of determining impact significance from levels of sensitivity of the receptors and magnitude of effect is however consistent with DMRB. In this respect, the methodology used also follows the approach outlined by CIEEM (2010).

5.9.4.2 To determine the significance of an impact, a sequence of criteria are evaluated against each species and each impact:

- Receptor sensitivity – based on a combination of the conservation value of the species, the vulnerability of the species to each particular impact, and the recoverability of a species' population after being subject to a particular impact;
- Magnitude of impact – based on a combination of spatial extent (and therefore number of birds that may be affected), duration, frequency and reversibility in relation to reference populations (e.g. regional, national); and

- Significance – based on a combination of receptor sensitivity and magnitude to determine which effects on which species may be considered significant in EIA terms.

5.9.4.3 These three steps are described in sequence in the following sections.

Receptor sensitivity

5.9.4.4 With regard to offshore ornithology, the overall sensitivity rating (negligible to very high) is based on a combination of conservation value, vulnerability and recoverability.

5.9.4.5 The value/importance of each receptor is based on standard guidelines by CIEEM (2010) which places the conservation value of receptors within a geographical frame of reference (e.g. international, national, regional). This is based on standard guidance and available information, and the distribution and status of the ecological features being considered (e.g. qualifying interest of a nearby SPA).

5.9.4.6 Evaluation of the ornithological assemblage identified by the baseline studies has been assessed in relation to its conservation value over a full range of geographical scales as recommended by CIEEM (2010) and listed in Table 5.11. This has been used to determine each species' sensitivity in a regional, national or international context.

5.9.4.7 The value/importance of each receptor has been defined in annex 5.1: Baseline Characterisation Report and is summarised in section 5.7.2 and Table 5.7.

5.9.4.8 For each impact considered (e.g. habitat loss, disturbance, collision risk), species' sensitivity also takes into consideration how vulnerable a species is to that impact, for example how flexible the species is in its habitat use or susceptibility to disturbance, based on classification by Wade *et al.* (2016). Where species or impacts are not covered by Wade *et al.*, (2016) other key literary sources on the impacts of offshore wind developments on birds are referred to (i.e. Langston, 2010; Maclean *et al.*, 2009; Garthe & Hüppop, 2004). In general, species are determined to be of low, medium or high vulnerability, based on their particular characteristics or requirements, relative to other seabird species.

5.9.4.9 The assessment of ornithological recoverability considers the ability of species' populations to return to their former status once background conditions return (i.e. when the effects of a particular impact cease, e.g. upon completion of the construction phase, or as birds habituate to an impact). It is thus important to evaluate the nature of the impact in terms of the duration required for recoverability, which is a factor of a species' natural productivity rate and background population trend in the absence of the impact.

5.9.4.10 Species with the potential to produce many young per year are considered to be able to recover more rapidly and hence to be at less risk than species that produce fewer young per year. This was determined using information on clutch size (average clutch size and maximum clutch size) and age at first breeding (as per Williams *et al.*, 1995 and Robinson, 2017). Species such as fulmar, gannet and guillemot that lay only one egg each year and do not breed until they are several years old, have the lowest recoverability. Conversely seaduck have large clutches and usually commence breeding at two or three years of age and so recoverability would be higher.

5.9.4.11 The second factor for recoverability is a species' population status (e.g. stable, declining) of for example, a regional breeding population, or during winter months for a national or flyway population.

5.9.4.12 Regional breeding status has been determined by comparing the trend in the populations of breeding colonies within mean maximum foraging range of Hornsea Three, between the Seabird 2000 survey results in Mitchell *et al.* (2004) and the most recent counts produced in JNCC's SMP database (JNCC 2017). Status of migratory/wintering populations has been determined at a broader national scale for each species, based on trends presented by JNCC (http://jncc.defra.gov.uk/page-1419).

5.9.4.13 Using these trends, the recoverability of a population can be determined. It was considered that a significantly increasing population (>25% increase) has a high recoverability, with a stable population (<25% change) rated medium, and a declining population (>25% decrease) rated as having a low recoverability (excluding differences in reproductive rate). In exceptional circumstances where the species' population would be at risk of extinction, there may be no ability for recovery.

5.9.4.14 Evaluation of the sensitivity of a species can therefore be assessed in relation to its conservation value over a range of geographical scales, its vulnerability to a particular impact, and recoverability based on population status and reproduction rate. Combined, this information can be used to determine each species' overall sensitivity to a particular impact using the definitions in Table 5.11. A summary of the overall sensitivity of the ornithological receptors considered for Hornsea Three is presented in Table 5.12. The sensitivities of the ornithological receptors and the location of individual impacts from Hornsea Three with respect to the abundance and distribution of species, as established in the baseline environment (section 5.7), have been used together with expert judgement to select VORs for assessment for all individual impacts to be considered in this chapter.

5.9.4.15 Table 5.13 presents a summary of VORs selected for assessment for all individual impacts considered in this chapter. Whether a species is to be considered for an individual impact will be made on expert judgement when considering a combination of:

- Abundance of birds in the Hornsea Three offshore ornithology study area and / or Hornsea Three offshore cable corridor is of a magnitude considered meaningful to consider an impact on the population;
- Species vulnerability to the impact; and

- Species use of Hornsea Three offshore ornithology study area and / or Hornsea Three offshore cable corridor e.g. for foraging, passage through on migration.

Table 5.11: Definition of terms relating to the overall sensitivity of ornithological receptors.

Sensitivity	Definition
Negligible	VOR is not vulnerable to the impact considered regardless of value/importance. VORs of Local value with low vulnerability and medium to high recoverability.
Low	VORs of Local value with moderate to high vulnerability and low recoverability. VORs of Regional value with low vulnerability and medium to high recoverability. VORs of National or International value with low vulnerability and high recoverability.
Medium	VORs of local value with high vulnerability and no ability for recovery. VORs of Regional value with moderate to high vulnerability and low recoverability. VORs of National or International value with moderate vulnerability and medium recoverability.
High	VORs of Regional value with high vulnerability and no ability for recovery. VORs of National or International value with high vulnerability and low recoverability.
Very High	VORs of National or International value with very high vulnerability and no ability for recovery.

Table 5.12: Information used to determine overall impact sensitivity of VORs, based on indications of conservation value, vulnerability and recoverability.

Species	Conservation value c (rationale)	Vulnerability (applicable across all phases of Hornsea Three) [d]					Factors potentially influencing recoverability					
		Collision	Displacement: structures	Displacement : vessels and helicopter	Barrier Effects	Habitat / prey interactions h	Clutch size and year of 1st breeding e	Mean-maximum foraging range (±1 SD) (km) f	Regional breeding population (individuals)	Regional trend (2000-10)	National trend (2000-16) g	Overall recoverability
Common scoter	International (SPA)	Low	Very high	Very high	Moderate	High	6-8 egg / 2 years	8.2 [k]	6,107[j] (non-breeding)	-	Not available	Medium
Red-throated diver	International (SPA)	Moderate	Very high	Very high	High	High	2 egg / 3 years	9	10,177 (non-breeding)	-	Not available	Medium
Fulmar	International (SPA)	Very low	Very low	Very low	Low	Very low	1 egg / 9 years	400 (± 245.8)	11,745	+ 16%	- 31%	Low
Gannet	International (SPA)	High	High	Very low	Very low	Very low	1 egg / 5 years	229.4 (± 124.3)	24,988	+ 289%	+ 34%[i]	High
Arctic skua	International (Migratory species)	High	Very low	Very low	Low	Low	2 eggs / 4 years	62.5 (± 17.7)	0	-	- 64%	Low
Great skua	International Migratory species)	High	Very low	Very low	Low	Low	2 eggs / 7 years	10.9 (± 3.0) / 86.4	0	-	+ 18%	Medium
Puffin	International (SPA)	Very low	Moderate	Moderate	High	Moderate	1 egg / 5 years	105.4 (± 46.0)	1,960	-	Not available	Low
Razorbill	Regional (Breeding/post-breeding population importance)	Very low	High	Moderate	High	Moderate	1 egg / 4 years	48.5 (± 35.0)	0	+ 84%	+ 32%	High
Guillemot	Regional (Non-breeding population importance)	Very low	High	Moderate	High	Moderate	1 egg / 5 years	84.2 (± 50.1)	0	+ 40%	+ 5%	Medium
Sandwich tern	International (SPA)	High	Low	Low	Very low	Moderate	1-2 eggs / 3 years	49.0 (± 7.1)	0	-	+ 13%	Medium
Common tern	International (Migratory species)	Moderate	Low	Low	Very low	Moderate	2-3 eggs / 3 years	15.2 (± 11.2)	0	-	- 10%	Medium
Arctic tern	International (Migratory species)	Moderate	Low	Low	Very low	Moderate	1-2 eggs / 4 years	24.2 (± 6.3)	0	-	- 17%	Medium
Kittiwake	International (SPA)	High	Low	Low	Low	Low	2 eggs / 4 years	60 (± 23.3)	102,002	- 47%	- 44%	Low
Little gull	International (Migratory species)	Moderate	Very low	Very low	Low	Moderate	2-3 eggs / 2-3 years	50 [b]	0	-	Not available	Medium
Lesser black-backed gull	Regional (Breeding population importance)	Very high	Low	Low	Very low	Very low	3 eggs / 4 years	141 (± 50.8)	4,544	+ 3%	Not available	Medium
Great black-backed gull	National (Non-breeding population importance)	Very high	Low	Very low	Low	Very low	2-3 eggs / 4 years	40 [a]	0	-	- 11%	Medium

Species	Conservation value c (rationale)	Vulnerability (applicable across all phases of Hornsea Three) d					Factors potentially influencing recoverability					
		Collision	Displacement: structures	Displacement : vessels and helicopter	Barrier Effects	Habitat / prey interactions h	Clutch size and year of 1st breeding e	Mean-maximum foraging range (±1 SD) (km) f	Regional breeding population (individuals)	Regional trend (2000-10)	National trend (2000-16) g	Overall recoverability

a maximum foraging range from Ratcliffe et al. (2000);
b maximum foraging range from seabird.wikispaces.com;
c SPA = qualifying species of an SPA either within foraging range during the breeding season or on migratory route;
d taken from Wade et al. (2016), Bradbury et al. (2014), Langston (2010) or Maclean et al. (2009);
e taken from Robinson (2017);
f taken from Thaxter et al. (2012) unless otherwise stated;
g taken from JNCC (2016);
h Habitat/prey interactions is termed habitat flexibility by Wade et al. (2016).
I Change between censuses in 2003-04 and colonies surveyed in 2013-14 and 2015
J Taken from Lawson et al. (2015) for the Greater Wash Area of Search (Bridlington Bay, East Yorkshire in the north, to where the Norfolk coast meets the Suffolk coast)
K Taken from Langston (2010)

Table 5.13: Summary of VORs selected for assessment for all individual impacts considered in this chapter.

Species	Conservation value[a] (rationale)	Construction / Decommissioning			Operation						
		Disturbance/displacement (vessels activity / construction activity)	Indirect effects (prey species and habitat loss)	Pollution	Displacement	Indirect effects (prey or habitat availability)	Collision	Barrier Effects	Lighting	Disturbance (maintenance activities)	Pollution
Red-throated diver	International (SPA)	✓	✓	✓	×	✓	×	×	×	✓	✓
Common scoter	International (SPA)	✓	✓	✓	×	✓	×	×	×	✓	✓
Fulmar	International (SPA)	×	✓	✓	✓	✓	×	✓	✓	✓	✓
Gannet	International (SPA)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arctic skua	International (SPA migrant)	×	×	×	×	×	✓	✓	✓	×	×
Great skua	International (SPA migrant)	×	×	×	×	×	✓	✓	✓	×	×
Puffin	International (SPA)	✓	✓	✓	✓	✓	×	✓	✓	✓	✓
Razorbill	Regional (non-breeding population importance)	✓	✓	✓	✓	✓	×	✓	✓	✓	✓
Guillemot	Regional (non-breeding population importance)	✓	✓	✓	✓	✓	×	✓	✓	✓	✓
Sandwich tern	International (SPA)	✓	✓	✓	×	✓	×	×	×	✓	✓
Common tern	International (Annex 1, Migratory species)	×	×	×	×	×	✓	✓	✓	×	×
Arctic tern	International (Annex 1, Migratory species)	×	×	×	×	×	✓	✓	✓	×	×
Kittiwake	International (SPA)	×	✓	✓	×	✓	✓	✓	✓	×	✓
Little gull	International (Migratory species)	×	×	×	×	×	✓	✓	✓	×	×
Lesser black-backed gull	Regional (Breeding population importance)	×	✓	✓	×	✓	✓	✓	✓	×	✓
Great black-backed gull	National (Non-breeding population importance)	×	✓	✓	×	✓	✓	✓	✓	×	✓
a SPA = qualifying species of an SPA either within foraging range during the breeding season or on migratory route											

Notes:

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Magnitude

5.9.4.16 Magnitude of effect is the degree of change predicted to occur to the sensitive receptor and, for the purposes of this assessment, is largely based on the CIEEM (2010) guidance. This guidance offers a standardised ecological impact assessment approach, which has been tailored for this assessment using expert judgement. The factors taken into account when determining the magnitude of the impact are:

- Spatial extent;
- Duration of the impact (long (more than five years), medium (greater than one year and less than five years) or short term (less than one year));
- Frequency (whether the receptor is subject to the effect once, intermittently or continuously); and
- Reversibility (recovery from) of the effect upon cessation of the impact.

5.9.4.17 These factors are combined to determine the scale of the change from baseline conditions ('no change' to 'high'), in relation to the conservation status of a particular feature (in this case a species' population size). The criteria for defining magnitude in this chapter are outlined in Table 5.14 below.

Table 5.14: Definition of terms relating to the magnitude of an impact upon ornithological receptors.

Magnitude	Definition
High	The proposal would affect the conservation status of the VOR with loss of ecological functionality. Recovery expected to be long term (e.g. 10 years) or irreversible following cessation of activity.
Medium	The VORs conservation status would not be affected, but the impact is likely to be significant in terms of ecological objectives or populations. Recovery expected to be medium term (e.g. 5 years) following cessation of activity.
Low	Minor shift away from baseline but the impact is of limited temporal or physical extent. Recovery expected to be short-term (e.g. less than 1 year) following cessation of activity.
Negligible	Very slight change from baseline condition. Any recovery expected to be rapid following cessation of activity.
No change	No change from baseline conditions.

Significance

5.9.4.18 The significance of the effect upon offshore ornithology is determined by correlating the magnitude of the impact and the sensitivity of the VOR. The particular method employed for this assessment is presented in Table 5.15. Where a range of significance of effect is presented in Table 5.15, the final assessment for each effect is based upon expert judgement.

Table 5.15: Matrix used for assessment of significance showing the combinations of receptor sensitivity and the magnitude of effect.

Sensitivity of receptor	Magnitude of Impact				
	No Change	Negligible	Low	Medium	High
Negligible	Negligible	Negligible	Negligible or minor	Negligible or minor	Minor
Low	Negligible	Negligible or minor	Negligible or minor	Minor	Minor or moderate
Medium	Negligible	Negligible or minor	Minor	Moderate	Moderate or major
High	Negligible	Minor	Minor or moderate	Moderate or major	Major or substantial
Very high	Negligible	Minor	Moderate or major	Major or substantial	Substantial

5.9.5 Designated sites

5.9.5.1 Where Natura 2000 sites (i.e. internationally designated sites) are considered, this chapter summarises the assessments made on the interest features of internationally designated sites as described within section 5.7.1 of this chapter (with the assessment on the site itself deferred to the RIAA for Hornsea Three (Ørsted, 2018)).

5.9.5.2 With respect to nationally and locally designated sites, where these sites fall within the boundaries of an internationally designated site (e.g. SSSIs which have not been assessed within the RIAA for Hornsea Three (Ørsted, 2018)), only the international site has been taken forward for assessment. This is because potential effects on the integrity and conservation status of the nationally designated site are assumed to be inherent within the assessment of the internationally designated site (i.e. a separate assessment for the national site is not undertaken). However, where a nationally designated site falls outside the boundaries of an international site, but within the study area, an assessment of the impacts on the overall site is made in this chapter using the EIA methodology presented here.

5.9.5.3 The RIAA has been prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (PINS, 2016) and will be submitted as part of the Application for Development Consent. It should be noted that a conclusion drawn within this chapter of 'no significant effect' on regional, national or international populations of a given species does not rule out the conclusion of an adverse effect within the HRA process as the context of the assessment may differ.

5.10 Measures adopted as part of Hornsea Three

5.10.1.1 As part of the project design process, a number of designed-in measures have been proposed to reduce the potential for impacts on offshore birds (see Table 5.16). As there is a commitment to implementing these measures, they are considered inherently part of the design of Hornsea Three and have therefore been considered in the assessment presented in section 5.11 below (i.e. the determination of magnitude and therefore significance assumes implementation of these measures). Some of these measures are considered standard industry practice for this type of development.

Table 5.16: Designed-in measures adopted as part of Hornsea Three.

Measures adopted as part of Hornsea Three	Justification
Relevant HSE procedures will be followed for all activities during construction, operation and maintenance, and decommissioning periods.	When using consumables that are potentially hazardous, or refuelling offshore, relevant HSE procedures will be followed, with the objective of mitigating any risk of pollution incidents.
A Code of Construction Practice (CoCP) will be developed and implemented to cover the construction phase. A Project Environmental Management and Monitoring Plan (PEMMP) will be produced and followed. The PEMMP will cover the operation and maintenance phase of Hornsea Three and will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details (e.g. Environment Agency, Natural England and Maritime and Coastguard Agency (MCA)). A Decommissioning Programme will be developed to cover the decommissioning phase..	Measures will be adopted to ensure that the potential for release of pollutants from construction, operation and maintenance, and decommissioning plant is minimised. In this manner, accidental release of contaminants from rigs and supply/service vessels will be strictly controlled, thus providing protection for birds and their prey species across all phases of the wind farm development.
Installation of appropriate lighting on wind farm structures.	Lighting of wind turbines will meet minimum requirements, namely as set out in the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) Recommendation O-117 on 'The Marking of Offshore Wind Farms' for navigation lighting and by the Civil Aviation Authority in the Air Navigation Orders (CAP 393 and guidance in CAP 764). In keeping with the minimum legal requirements, this will minimise the risks of migrating birds becoming attracted to, or disorientated by turbines at night or in poor weather.
A minimum wind turbine hub-height of 127.47 m (above LAT) will be used for Hornsea Three. This provides for a lower blade tip height clearance of 34.97 m LAT.	This hub-height is considered appropriately conservative so as to minimise the risk of bird collisions.

5.11 Assessment of significance

5.11.1 Construction phase

5.11.1.1 The impacts of the offshore construction of Hornsea Three have been assessed on offshore ornithology. The environmental impacts arising from the construction of Hornsea Three are listed in Table 5.8 above along with the maximum design scenario against which each construction phase impact has been assessed.

5.11.1.2 A description of the potential effect on offshore ornithology receptors caused by each identified impact is given below.

The impact of construction activities such as increased vessel activity and underwater noise may result in direct disturbance or displacement from important foraging and habitat areas of seabirds.

5.11.1.3 Disturbance during the construction of a wind farm (visual presence, vessel activity and underwater noise) may displace birds from an area of sea, effectively amounting to habitat loss during the period of disturbance (Drewitt and Langston, 2006). Disturbance caused by construction activities may directly displace birds from foraging or loafing areas thus potentially affecting breeding productivity or survival rates of an individual or population. However, on several occasions during the construction of Lincs offshore wind farm gulls were clearly associated with the jack-up barge, the guard vessels and with the construction vessel while piling was in progress (RPS, 2012). Disturbance caused by construction activities either along the Hornsea Three offshore cable corridor or at the Hornsea Three array area (i.e. within the order limits for Hornsea Three) are considered to represent the maximum design scenario for relevant species as it is these areas that will be disproportionately affected by the presence of vessels and helicopters. The movements of vessels or helicopters to either the Hornsea Three array area or the Hornsea Three offshore cable corridor that occur within areas outside of the order limits for Hornsea Three is not considered to represent an effect larger than that that will occur at the Hornsea Three array area or along the Hornsea Three offshore cable corridor.

5.11.1.4 Although the port of origin for vessels has not yet been selected, any vessel movements are likely to occur along well-defined vessel routes, especially in areas closer to shore that may be occupied by sensitive species such as divers or seaduck. In addition, to this the sea area along the eastern coast of the UK is used extensively by vessels travelling to ports in the UK and further afield. As an example, shipping statistics for ports located in the Humber estuary, The Wash and along the northern coast of East Anglia show that in 2015 a total of 17,287 vessels arrived at these ports. If it is assumed that each vessel also leaves each port this would represent at least 34,574 vessel movements through the Greater Wash pSPA per annum. This total however, does not account for vessels that may travel through the Greater Wash travelling to ports located further away. There are predicted to be 10,474 vessel movements across the construction phase of Hornsea Three. Construction will occur over eight years and therefore there will be on average 1,347 additional vessel movements in the North Sea as a result of construction activities at Hornsea Three. This would represent a 3.9% increase on current traffic levels. It should be noted, however, that is likely to be a considerable over-estimate with many of these vessel movements likely to originate from ports outside of the UK and therefore will not affect sensitive VORs that have a more coastal distribution. In addition, vessel movements from ports to Hornsea Three are likely to follow to follow existing shipping routes with these areas not likely to support notable densities of species sensitive to disturbance. Similarly, helicopter movements to Hornsea Three will do so over areas already transited by other aircraft and vessels.

5.11.1.5 Disturbance associated with vessel/helicopter movements is of limited duration and also represents a transient impact as vessels/helicopters will move through an area quickly. Impacts are therefore spatially and temporally restricted and are considered unlikely to affect the breeding productivity or survival rates of an individual or population. It is therefore considered that additional vessel and helicopter movements to and from Hornsea Three will be indiscernible from baseline levels and that the relatively constant presence of vessels and helicopters at areas such as the Hornsea Three offshore cable corridor and the Hornsea Three array area will represent an impact of larger magnitude.

5.11.1.6 For each ornithological receptor, the increase in vibration and noise disturbance associated with human construction activities has been evaluated. This involves initially assessing the potential for displacement of mean peak densities within a particular extent around the disturbance source (e.g. piling activities) within Hornsea Three or along the cable route corridor, in the context of relevant regional, national, international or SPA populations due to construction activities.

5.11.1.7 In general, it is considered that effects are likely to last only for the duration of construction activity, and therefore will be direct, but temporary, reversible and short-term in nature for a specific event. The construction of offshore components of Hornsea Three will occur over a maximum duration of eight years, assuming a two phase construction scenario (Table 5.8). A gap of three years may occur between the same activity in different phases with the construction period considered of medium term duration. During the construction period, birds may return to areas when activities are not currently occurring. The largest impacts are likely to be due to irregular but intensive pile-driving activities which may cause extensive, intermittent noise and vibrations. Although effects of underwater noise associated with pile-driving activity are well known on cetaceans and fish (Madsen *et al.*, 2006), very little is known about the effects on seabirds.

5.11.1.8 The U.S. Department of the Interior (2004) concluded that noise from seismic studies might only impact those species that spend large quantities of time underwater. Bird species most likely to be vulnerable to underwater sound are those that forage by diving after fish or shellfish, and include auks, divers and seaduck. Gull and tern species feed at the surface only and are considered the least vulnerable.

5.11.1.9 Fulmar, gulls and skuas are opportunistic scavengers that like terns will forage within tens of metres of moving machinery, including vessels, and where feeding opportunities are recognised, close to humans when confident from experience to do so. On that basis together with consideration of their vulnerability to underwater noise, species therefore considered for this impact are common scoter, red-throated diver, gannet, guillemot, razorbill and puffin.

5.11.1.10 For the purposes of defining the conservation value of a VOR population for this assessment of Hornsea Three, a precautionary geographical extent of Hornsea Three offshore ornithology study area is used (Table 5.7). However it is recognised that smaller geographical scales are relevant (depending on an individual species vulnerability) within the assessment of displacement impacts (Natural England and JNCC, 2012). As previously mentioned (section 5.6.4.10), buffers taken forward to assessment of displacement impacts for Hornsea Three are the wind farm array area plus a 2 km buffer and the Hornsea Three offshore cable corridor plus a 2 km buffer (i.e. Hornsea Three offshore cable corridor) for all species.

Common scoter

<u>Magnitude of impact</u>

5.11.1.11 No common scoter were recorded in aerial surveys undertaken across Hornsea Three offshore ornithology study area and as such, only displacement impacts associated with construction activities along the Hornsea Three offshore cable corridor are considered. The absence of common scoter in offshore areas is also supported by the results presented in Stone *et al.* (1995) with high densities of common scoter in inshore areas.

5.11.1.12 In order to calculate the magnitude of impact associated with construction activities related to export cable installation survey data incorporated into Lawson *et al.* (2015) has been analysed in order to calculate the population of common scoter that may be affected. These surveys were undertaken during the wintering period (October to March) between 2002 and 2008 and covered the Greater Wash Area of Search, an area stretching from Bridlington Bay, East Yorkshire in the north and Great Yarmouth, Norfolk in the south, extending over 50 km offshore in some places (Figure 5.2).

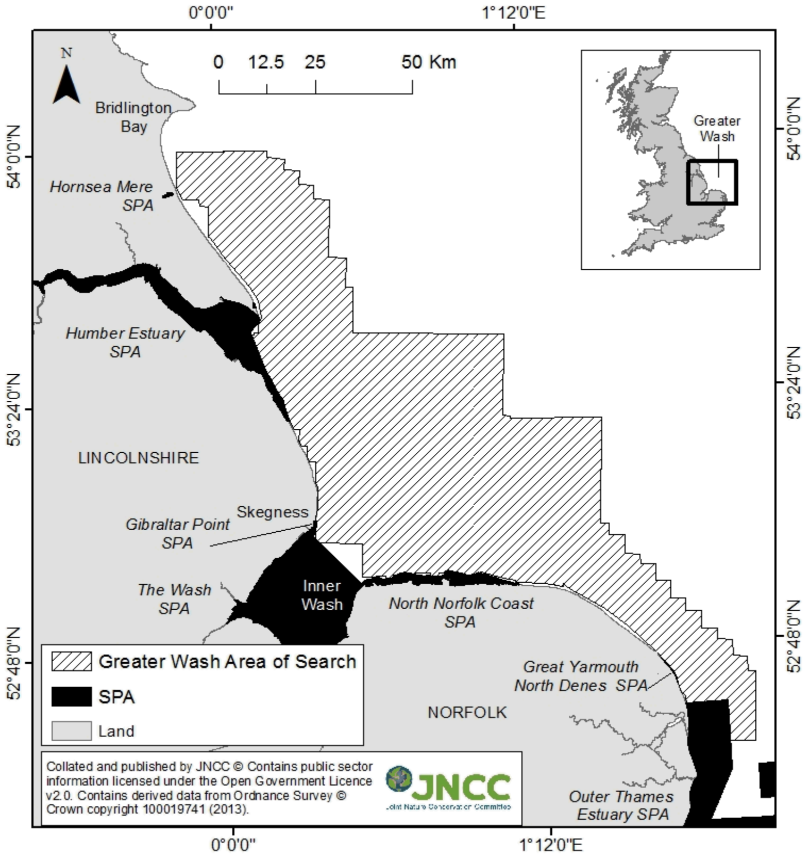

Figure 5.2: The Greater Wash Area of Search as defined in Lawson *et al.* (2015). (Source: Lawson *et al.*, 2015).

5.11.1.13 The main concentrations of common scoter in the Greater Wash Area of Search occur along the North Norfolk Coast and into The Wash, with densities of up to 56.6 birds/km^2 occurring in these areas (Figure 5.3). No common scoter were present along the export cable route with this derived by interrogating the underlying data supporting the density map presented in Figure 5.3.

5.11.1.14 The effects associated with export cable installation are expected to be highly localised as cable laying vessels are slow moving during the installation of cables. Furthermore, cable laying activity will be intermittent and therefore any displacement will be temporary and short term in nature. The level of noise associated with offshore cable installation activity is low when compared to activities such as piling with the presence of vessels the main cause of disturbance. The area of habitat disturbed due to vessel movements (see paragraph 3.11.1.42 of volume 2, chapter 3: Fish and Shellfish Ecology) is considered to be very small in the context of the distribution of common scoter (i.e. limited to the immediate vicinity of where works are being carried out) within the Greater Wash Area of Search. This also holds true when including the vessel activities associated with the potential offshore HVAC booster substations located along the cable route (within the offshore transformer substation search area). The cable route does not pass through areas that contain notable densities of common scoter no birds present in the export cable route temporary working area plus a 2 km buffer as derived from interrogating the underlying data supporting the density map presented in Figure 5.3.

5.11.1.15 Lawson *et al.* (2015) demonstrated that the distribution of common scoter in the Greater Wash Area of Search is limited and consistently restricted to specific areas. The Hornsea Three offshore cable corridor runs through the Greater Wash Area of Search making landfall at Weybourne on the North Norfolk coast, approximately 35 km east of the highest densities of common scoter which are located in the mouth of The Wash (Figure 5.3). It is worth noting that the Hornsea Three offshore cable corridor runs through an area of high vessel activity associated with vessels travelling adjacent to the north-east coast of Norfolk Figure 5.4. Shipping statistics for ports along the east coast of England between Berwick and Lowestoft indicate that in 2015 there were a total of 23,968 vessel arrivals into these ports, in addition there will many vessels moving through the Greater Wash Area of Search travelling towards ports in Scotland. The baseline therefore already represents an area of high disturbance thus further limiting the impact Project activity in this area will have.

5.11.1.16 It should be noted that installation of export cables will occur over a maximum duration of three years which may or may not be consecutive. The export cables could be installed in up to two phases, however, for this assessment the maximum design scenario is considered to be construction in two phases with a gap of three years between phases. Therefore the maximum duration over which export cables could be installed is eight years (Table 5.8). This is considered the maximum design scenario as a consequence of it being the scenario with the greatest gap between phases, two phases in this scenario and therefore the greatest temporal span disturbance events would occur. Other scenarios include the export cables being installed in one or two phases.

5.11.1.17 A worst-case of displacement is considered to be limited to the area around construction activities within the Hornsea Three offshore cable corridor that will be transitory in nature. Numbers affected will depend on the overlap of such activity with food resources at any particular time. It is however expected that considering the species distribution in the Greater Wash, no aggregations would be exposed to disturbance. It is considered that any disturbance would not affect foraging resources for common scoter and that there would therefore be no detectable consequences of the impact. Overall the impact is predicted to be of local spatial extent, medium term duration, intermittent and with high reversibility. It is predicted that the impact will affect the receptor directly. As less than one bird will be affected, the impact magnitude is therefore, considered to be of no change.

Sensitivity of the receptor

5.11.1.18 Common scoters are considered to be particularly vulnerable to disturbance from vessel traffic and are identified as one of the most sensitive species to disturbance (Wade *et al.*, 2016). Common scoters are known to aggregate in areas that have little shipping activity with the number of birds declining steeply with an increase in the level of shipping traffic (Kaiser *et al.*, 2002). The sensitivity to disturbance as defined by Wade *et al.* (2016) is based on the work by Kaiser *et al.* (2002), in particular the observations that common scoter flushed from a 35 m vessel at distances of 1000-2000 m for large flocks (26 observations) and <1000 m for smaller flocks (23 observations). Similar observations were also recorded by Schwemmer *et al.* (2011) with boats flushing birds over 1000 m distant.

5.11.1.19 Common scoter is deemed to be of very high vulnerability, moderate recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of the effect

5.11.1.20 Overall, the sensitivity of the receptor is considered to be high while the impact magnitude is deemed to be of no change. The effect will therefore, be of **negligible** significance, which is not significant in EIA terms.

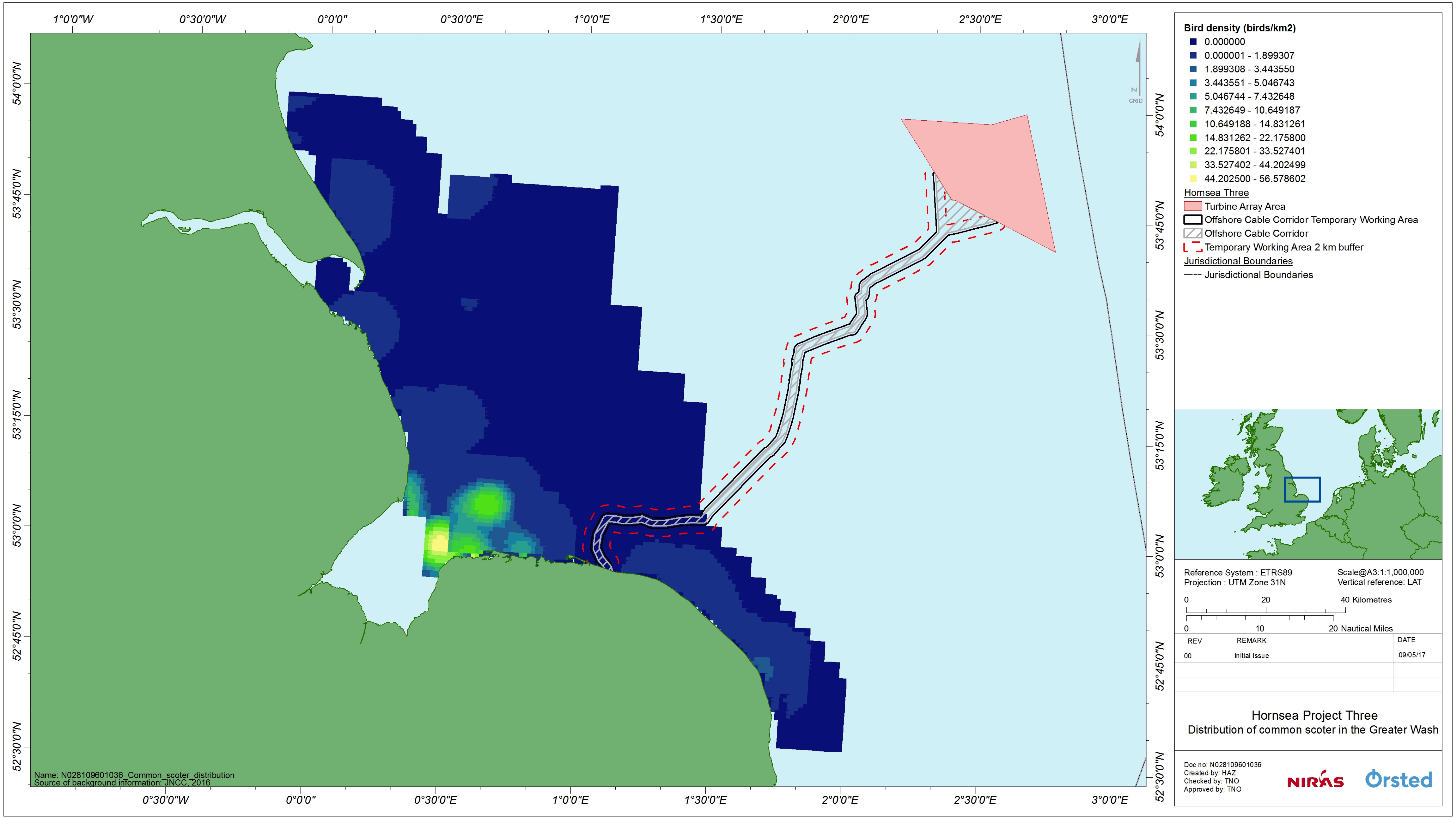

Figure 5.3: Distribution of common scoter in the Greater Wash.

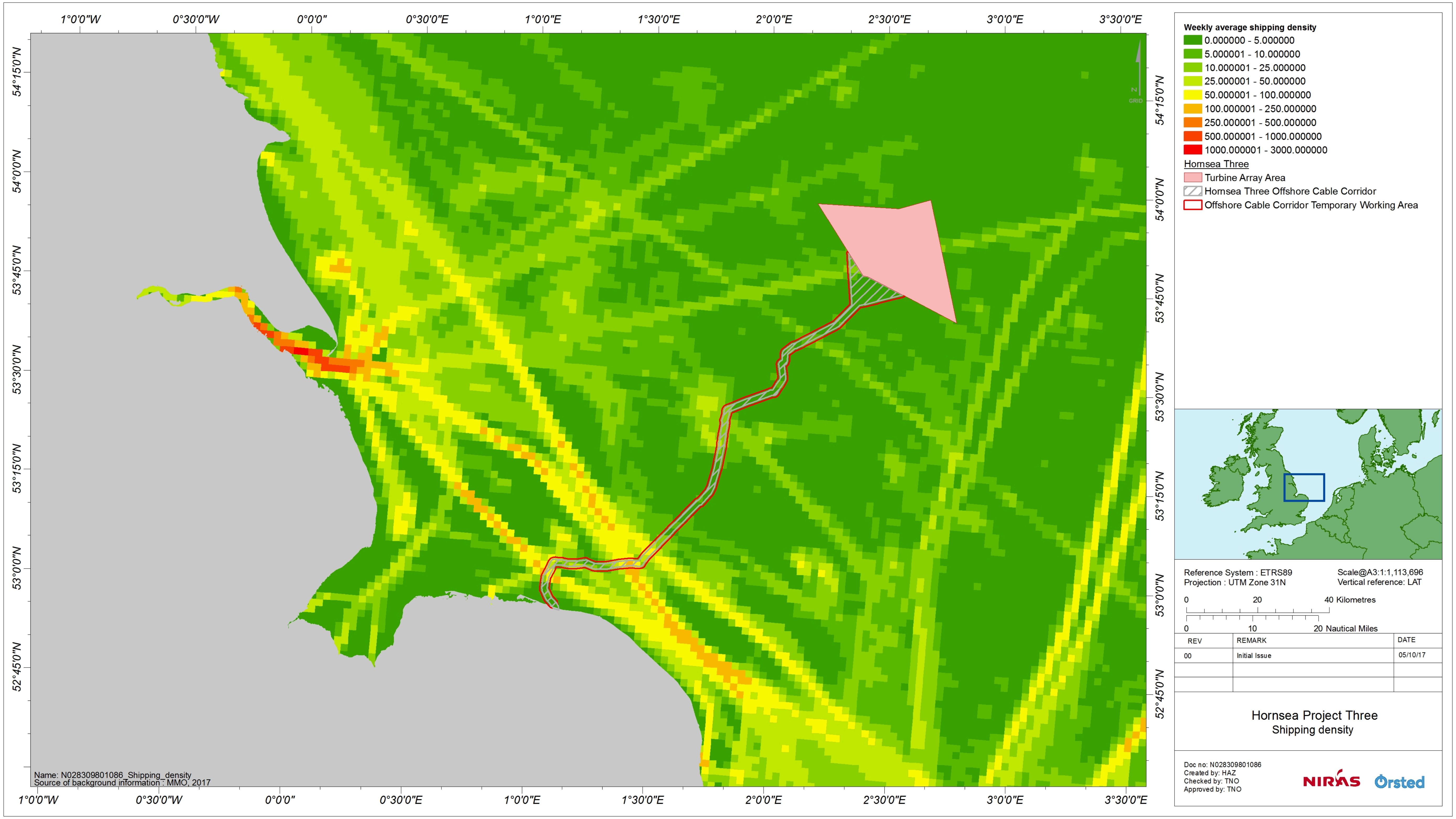

Figure 5.4: East coast weekly average vessel density 2015 (Source: MMO, 2017).

Red-throated diver

Magnitude of impact

5.11.1.21 As noted in in the assessment presented above for common scoter, the nature of cable laying activities (highly localised, slow moving vessel, low noise levels and limited spatial extent of impact) reduces the likelihood for impacts on red-throated diver.

5.11.1.22 The main concentrations of red-throated diver in the Greater Wash Area of Search are located off the north Norfolk coast and the Lincolnshire coast around Gibraltar Point, with densities of up to 3.38 birds/km^2 occurring in these areas (Figure 5.5). The Hornsea Three offshore cable corridor runs through an area of relatively low densities, when compared to densities elsewhere in the Greater Wash with densities of up to 0.46 birds/km^2 possible along the cable route (Figure 5.5).

5.11.1.23 The maximum area from which red-throated divers could be displaced due to construction activities associated with the Hornsea Three offshore cable corridor is defined as a 2 km buffer around each of the vessels directly involved in the installation of the export cable. This equates to an area of 113.1 km^2 (2 km buffer around nine vessels) which is considered to be precautionary as each vessel will not be located 2 km or more from other vessels and disturbance areas are expected to overlap.

5.11.1.24 In order to determine the potential impact on red-throated diver as a result of construction activities along the Hornsea Three offshore cable corridor, an estimate of the likely mean-peak population present is required (as recommended by JNCC *et al.,* 2017). The mean density surface presented in Figure 5.5 represents the average densities that would occur in each 1 km x 1 km square within the Greater Wash and if these values were to be used it could therefore be suggested that these would represent an under-estimate of the likely impact. In order to calculate a mean-peak population, the individual survey density surfaces that were used to calculate the mean density surface presented in Figure 5.5 were analysed to provide an average density for the Hornsea Three offshore cable corridor (represented by the temporary working area plus a 2 km buffer) for each individual survey. This was achieved by extracting and averaging all data that falls within the Hornsea Three offshore cable corridor temporary working area plus a 2 km buffer. Using data from each individual survey, the peak densities in each season were then identified and these then averaged to provide a mean-peak density.

5.11.1.25 The mean-peak density of red-throated diver within the Hornsea Three offshore cable corridor as calculated from individual survey density surfaces is 0.19 birds/km^2. If it is assumed that 100% of birds within the area in which construction activities will occur (113.1 km^2) are displaced, then using a bird density of 0.19 birds/km^2 it is predicted that 21 birds would be displaced during the installation of the export cable.

5.11.1.26 Following JNCC *et al.* (2017) interim guidance, a range of mortality rates have been applied to the displaced population of birds (Table 5.17). The regional population for red-throated diver is defined as the BDMPS population of red-throated diver that occurs in the south-west North Sea (10,177 birds) (Furness, 2015).

5.11.1.27 It should be noted that installation of export cables will occur over a maximum duration of three years which may or may not be consecutive. The export cables could be installed in up to two phases with a gap of three years between phases. Therefore the maximum duration over which export cables could be installed is eight years (Table 5.8). A worst-case of displacement is considered to be limited to the area around construction activities that will be transitory in nature within the Hornsea Three offshore cable corridor. Numbers affected will depend on the overlap of such activity with food resources at any particular time.

Table 5.17: Displacement mortality of red-throated diver along the Hornsea Three offshore cable corridor.

Magnitude of impact	Mortality rate (%)			
	1	2	5	10
Displacement mortality (no. of birds)	0.21	0.43	1.06	2.13
% of regional population	0.00	0.00	0.01	0.02
% increase in baseline mortality	0.01	0.03	0.07	0.13

5.11.1.28 The impact is predicted to be of local spatial extent, medium term duration, intermittent and with high reversibility. It is predicted that the impact will affect the receptor directly although a very small number of individuals would be affected representing a limited fraction of the regional population. The impact magnitude is therefore, considered to be of negligible.

Sensitivity of the receptor

5.11.1.29 Red-throated diver is considered to be a species with a very high vulnerability to vessel and helicopter disturbance (Wade *et al.*, 2016). Divers exhibit a degree of susceptibility to disturbance by flushing on approach by a vessel and the distance of displacement may be substantial (Ruddock and Whitfield, 2007).

5.11.1.30 Red-throated diver is deemed to be of very high vulnerability, moderate recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of the effect

5.11.1.31 Mortality rates associated with the disturbance of birds due to construction activities are unknown with no evidence that displacement by vessels will result in direct mortality of individual birds. Mortality as a consequence of displacement is more likely to occur as a result of increased densities outside of the impacted area, which may lead to increased competition for resources. Displacement of birds from low density areas (e.g. the area associated with the cable route) is less likely to result in mortality as these areas are likely to be of lower habitat quality. As such, the use of a 1% mortality rate is considered appropriate for this assessment.

5.11.1.32 Applying a 1% mortality rate results in a displacement mortality of less than one bird. This level of impact is considered to be of an insignificant magnitude in relation to the regional population of red-throated diver (10,177 birds). Such a low level of displacement mortality represents less than 0.01% of the regional population of red-throated diver and only a 0.01% increase in the baseline mortality (1,628 birds) of this population. It is therefore considered that activities associated with the installation of the export cable do not have the potential to cause an effect that would significantly impact red-throated diver.

5.11.1.33 Overall, the sensitivity of the receptor is considered to be high and the impact magnitude is deemed to be negligible. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Gannet

Magnitude of impact

5.11.1.34 As gannet is likely to be largely unaffected by disturbance, it is considered that the extent of any impact due to construction activities will extend no further than the close proximity around disturbance sources within Hornsea Three itself (i.e. within no more than 500 m, based on deflection distances of birds in flight around turbines recorded by Krijgsveld *et al.*, 2011).

5.11.1.35 The peak population estimate within Hornsea Three offshore ornithology study area occurred during the breeding period with the highest peak of 2,207 individuals occurring in August 2017. This corresponds to approximately 8.8% of the regional population (24,988 breeding adults). Hornsea Three array area with a 2 km buffer zone would then have a population of 1,738, which is equivalent to approximately 7.0% of the regional population.

5.11.1.36 Assuming even an unlikely worst-case of total displacement within Hornsea Three only, the impact is predicted to be of local spatial extent, medium term duration, intermittent, and with high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore considered to be low at a regional population scale.

Sensitivity of the receptor

5.11.1.37 Gannet is of international conservation value as the population at the FFC pSPA is within mean maximum foraging range of Hornsea Three. The species regional (which is identical to the pSPA population) and national populations are likely to be stable at least and so recoverability is rated medium, since productivity rates are low for this species.

5.11.1.38 In common with gulls and fulmar, gannet is likely to be largely unaffected by construction disturbance, being wide-ranging and seemingly tolerant of human activities at sea, with recent evidence showing that discards from fishing vessels form an important source of food for the species (Votier *et al.*, 2013). Indeed, Wade *et al.* (2016) consider gannet as being of very low vulnerability to displacement by vessels. As Wade *et al.* (2016) consider gannet as being of high vulnerability to displacement by structures, and construction does involve the building of structures at the start, for the purpose of this impact the species is deemed to be of low vulnerability to construction.

5.11.1.39 In summary, gannet is deemed to be of very low vulnerability (to e.g. construction vessels), high recoverability and international value. The sensitivity of the receptor is therefore, considered to be low.

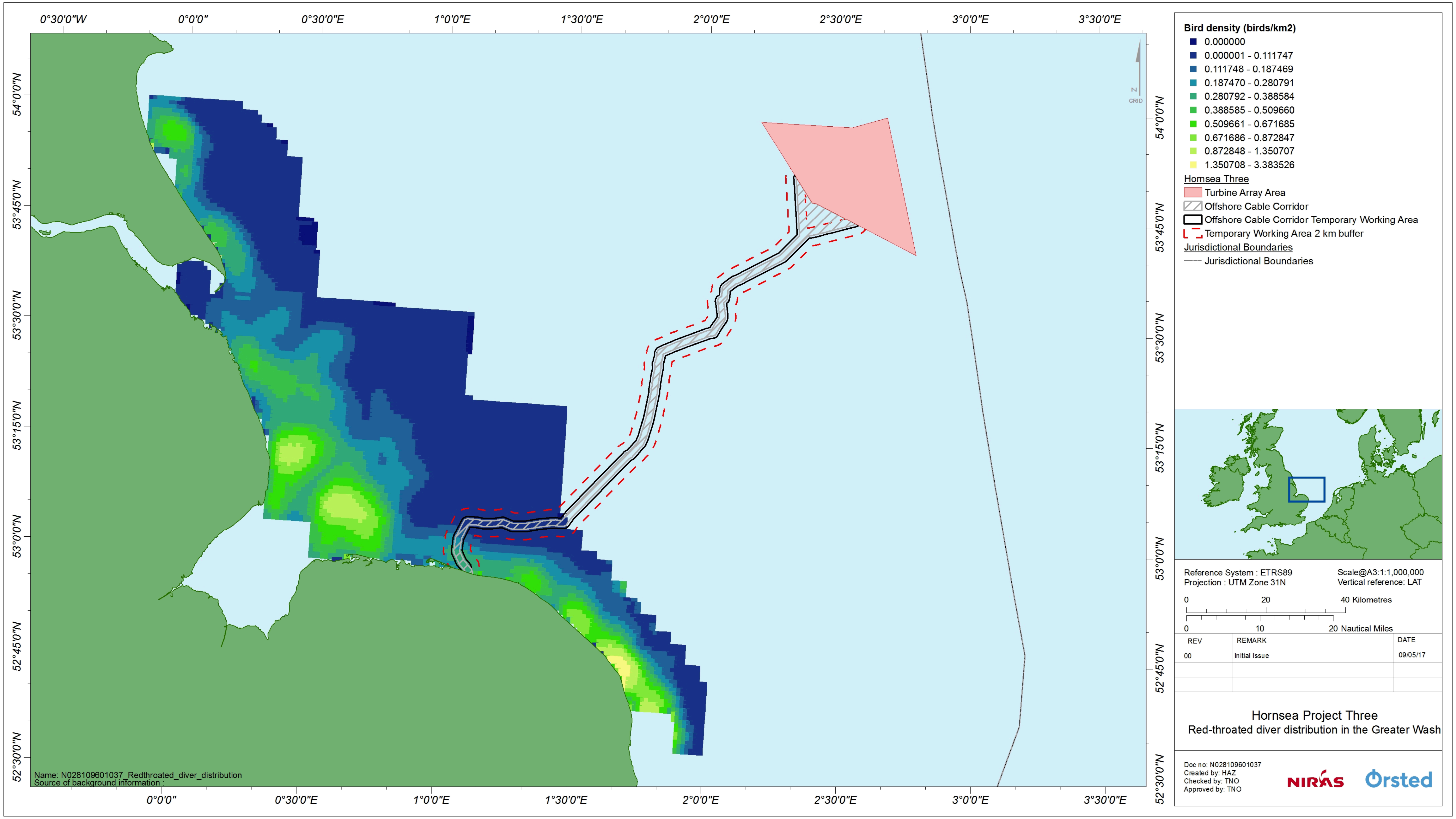

Figure 5.5: Red-throated diver distribution in the Greater Wash

Significance of the effect

5.11.1.40 Overall, the sensitivity of the receptor is considered to be low and the impact magnitude is deemed to be low. The effect will, therefore, be of **negligible** or **minor adverse** significance, which is not significant in EIA terms.

Puffin

Magnitude of impact

5.11.1.41 JNCC *et al.* (2017) recommend the use of a 2 km displacement buffer for auks. However, considering the limited spatial relevance of construction disturbance with construction slowly moving out across the project, it is considered very unlikely that all birds will be displaced within Hornsea Three array area plus 2 km buffer, even if construction activity is concurrent at two locations. Puffin, in common with other auk species, may continue to forage beyond a 1 km buffer from temporary construction activities but may still be located within Hornsea Three since construction activities will take place only within a small area of the site at any time. It should also be noted that no gradient of impact of displacement level is applied to the 2 km buffer zone following the guidance of JNCC *et al.* (2017), a precautionary approach that doesn't represent the reality of some degree of gradient on the closeness of approach by individual birds.

5.11.1.42 Cable installation may also disturb birds although this is generally considered to be of lower magnitude than foundation installation for example.

5.11.1.43 The highest population estimate of puffin in the Hornsea Three array area plus 2 km buffer was 288 birds in May 2016, in the breeding season. This is equivalent to 14.7% of the regional breeding population (1,960 birds). Outside of the breeding season, the abundance of puffin at Hornsea Three was generally relatively low amounting to below 50 birds in the Hornsea Three array area plus 2 km buffer in all surveys except the April 2016 survey.

5.11.1.44 A worst-case of total displacement within Hornsea Three array area plus 2 km buffer is considered very unlikely. Wernham *et al.* (2002) indicate that puffins rarely congregate away from colonies and so any disturbance impacts would only affect a small number of individuals at any particular time. In addition, even if birds are displaced, the medium-term nature of this, and the availability of alternative habitat mean that this would be unlikely to result in a significant decline in productivity or survival at a population level, especially due to the long lifespan of the species.

5.11.1.45 The impact is predicted to be of local spatial extent, medium term duration, intermittent and with high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Sensitivity of the receptor

5.11.1.46 As a potential qualifying species of the FFC pSPA, puffin is considered to be an ornithological receptor of international conservation value within the context of Project Three. The species is deemed to be of moderate vulnerability to displacement (Wade *et al.*, 2016), although in comparison to other auks, the period of moult is much later in the winter, and may occur in the pre-breeding period.

5.11.1.47 Although there are no recent national trends available, puffin has experienced an apparent large decline in regional numbers, and so has a low recoverability potential.

5.11.1.48 Puffin is deemed to be of moderate vulnerability, low recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium to high.

Significance of the effect

5.11.1.49 A disturbance impact of low magnitude on a medium to high sensitivity receptor such as puffin in the breeding season is predicted to produce (at worse case) a minor to moderate adverse effect on the regional population. For reasons outlined above (e.g. extensive availability of foraging habitat), this is considered to tend towards **minor adverse** which is not considered significant in EIA terms.

Razorbill

Magnitude of impact

5.11.1.50 Effects of construction disturbance on razorbill are currently unclear; however, during construction surveys at Lynn and Inner Dowsing there appeared to be no significant patterns of change in razorbill abundance between the wind farm and control sites (ECON, 2012).

5.11.1.51 Similar to puffin, it is considered that the extent of any disturbance due to construction activities is unlikely to extend to 2 km from source. Cable installation may also disturb birds although this is generally considered to be of lower magnitude than foundation installation for example.

5.11.1.52 The peak population estimates of razorbill within Hornsea Three occurred in the non-breeding period (November and December) with the highest monthly estimate of 4,382 razorbills occurring in November in the Hornsea Three array area plus 2 km buffer. Compared to the non-breeding regional population estimate (218,622 birds), the peak population at Hornsea Three array area plus 2 km buffer represents an equivalent of 2.0%. The peak population estimates of razorbill in the post-breeding season and pre-breeding seasons (466 and 1,442 individuals, respectively) are equivalent of 0.08% and 0.24% of the defined regional population (591,874 individuals.)

5.11.1.53 Total displacement of razorbill within Hornsea Three array area plus 2 km buffer (i.e. 100%) is considered to be very unlikely during the construction phase. The maximum design scenario for this assessment is more realistically assessed as displacement limited to the area around construction activities. The actual numbers of birds affected will depend on the location of food sources at a particular time, although the species is likely to be wide ranging once breeding ends (Cramp and Perrins, 1977 - 1994).

5.11.1.54 The impact is predicted to be of local spatial extent, medium term duration, intermittent and with low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low at a regional population scale during the post-breeding period.

Sensitivity of the receptor

5.11.1.55 Regionally important populations of razorbill occurred within the Hornsea Three offshore ornithology study area during the non-breeding season. Hornsea Three is located outside of mean maximum (and maximum) foraging range from FFC pSPA. Razorbill is considered to be a VOR of regional conservation value within the context of Project Three.

5.11.1.56 Due to its potential connectivity and concentration of breeding within a few colonies across the UK the species is considered to be of high vulnerability to displacement (Wade *et al.*, 2016), although it may be particularly sensitive during the post-breeding period during moult and when attending young. With a sizeable increase in national and regional populations over the last decade, but a low productivity rate, razorbill has medium recoverability potential.

5.11.1.57 Razorbill is deemed to be of high vulnerability, medium recoverability and regional value. The sensitivity of the receptor is therefore, considered to be low to medium.

Significance of the effect

5.11.1.58 A disturbance impact of low magnitude on a medium sensitivity receptor such as razorbill in the post-breeding season will produce a minor adverse effect on the regional population.

5.11.1.59 Although the sensitivity of razorbill may be high during the post-breeding period, and Hornsea Three may be of some importance to the species at this time, it is considered very unlikely that all birds will be displaced within Hornsea Three array area plus 2 km buffer, even if construction activity is concurrent at two locations. Razorbills are likely to continue to forage beyond the Hornsea Three boundary as a result of temporary construction activities and may also still be located within Hornsea Three. In addition, even if birds are displaced, the short-term nature of this and the availability of alternative habitat are unlikely to result in a significant decline in productivity or survival at a population level.

5.11.1.60 Overall, the sensitivity of the receptor is considered to be low to medium and the impact magnitude is deemed to be low. The effect will, therefore, be of **negligible to minor adverse** significance, which is not significant in EIA terms.

Guillemot

Magnitude of impact

5.11.1.61 Effects of construction disturbance on guillemots are currently unclear; during construction surveys at Lynn and Inner Dowsing there appeared to be no significant patterns of change in guillemot abundance between the wind farm and control sites (ECON, 2012). Leopold *et al.* (2010) found indications of disturbance to auks during some surveys at Egmond aan Zee, but numbers were too low to reach statistical significance.

5.11.1.62 Wade *et al.* (2016) report that auks may be disturbed by boats at several hundreds of metres distance although survey vessels have often approached to less than ten of metres before eliciting an evasion response, for example many birds are recorded within fifty metres during boat-based surveys at offshore wind farms.

5.11.1.63 Like the other auks, it is considered that the extent of any disturbance due to construction activities is unlikely to extend to 2 km from source. Cable installation may also disturb birds although this is generally considered to be of lower magnitude than foundation installation for example.

5.11.1.64 The peak population estimate within Hornsea Three array area plus 2 km buffer occurred during the non-breeding period (December) with notable peaks also occurring in June/July 2016 and July 2017 at the end of the breeding period. Birds may be particularly vulnerable at the end of the breeding period if they are undergoing moult and attending young and have restricted mobility. A mean peak breeding population of 13,374 birds was calculated in this period for Hornsea Three array area plus 2 km buffer. This is equivalent to around 0.7% of the national breeding population (1,900,000 individuals). A mean peak non-breeding population of 16,807 birds was calculated in this period for Hornsea Three array area plus 2 km buffer which is approximately 1.0% of the national breeding population of 1,617,306 individuals.

5.11.1.65 It is considered that disturbance of the guillemot population within Hornsea Three array area plus 2 km buffer is very unlikely, with any disturbance localised within an area around the source (e.g. turbine installation or cable laying) and up to a 1 km buffer. Numbers affected will depend on the overlap of such activity with food resources at any particular time.

5.11.1.66 The impact is predicted to be of local spatial extent, medium term duration, intermittent and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low at a regional population scale.

Sensitivity of the receptor

5.11.1.67 Guillemot is considered to be a VOR of national conservation value within the context of Hornsea Three. The species is considered to be of high vulnerability to displacement (Wade *et al.*, 2016), and may be particularly sensitive during the post-breeding period during moult and when attending young at sea.

5.11.1.68 There has been an increase in regional and national populations over the last decade (+40% and +4% respectively), although as a single egg layer and late first breeder (Table 5.12), guillemot is considered to have a medium recoverability potential. The sensitivity of this receptor to this impact is therefore considered to be medium.

5.11.1.69 Guillemot is deemed to be of high vulnerability, medium recoverability and national value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of the effect

5.11.1.70 Although the sensitivity of guillemots may be high at the end of the breeding period, and Hornsea Three being of some importance to the species at this time, it is considered very unlikely that all birds will be displaced within Hornsea Three array area plus 2 km buffer, even if construction activity is concurrent at two locations. Guillemots may continue to forage beyond a 1 km buffer from temporary construction activities but may still be located within Hornsea Three since construction activities will take place only within a small area of the site at any time. In addition, even if birds are displaced, the short-term nature of this and the availability of alternative habitat are unlikely to result in a significant decline in productivity or survival at a population level, with the wider previously defined former Hornsea Zone also being used consistently by guillemots (Smart Wind, 2015a).

5.11.1.71 Overall, it is predicted that the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Sandwich tern

Magnitude of impact

5.11.1.72 As noted in the assessment presented above for common scoter, the nature of cable laying activities (highly localised, slow moving vessel, low noise levels and limited spatial extent of impact) will also reduce the likelihood of impacts on Sandwich tern. It is considered that the extent of any impact due to construction activities will extend no further than the close proximity around disturbance sources associated with the Hornsea Three offshore cable corridor. Therefore, Sandwich tern is likely to be largely unaffected by disturbance.

5.11.1.73 The predicted usage of the Hornsea Three offshore cable corridor by Sandwich terns from the breeding colony at Blakeney Point is low with areas of higher usage located much closer to the colony (Figure 5.6). As such, it is considered that even if disturbance were to occur, it would affect a limited number of birds in an area that is of limited importance for foraging when compared to other areas. The majority of the foraging areas utilised by Sandwich terns from Blakeney Point, including those of highest utilisation, as identified by Wilson *et al.* (2014) will be unaffected by disturbance from activities associated with the Hornsea Three offshore cable corridor. The impact magnitude is therefore considered to be negligible at a regional population scale.

Sensitivity of the receptor

5.11.1.74 Sandwich tern is considered to be a species with a low sensitivity to vessel and helicopter disturbance (Wade *et al.*, 2016) with the species seemingly tolerant of human activities at sea. For example, tracking of foraging birds is conducted from boats which approach within 50-100 m (e.g. see Perrow *et al.,* 2010).

5.11.1.75 Sandwich tern is of international conservation value as the Hornsea Three offshore cable corridor passes through the Greater Wash pSPA for which the foraging areas of the species from breeding colonies that form part of the North Norfolk Coast SPA are proposed to be designated. In recent years the number of breeding pairs at Blakeney Point, the nearest breeding colony to the Hornsea Three offshore cable corridor, has declined from a peak of 4,120 pairs in 2013 to only 3 pairs in 2017. However, numbers at large colonies are known to vary considerably between years and when few birds nest at Blakeney Point, larger numbers may occur at nearby colonies with this having occurred at Scolt Head located further west on the Norfolk coast (550 pairs in 2013 increasing to 3,365 in 2016) (JNCC, 2017). In contrast to the trend at Blakeney Point, nationally the species has experienced a 13% increase in breeding numbers.

5.11.1.76 Sandwich tern is deemed to be of low vulnerability, moderate recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of the effect

5.11.1.77 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be negligible. The effect will, therefore, be of **negligible or minor adverse** significance, which is not significant in EIA terms.

Summary of disturbance/displacement due to construction activities

5.11.1.78 A summary of the impact of disturbance/displacement due to construction activity on each VOR is presented in Table 5.18. The significance of impacts ranges from negligible to minor adverse with no impacts considered to be significant in EIA terms.

Table 5.18: Summary of impacts of disturbance/displacement due to construction activity on each VOR.

VOR	Sensitivity	Magnitude	Significance
Common scoter	High	No change	Negligible
Red-throated diver	High	Negligible	Minor adverse
Gannet	Low	Low	Negligible or minor adverse
Puffin	Medium to high	Low	Minor adverse
Razorbill	Low to medium	Low	Negligible or minor adverse
Guillemot	Medium	Low	Minor adverse

VOR	Sensitivity	Magnitude	Significance
Sandwich tern	Medium	Negligible	Negligible or minor adverse

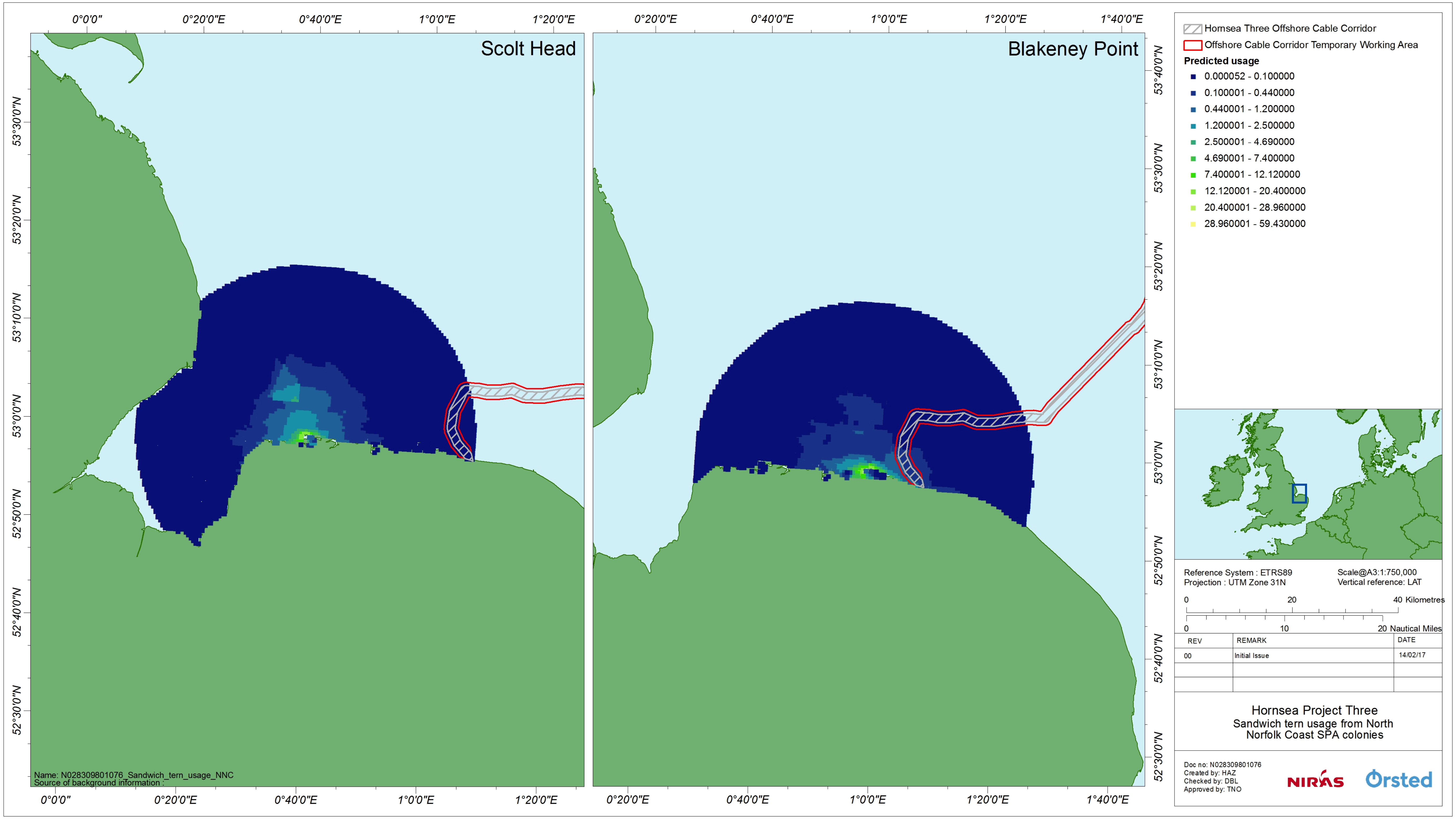

Figure 5.6: Predicted usage of offshore areas along the North Norfolk Coast by Sandwich terns from the breeding colonies at Scolt Head and Blakeney Point (data obtained from Natural England).

Indirect effects, such as changes in habitat or abundance and distribution of prey resulting in potential effect on seabirds

5.11.1.79 The indirect impacts on seabird prey resource and habitats are detailed in volume 2, chapter 2: Benthic Ecology and volume 2, chapter 3: Fish and Shellfish Ecology. Principal impacts on these resources and habitats are likely to be as a result of construction noise and physical disturbance experienced during foundation, particularly piling activities, and cable installation.

5.11.1.80 Detailed assessments of the following potential construction impacts have been undertaken in volume 2 chapter 3: Fish and Shellfish Ecology for key seabird prey species (including cod, sprat, herring, mackerel and sandeel species):

- Temporary habitat loss/disturbance from construction operations including foundation installation and cable laying operations;
- Increased suspended sediment concentrations as a result of foundation installation, cable installation and seabed preparation resulting in potential effects on fish and shellfish receptors;
- Sediment deposition as a result of foundation installation, cable installation and seabed preparation resulting in potential effects on fish and shellfish receptors; and
- Underwater noise as a result of foundation installation (i.e., piling) and other construction activities (e.g., cable installation) resulting in potential effects on fish and shellfish receptors

5.11.1.81 Details of the fish and shellfish ecology assessment are summarised in Table 5.19 justifications for this assessment will not be repeated in this chapter. Evidence, modelling and justifications for these assessments are provided in volume 2, chapter 3: Fish and Shellfish Ecology.

5.11.1.82 An assessment of the significance of indirect effects on sensitive receptors (i.e. those resulting from the influence of construction activity on prey species) was made on the basis of knowledge of the prey species targeted by each species, as well as their level of inflexibility of habitat use (Garthe and Hüppop, 2004; Wade *et al.*, 2016). The results of these analyses were evaluated against the indirect impacts on seabird prey resource and habitats as detailed in volume 2, chapter 2: Benthic Ecology and volume 2, chapter 3: Fish and Shellfish Ecology, prior information from operational wind farms and specific information from surveys at Hornsea Three.

5.11.1.83 Direct habitat loss may result in removal or fragmentation of foraging or loafing habitat for particular species. For wind farm developments, this long-term habitat loss is generally relatively small, amounting to the area lost to turbine bases and associated infrastructure; typically <1% of the total development footprint (Drewitt and Langston, 2006), although short-term habitat loss associated with construction processes (see Table 5.8) may be larger.

5.11.1.84 The VORs common scoter, red-throated diver, fulmar, gannet, Sandwich tern, kittiwake, lesser black-backed gull, great black-backed gull, puffin, razorbill and guillemot, are included in the assessment of habitat loss in the construction phase.

Table 5.19: Significance of effects of construction impacts on fish and shellfish ecology.

Potential impact	Species	Significance of effect
Habitat loss/ disturbance	Sandeel and herring	Minor
	All other fish and shellfish species	Minor
Increased suspended sediment concentrations	Sandeel and herring	Minor
	All other fish and shellfish species	Minor
Sediment deposition	Sandeel and herring	Minor
	All other fish and shellfish species	Minor
Underwater noise	Shellfish	Negligible
	Demersal finfish	Negligible
	Pelagic finfish	Negligible

Common scoter

Magnitude of impact

5.11.1.85 No common scoter were recorded in aerial surveys undertaken across the Hornsea Three offshore ornithology study area and as such, only indirect impacts on seabird prey resource and habitats associated with construction activities along the Hornsea Three offshore cable corridor are considered. The absence of common scoter in offshore areas is also supported by the results presented in Stone *et al.* (1995) with high densities of common scoter in inshore areas.

5.11.1.86 As presented above in paragraphs 5.11.1.15 and 5.11.1.17 the average density of common scoter within the Hornsea Three offshore cable corridor is significantly less than 0.01 birds/km^2. Even if it is assumed that the impact will occur simultaneously throughout the entire Hornsea Three offshore cable corridor (1,146 km^2) at the same time, this would affect a population of less than one bird.

5.11.1.87 It should be noted that installation of export cables will occur over a maximum duration of three years. The export cables could be installed in up to two phases with a gap of three years between phases. Therefore, the maximum duration over which export cables could be installed is eight years (Table 5.8). Numbers of common scoter affected will depend on the overlap of such activity with food resources at any particular time. Overall the impact is predicted to be of local spatial extent, medium term duration, intermittent and with high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be of no change.

Sensitivity of the receptor

5.11.1.88 Common scoters show limited flexibility in feeding habitats, being dependant on shallow feeding grounds with shellfish banks (Furness *et al.* 2013; Wade *et al.*, 2016). In consequence, the species is more likely to be adversely impacted by loss of habitat if construction activities take place within areas that they would otherwise use for foraging.

5.11.1.89 Common scoter is deemed to be of very high vulnerability, medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of the effect

5.11.1.90 Overall, the sensitivity of the receptor is considered to be high and the impact magnitude is deemed to be no change. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Red-throated diver

Magnitude of impact

5.11.1.91 Red-throated diver qualified as a VOR in this assessment for only the Hornsea Three offshore cable corridor. As noted in in the assessment presented above for common scoter, the nature of cable laying activities (highly localised, limited vessel movement, low noise levels and limited spatial extent of impact) reduces the likelihood for impacts on red-throated diver.

5.11.1.92 As presented above in paragraphs 5.11.1.25, the mean-peak density of red-throated diver within the Hornsea Three offshore cable corridor is 0.19 birds/km^2, as calculated from the underlying data supporting Lawson *et al.* (2015). If it is assumed that the impact will occur simultaneously throughout the entire Hornsea Three offshore cable corridor (1,146 km^2) at the same time, this would have the potential to impact 218 birds. However, it should be noted that export cable installation will be highly localised as cable laying vessels are slow moving during the installation of cables which will occur over a maximum duration of three years. The export cables could be installed in up to two phases with a gap of three years between phases. Therefore the maximum duration over which export cables could be installed is eight years (Table 5.8).

5.11.1.93 Numbers of red-throated diver affected will depend on the overlap of such activity with food resources at any particular time. Moreover the above mentioned spatial and temporal parameters of the cable installation together with the findings of chapter 3: Fish and Shellfish Ecology that the relevant significance of effects of construction impacts on prey species is no greater than minor, suggest any potential impact from construction being upon a much reduced number of red-throated diver than the 218 birds estimated in the entire Hornsea Three offshore cable corridor. This equally applies when also considering the construction activities associated with the potential offshore HVAC booster substations located along the cable route (within the offshore HVAC booster substation search area).

5.11.1.94 Overall the impact is predicted to be of local spatial extent, medium term duration, intermittent and with high reversibility. It is predicted that the impact will affect the receptor directly although a very small number of individuals would be affected representing a limited fraction of the regional population. The impact magnitude is therefore, considered to be of negligible.

Sensitivity of the receptor

5.11.1.95 Herring and sprat are amongst the most frequently recorded prey species of red-throated divers (Cramp & Simmons 1977 - 1994), although this species is considered to be an opportunistic feeder, taking a rather broad range of fish species (Guse *et al.,* 2009). The species however shows limited flexibility in feeding habitats, being dependant on shallow feeding grounds with shellfish banks (Furness *et al.* 2013; Wade *et al.*, 2016). In consequence, the species is amongst those more likely to be adversely impacted by loss of habitat if construction activities take place within areas that they would otherwise use for foraging.

5.11.1.96 Red-throated diver is deemed to be of very high vulnerability, medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of the effect

5.11.1.97 Overall, the sensitivity of the receptor is considered to be high and the impact magnitude is deemed to be negligible. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Sandwich tern

Magnitude of impact

5.11.1.98 Sandwich tern were only recorded in two of the aerial surveys undertaken across the Hornsea Three offshore ornithology study area with these records occurring in August and September, representing passage movements of birds through the Hornsea Three offshore ornithology study area . As such, these birds are not considered vulnerable to indirect impacts that may occur at the Hornsea Three array area. However, the Hornsea Three offshore cable corridor passes through potential foraging areas utilised by Sandwich tern from the Blakeney Point breeding colony that form part of the Greater Wash pSPA and as such indirect impacts on seabird prey resource and habitats associated with construction activities along the Hornsea Three offshore cable corridor are considered.

5.11.1.99 The predicted usage of the Hornsea Three offshore cable corridor by Sandwich tern is considered to be low (Figure 5.6) with the majority of foraging areas used by Sandwich terns from Blakeney Point, including those of high usage, unaffected by construction activities associated with the Hornsea Three offshore cable corridor.

5.11.1.100 Numbers of Sandwich tern affected will depend on the overlap of such activity with food resources at any particular time. Moreover the above mentioned spatial and temporal parameters of the cable installation together with the findings of chapter 3: Fish and Shellfish Ecology indicate that the relevant significance of effects of construction impacts on prey species is no greater than minor, suggesting any potential impact from construction affecting only a limited number of Sandwich terns. This equally applies when also considering the construction activities associated with the potential offshore HVAC booster substations located along the cable route (within the offshore HVAC booster substation search area).

5.11.1.101 Overall the impact is predicted to be of local spatial extent, medium term duration, intermittent and with high reversibility. It is predicted that the impact will affect the receptor directly although a very small number of individuals would be affected representing a limited fraction of the regional population. The impact magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

5.11.1.102 Sandwich tern is considered to have a moderate habitat use flexibility meaning that the species is, to some extent, able to respond to changes in habitat conditions (Wade *et al.,* 2016). Sandwich tern feed on small fish, including sandeel, herring and sprat (Cramp & Simmons 1977 - 1994).

5.11.1.103 Sandwich tern is of international conservation value as the Hornsea Three offshore cable corridor passes through the Greater Wash pSPA which is designated for foraging areas of Sandwich tern from breeding colonies that form part of the North Norfolk Coast SPA. The population trends of Sandwich tern at the colonies that form part of the North Norfolk Coast pSPA are discussed in paragraph 5.11.1.75.

5.11.1.104 Sandwich tern is deemed to be of moderate vulnerability, moderate recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of the effect

5.11.1.105 The significance of impacts on seabird prey resource and habitats from the effects of construction impacts, as detailed in volume 2, chapter 2: Benthic Ecology and volume 2, chapter 3: Fish and Shellfish Ecology (Table 5.19) are assessed at most as minor adverse, which is not significant in EIA terms.

5.11.1.106 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be negligible. The effect will, therefore, be of **negligible or minor adverse** significance, which is not significant in EIA terms.

Kittiwake

Magnitude of impact

5.11.1.107 In the maximum design scenario layout (Table 5.8), maximum long-term seabed habitat loss within Hornsea Three array area will be the total area of 300 turbine bases, plus other ancillary structures, and associated scour protection, to give a total temporary habitat loss of 35.9 km^2. The total area affected will constitute 5.2% of the total area of Hornsea Three array area (696 km^2). However the significance of impacts on seabird prey resource and habitats from the effects of construction impacts, as detailed in volume 2, chapter 2: Benthic Ecology and volume 2, chapter 3: Fish and Shellfish Ecology (Table 5.19) are assessed at most as minor adverse, which is not significant in EIA terms.

5.11.1.108 The impact on kittiwake is therefore predicted to be of local to regional spatial extent, medium to long term duration (cable route corridor versus turbine infrastructure), continuous and medium to high reversibility (long-term turbine infrastructure versus temporary loss from cable installation). It is predicted that the impact will affect the receptor both directly and indirectly. Kittiwakes feed on mobile prey species such as herring and sandeels, and therefore the impact magnitude of habitat loss is considered to be negligible at a national population scale.

Sensitivity of the receptor

5.11.1.109 The vulnerability of bird species to changes in habitat or abundance and distribution of prey depends on their foraging flexibility, in particular their specific habitat and dietary requirements. Wade *et al.* (2016) consider that kittiwake is of low sensitivity as birds forage across the continental shelf within the 200 m depth contour, and are extremely pelagic, particularly in winter months. This has been shown in recent studies by Fredericksen *et al.* (2012) for example, where birds range widely across the North Sea and Atlantic. Langston (2010) also rated the species as being of low vulnerability to habitat and prey interactions.

5.11.1.110 Kittiwake is an ornithological receptor of international conservation value within the context of Hornsea Three and has low recoverability potential due to regional and national declines. The sensitivity of the receptor to this impact is therefore considered to be low to medium, particularly during the winter period when numbers are augmented by continental birds and foraging will occur over a much wider area away from colonies.

Significance of the effect

5.11.1.111 Overall, the sensitivity of kittiwake is considered to be low to medium and the magnitude is deemed to be negligible. The effect will, therefore, be of a **negligible or minor adverse** effect on the regional population, which is not significant in EIA terms.

Auks

5.11.1.112 The auks (puffin, razorbill and guillemot) foraging behaviour and prey species are similar and therefore for the purposes of this assessment are considered together.

Magnitude of impact

5.11.1.113 Based on respective densities of guillemot and razorbill in comparison with the wider North Sea area, there is some evidence that Hornsea Three is of importance in at least a regional context during the non-breeding period (annex 5.1: Baseline Characterisation Report). Populations of guillemot and puffin were also found to be nationally or regionally important, respectively during the breeding season.

5.11.1.114 Auks may preferentially forage for sandeels, but they also obtain wide-ranging mobile prey species during this period. Whilst there may be intermittent displacement of prey from a region around the wind farm, there is no indication that the overall availability of prey for auk species will be reduced. It is expected that for those periods when auk peak abundance and construction activities coincide that auk species will redistribute themselves in relation to the availability of prey abundance. There is evidence that waters closer to the coast within the former Hornsea Zone are preferred in the breeding season at least (Smart Wind, 2015b), although the results of the aerial surveys undertaken across Hornsea Three plus a 4 km buffer do not appear to show any clear bias in the distribution of auk species.

5.11.1.115 The impact is predicted to be of local to regional spatial extent, medium to long term duration (cable route corridor versus turbine infrastructure), continuous and medium to high reversibility (long-term turbine infrastructure versus temporary loss from cable installation and piling activity). It is predicted that the impact will affect the receptor both directly and indirectly. The impact magnitude is therefore, considered to be negligible at a regional population scale (Table 5.7).

Sensitivity of the receptor

5.11.1.116 Auks feed mainly on sandeels, sprat and herring and typically forage offshore with inshore and pelagic feeding less common. Guillemot, razorbill and puffin were all classified as being of moderate vulnerability to habitat/prey interactions and therefore likely habitat loss by Wade *et al.* (2016).

5.11.1.117 Guillemot and razorbill are considered to be of national and regional conservation value respectively (Table 5.12). While puffin is of international conservation value within the context of Hornsea Three.

5.11.1.118 Whilst it appears that both national guillemot and regional razorbill populations have remained stable and even increased (signifying medium and high recoverability respectively for the species), the international puffin population appears to have significantly declined, indicating a low level of recoverability.

5.11.1.119 When considering the above factors, it is determined that the sensitivity of guillemot and razorbill is low to medium and for puffin it is medium to high.

Significance of the effect

5.11.1.120 Overall, the sensitivity of the receptor is considered to be low to medium or medium to high and the impact magnitude is deemed to be negligible. The effect will, therefore, be of **negligible** or **minor adverse,** or **minor adverse** significance, which are both not significant in EIA terms.

All other species

5.11.1.121 This assessment is considering the indirect impacts on seabird prey resource and habitats at Hornsea Three and therefore is of minimal importance to species actively migrating and briefly transiting Hornsea Three. In the absence of a pathway for effect for migrant seabirds, the VORs considered for this potential impact are those species using the Hornsea Three offshore ornithology study area and The Hornsea Three offshore cable corridor i.e. fulmar, gannet, puffin, razorbill, guillemot, kittiwake, lesser black-backed gull and great black-backed gull.

Magnitude of impact

5.11.1.122 The magnitude of changes in habitat or abundance and distribution of prey, will be negligible compared to overall foraging range for each species, the impact is predicted to be of local to regional spatial extent, medium to long term duration (cable route corridor versus turbine infrastructure), continuous and of medium to high reversibility. It is predicted that the impact will affect each receptor directly and indirectly. For all other ornithological receptors the impact magnitude is therefore considered to be negligible.

Sensitivity of the receptor

5.11.1.123 For other ornithological receptors, the vulnerability to habitat/prey interactions was considered by Wade *et al.* (2016) (where it is termed habitat flexibility in this reference) as being very low for fulmar, gannet, lesser black-backed gull and great black-backed gull. Conservation value ranged from regional (lesser black-backed gull), national (great black-backed gull) to international (fulmar and gannet) and all four species are rated as having low (fulmar), high (gannet) or medium recoverability.

5.11.1.124 As a result, the sensitivity to changes in habitat or abundance and distribution of prey is considered to be low for gannet, lesser black-backed gull and great black-backed gull, as well as fulmar which is unlikely to reach moderate sensitivity due to the wide-ranging nature of the species.

5.11.1.125 These VORs are deemed to be of very low vulnerability and regional to international value. The sensitivity of the receptors is therefore, considered to be at most medium.

Significance of the effect

5.11.1.126 Overall, the sensitivity of these receptors will be medium at most and the impact magnitude is deemed to be negligible. The effect will, therefore, be of **negligible or minor adverse** significance, which is not significant in EIA terms.

Summary of indirect effects during the construction phase

5.11.1.127 A summary of the indirect impacted by impacts of habitat loss the during construction phases on each VOR is presented in Table 5.20. The significance of impacts ranges from negligible to minor adverse with no impacts considered to be significant in EIA terms.

Table 5.20: Summary of impacts of indirect effects, such as changes in habitat or abundance and distribution of prey on each VOR.

VOR	Sensitivity	Magnitude	Significance
Common scoter	High	No change	Negligible
Red-throated diver	High	Negligible	Minor adverse
Fulmar	Medium	Negligible	Negligible or minor adverse
Gannet	Low	Negligible	Negligible or minor adverse
Kittiwake	Low to medium	Negligible	Negligible or minor adverse
Puffin	Medium to high	Negligible	Minor adverse
Razorbill	Low to medium	Negligible	Negligible or minor adverse
Guillemot	Low to medium	Negligible	Negligible or minor adverse
Sandwich tern	Medium	Negligible	Negligible or minor adverse
Lesser black-backed gull	Low	Negligible	Negligible or minor adverse
Great black-backed gull	Low	Negligible	Negligible or minor adverse

The impact of pollution including accidental spills and contaminant releases which may affect species' survival rates or foraging activity

5.11.1.128 During construction, support vessels and machinery present will contain a fuel supply and lubricants which, in the event of an incident such as a collision, may be released into the surrounding sea. A maximum design scenario has identified oil, synthetic compounds, heavy metal and hydrocarbon contamination resulting from offshore infrastructure installation, and a maximum of 10,474 vessel movements within the area of proposed development by construction vessels over the longest construction phase duration (i.e. a maximum duration of eight years, assuming a two phase construction scenario with a six year gap; Table 5.8).

5.11.1.129 The best available information indicates that the most frequently recorded spills from vessels offshore is associated with upsets in the bilge treatment systems and the losses are usually small. This type of partial inventory loss is likely to result in tens of litres being lost to the environment which is not considered to be significant at any level.

5.11.1.130 The worst-case spill from a single tank rupture in the large installation vessels would release diesel into the marine environment. This scenario is considered, however, to be very unlikely, particularly when mitigation measures are included, and so the assessment will take this likelihood into account when reaching levels of significance

5.11.1.131 Each turbine will contain components which require lubricants, coolant, diesel fuel and hydraulic oils in order to operate (Table 5.8). In addition, substations and accommodation platforms will require coolant, diesel fuel and hydraulic oils whilst there will also be a need for helicopter fuel to be stored across the wind farm. During the operation and maintenance phase, each turbine will undergo a routine service every year. As part of this process, hydraulic fluids, gearbox oils and lubricants will be replaced and solid consumables such as filters will be disposed of.

5.11.1.132 Although likelihood of occurrence and associated risks are low, seabirds utilising the environment in the vicinity of a pollution incident may be vulnerable to either direct mortality from oil coverage preventing flight for example, or indirectly via a reduction in ability to forage.

5.11.1.133 The magnitude of the impact is dependent on the nature of the pollution incident but the Strategic Environmental Assessment carried out by DECC (2011c) recognised that, "*renewable energy developments have a generally limited potential for accidental loss of containment of hydrocarbons and chemicals, due to the relatively small inventories contained on the installations (principally hydraulic, gearbox and other lubricating oils, depending on the type of installation)*". Any spill or leak within the offshore regions of the Hornsea Three site would be immediately diluted and rapidly dispersed. The historical frequency of pollution events in the southern North Sea is low considering the density of existing marine traffic in the area. In addition, a number of designed-in measures outlined in Table 5.16 (e.g. Project Environmental Management and Monitoring Plan (PEMMP) and the Code of Construction Practice (CoCP)) will significantly reduce the likelihood of an incident occurring in either the offshore or intertidal construction areas that would result in accidental pollution.

5.11.1.134 A quantitative oil vulnerability index of seabird species to surface pollution in the North Sea was developed by Williams *et al.* (1995), based on four factors. These factors were: (a) the proportion which was oiled of each species found dead (or moribund) on the shoreline, and the proportion of time spent on the surface of the sea by that species: (b) the size of the biogeographic population of the species: (c) the potential rate of recovery following a reduction in numbers for each species; and (d) the reliance on the marine environment by each species.

5.11.1.135 Although populations of some species may have changed since the date of this study, it is still considered to reflect the relative vulnerability of each species to a pollution incident, and so is used for each VOR considered here.

5.11.1.136 This assessment is considering the impact of pollution which may affect species' survival rates or foraging activity at Hornsea Three and therefore is of minimal importance to species actively migrating when only briefly transiting Hornsea Three. In the absence of a pathway for effect for migrant seabirds, the VORs considered for this potential impact are those species using the Hornsea Three offshore ornithology study area and The Hornsea Three offshore cable corridor i.e. common scoter, red-throated diver, fulmar, gannet, puffin, razorbill, guillemot, Sandwich tern, kittiwake, lesser black-backed gull and great black-backed gull.

All receptors

Magnitude of impact

5.11.1.137 The magnitude of any incident is difficult to determine due to the unpredictability of such events, as well as the influence of seasonality and conditions.

5.11.1.138 Any impact on receptors within Hornsea Three is therefore considered likely to be of similar magnitude to those outlined in the effects of construction disturbance section, where appropriate. In the example case of guillemot, the highest estimated peaks occur in the non-breeding season. If the peak guillemot population within Hornsea Three array area plus 2 km buffer were affected due to an incident, this would result in the redistribution and/or direct mortality of up to 16,655 birds in the non-breeding period, which represents 1.03% of the regional non-breeding population (1,617,306 individuals). A smaller peak was predicted in the breeding season (15,017 birds), which represents 0.79% of the national breeding population (1,900,000 individuals).

5.11.1.139 With a number of designed-in measures as outlined in Table 5.16 implemented in full i.e. PEMMP and CoCP, complete mortality within the equivalent extent of the Hornsea Three array area plus 2 km buffer is considered very unlikely to occur, and a major incident that may impact any species at a population level is considered very unlikely. Given the likely size of potential pollution incidents (based on the volumes of any chemicals carried by one vessel) and the designed-in measures, the impact is therefore predicted to be of local spatial extent, short term duration, intermittent and high reversibility within the context of the regional populations. It is predicted that the impact will affect the receptor both directly and indirectly. The impact magnitude is therefore, considered to be **no change** at a regional population scale (Table 5.7), for all species.

Sensitivity of the receptor

5.11.1.140 The vulnerability of species to accidental spills and pollution incidents depends on their habitat flexibility in addition to their foraging behaviour and dietary requirements.

5.11.1.141 For surface feeders (as in fulmar and all gulls) direct mortality is considered to be of lower likelihood than for other species, and birds are able to forage widely to find alternative resources. In their assessment of seabird vulnerability to surface pollutants, Williams *et al.* (1995) considered fulmar to be of low vulnerability and therefore **low** sensitivity, ranking it 28th out of 37 seabird species. As surface feeders the sensitivity of lesser black-backed gull and great black-backed gull is also considered to be low.

5.11.1.142 Diving species that are also found for long periods on the sea surface (particularly during moult periods as in auks) are more likely to be affected. Guillemot survival rates on Skomer were negatively affected by the occurrence of major oil spills on their wintering grounds (JNCC, 2013). Williams *et al.* (1995) ranked the species as being medium to high vulnerability and therefore sensitivity, coming 14th out of 37 seabird species.

5.11.1.143 Gannet and Sandwich tern are diving species, and so are considered to be relatively vulnerable to pollution incidents by Williams *et al.* (1995), being ranked 13th and 22nd out of 37 seabird species. Gannet is therefore considered to be of medium to high vulnerability with Sandwich tern of medium vulnerability.

Significance of the effect

5.11.1.144 Based on an impact of whose magnitude for all receptors is no change, irrespective of the sensitivity of the receptor, a **negligible** effect on the regional population is predicted which is not significant in EIA terms.

Summary of accidental pollution events

5.11.1.145 A summary of pollution impacts on each VOR is presented in Table 5.21. Impacts of negligible significance are predicted for all VORs with this not considered to be significant in EIA terms.

Future monitoring

5.11.1.146 The proposed approach to monitoring for offshore ornithology is discussed in the In Principle Monitoring Plan. An Ornithological Monitoring Plan will be produced which will identify the monitoring objectives for key ornithological receptors that will be associated with the assumptions made within assessments potentially relating to flight heights, demographics and proportion of SPA breeding birds at Hornsea Three, foraging ranges, avoidance rates and consequences of displacement.

Table 5.21: Summary of impacts of pollution including accidental spills and contaminant releases associated with rigs and supply/service vessels which may affect species' survival rates or foraging activity.

VOR	Sensitivity	Magnitude	Significance
Common scoter	Medium to high	No change	Negligible
Red-throated diver	Medium to high	No change	Negligible
Fulmar	Low	No change	Negligible
Gannet	Medium to high	No change	Negligible
Puffin	Medium to high	No change	Negligible
Razorbill	Medium to high	No change	Negligible
Guillemot	Medium to high	No change	Negligible
Kittiwake	Low to medium	No change	Negligible
Sandwich tern	Medium	No change	Negligible
Lesser black-backed gull	Low	No change	Negligible
Great black-backed gull	Low	No change	Negligible

5.11.2 Operational and maintenance phase

5.11.2.1 The impacts of the offshore operation and maintenance of Hornsea Three have been assessed on offshore ornithology. The environmental impacts arising from the operation and maintenance of Hornsea Three are listed in Table 5.8 along with the maximum design scenario against which each operation and maintenance phase impact has been assessed.

5.11.2.2 A description of the potential effect on VORs caused by each identified impact is given below.

The impact of physical displacement from the Hornsea Three array area during the operational and maintenance phase of the development may result in effective habitat loss and reduction in survival or fitness rates of seabirds.

5.11.2.3 The displacement effects attributable to wind farms are considered to be highly variable and are species, season, and site-specific. As displacement effectively leads to exclusion from areas of suitable habitat, it can be regarded as being similar to habitat loss in its effect on birds, although it may be more spatially extensive.

5.11.2.4 The biological consequences of such displacement and any resultant population-level effects will depend on the importance of the area from which birds are displaced and the capacity of alternative habitats to support these displaced birds. Migratory species are unlikely to find the area particularly important unless it is recognised as an important staging area, whereas impacts may be more acutely felt if a loss of prime foraging habitat for a breeding colony results.

5.11.2.5 The period of time and constancy that individuals within a population may be subject to displacement impacts is uncertain. It is likely that the impacts will be felt at greatest intensity during the first year of exposure, before there is any opportunity for habituation. Mortality is likely to be greatest in this year while in subsequent years it is possible that birds may become habituated to a certain extent, thereby reducing mortality rates. However, if the population has a large number of non-breeding 'floaters' then mortality rates may stay at similar levels for a number of years until this pool is used up.

5.11.2.6 If this is the case then absolute mortality may be lower in subsequent years because the population reaches an equilibrium as the result of previous loss of habitat available for foraging. In the long-term the impact is potentially more likely to result in a decrease in productivity rather than an additive annual mortality that has been predicted here, and so these predicted values of annual mortality should not be summed to make total mortality across the lifespan of Hornsea Three.

5.11.2.7 Disturbance by operating wind turbines can exclude birds from suitable breeding, roosting, and feeding habitats around a larger area than otherwise would occur through direct habitat loss (Exo *et al.*, 2003; Petersen *et al.*, 2006; Maclean *et al.*, 2009). Although some species show little avoidance, others such as divers, auks and pelagic birds may not fly or forage within hundreds of metres of the turbines (Kerlinger and Curry, 2002).

5.11.2.8 Comparatively, some gull species, cormorant and terns have generally shown little avoidance to wind farms and for instance were seen regularly foraging within the Egmond aan Zee offshore wind farm (Krijgsveld *et al.*, 2010; 2011).

5.11.2.9 A study at Tuno Knob, in Denmark, reported effects on nocturnal flights of eiders out to 1,500 m from turbines (Tulp *et al.*, 1999). Conversely, other studies at operational wind farms have not observed significant effects on the abundance or distribution of local seabirds (Leopold *et al.*, 2010; Barrow Offshore Wind Ltd., 2009). With the exception of red-throated diver, monitoring at Kentish Flats also reported no avoidance behaviour (Percival, 2009; 2010). It has been postulated that other natural environmental variables were the driver for any observed effects, as well as the influence of fishing vessels on some species (particularly gulls) (e.g. Leopold *et al.*, 2011).

5.11.2.10 In general, migrants appear to be more obviously displaced than local resident birds, likely due to the lack of habituation of birds passing briefly through the area (Petersen *et al.*, 2004; Petersen, 2005). Habituation is likely to occur for some species once turbines are operational and human activity is reduced. A study conducted at Blyth Harbour in Northumberland showed that eiders and other birds did habituate to the turbines so that impacts were not considered significant (Lowther, 2000). Seaducks initially avoided the Horns Rev Offshore Wind Farm, but later assembled between turbines, possibly after successful recruitment of benthic prey (Petersen and Fox, 2007).

5.11.2.11 Significant degrees of precaution are built into the assessment of displacement effects. During discussions with JNCC and Natural England, and based on JNCC *et al.* (2017) interim guidance it was agreed that in order to assess the displacement effect the current assessment uses the mean peak number of birds recorded within Hornsea Three (plus an appropriate buffer) during appropriate seasons defined for each VOR. The mean peak number (i.e. the mean of the highest population estimates within a particular season, which do not necessarily occur within the same month each year) is considered sufficiently precautionary for the realistic worst-case. It is considered likely that displacement responses by seabirds are highly likely to decline the further distant from the disturbance source. A notable example of this was recorded for red-throated divers at Kentish Flats Offshore Wind Farm (Percival, 2010). However, in general, species specific information is lacking on geographically defined displacement rates and therefore on a precautionary basis a consistent displacement rate is applied through Hornsea Three array area plus 2 km buffer. This therefore means that assessments of displacement effects are associated with a significant degree of in-built precaution.

5.11.2.12 Within this assessment of operational displacement, VORs considered are fulmar, gannet, guillemot, razorbill and puffin. Full displacement matrices for each biological season are presented in annex 5.2: Analysis of Displacement Impacts on Seabirds. Buffers taken forward to impact assessment for Hornsea Three are the wind farm plus a 2 km buffer for all species (see section 5.9.2). Section 5.6.4.10 presents proposed rates for displacement and mortality for VORs which form the focus of this assessment.

Fulmar

Magnitude of impact

5.11.2.13 Fulmar has undergone one of the most dramatic expansions in range and population of any UK breeding seabird in recent years (Brown and Grice, 2005; Forrester *et al.*, 2007). Fulmars feed on a wide diversity of food including planktonic crustacean, cephalopods and small fish (Cramp and Perrins, 1977).

5.11.2.14 Fulmar have an extensive foraging range with Hornsea Three only representing a small percentage of the available foraging area, as defined by the mean-maximum foraging range of 400 km from their breeding colonies (Thaxter *et al.*, 2012). They are a highly pelagic seabird and foraging trips can last up to 30 hours (Furness and Todd, 1984).

5.11.2.15 The displacement rate range considered appropriate for fulmar is 10-30% across all seasons. The mortality rate considered appropriate for fulmar in the breeding season is 2% with a 1% applied in all other seasons (see section 5.9.2).

Breeding season

5.11.2.16 The mean peak fulmar population estimate calculated for Hornsea Three array area plus 2 km buffer during the breeding season (April to August) was 1,423 birds. Based on a mortality rate of 2% (due to the large foraging range of the species providing sufficient alternative foraging opportunities) and a displacement rate range of 10-30%, between three and nine individuals may be lost as a result of displacement (Table 1.5 of annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.17 This predicted level of mortality represents a 0.4-1.2% increase in the baseline mortality of the regional breeding population (baseline mortality = 752 individuals) however, the regional breeding population defined for fulmar is composed of breeding adults only whereas in reality there are likely to be immature and non-breeding birds present in the North Sea during the breeding season. The impact of displacement on fulmar during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Post-breeding season

5.11.2.18 During the post-breeding season (September to October) the mean peak population estimate calculated for the Hornsea Three array area plus 2 km buffer was 977 birds. Based on a displacement rate range of 10-30% and a mortality rate of 1% (due to the larger distributional range of the species during this season providing sufficient alternative foraging opportunities), between one and three individuals may be lost as a result of displacement. This predicted low level of mortality does not surpass 1% of baseline mortality of the regional post-breeding population (1% of baseline mortality = 613 individuals) (Table 1.6 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.19 The impact of displacement on fulmar during the post-breeding season is predicted to be of local spatial extent, long term duration, continuous and of high reversibility involving only a small number of individual birds representing a limited proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Non-breeding season

5.11.2.20 During the non-breeding season (November) the mean peak population estimate calculated for the Hornsea Three array area plus 2 km buffer was 352 individual fulmar. Based on a displacement rate range of 10-30% and a mortality rate of 1% (due to the very large distributional range of the species providing sufficient alternative foraging opportunities), up to one individual may be lost as a result of displacement. This predicted level of mortality does not surpass 1% of baseline mortality of the regional non-breeding population (1% of baseline mortality = 364 individuals) (Table 1.7 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.21 The impact of displacement on fulmar during the non-breeding season is predicted to be of local spatial extent, long term duration, continuous and of high reversibility involving only a small number of individual birds representing a limited proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Pre-breeding season

5.11.2.22 The mean peak population estimate of fulmar calculated for the Hornsea Three array area plus a 2 km buffer in the pre-breeding season (December to March) was 525 birds in the Hornsea Three array area and 2 km buffer. Based on a displacement rate range of 10-30% and a mortality rate of 1% (again based on the larger distributional range of the species providing foraging opportunities), between one to two individuals may be lost as a result of displacement. This predicted level of mortality does not surpass 1% of baseline mortality of the regional pre-breeding population (1% of baseline mortality = 613 individuals) (Table 1.8 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.23 The impact of displacement on fulmar during the pre-breeding season is predicted to be of local spatial extent, long term duration, continuous and of high reversibility involving only a small number of individual birds representing a limited proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

<u>Sensitivity of the receptor</u>

Fulmar is considered to be of international conservation value as a result of Hornsea Three being in mean maximum foraging range of FFC pSPA, Coquet Island pSPA, Farne Islands pSPA and Forth Islands SPA. With a regional and national population trend likely to be relatively stable, but with low productivity rate, the species' recoverability is considered to be low. Behaviourally, fulmar was considered to be of very low vulnerability to displacement by Wade *et al.* (2016). In summary, fulmar is deemed to be of very low vulnerability, low recoverability and international value. The sensitivity of the VOR is therefore, considered to be medium.

<u>Significance of the effect</u>

5.11.2.24 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be negligible - low. The effect will, therefore, be of **negligible – minor adverse** significance, which is not significant in EIA terms.

Gannet

<u>Magnitude of impact</u>

5.11.2.25 The displacement rate range considered appropriate for gannet is 30-70% across all seasons. The mortality rate considered appropriate for gannet in the breeding season is 2% with 1% applied in all other seasons (see section 5.9.2).

5.11.2.26 In each of the three years 2010-2012, adult gannets from Bempton Cliffs, a component of the pSPA, were fitted with satellite tags by RSPB to investigate their foraging ranges during chick-rearing and early post-breeding periods. This was undertaken in order to establish whether there was overlap with any proposed Round 3 Zones (Langston *et al.,* 2013). The study had the following objectives: to determine foraging ranges, flight directions, and foraging destinations of adult gannets from the breeding colony at Bempton Cliffs; to determine whether adult gannets from Bempton Cliffs forage within or pass through, on their way to foraging locations, the Round 3 zones of Dogger Bank, Hornsea and East Anglia; and to seek to obtain a measure of relative importance of the sea areas used.

5.11.2.27 The three seasons of study, in 2010 (n=14 birds), 2011 (n=13) and 2012 (n=15), showed tagged birds during the breeding season to coincide with the western half of the former Hornsea Zone in particular (with only occasional records from the Hornsea Three area), and some birds recorded on Dogger Bank and a few records in the East Anglia Zone, as well as within the Greater Wash strategic area. Post-breeding locations overlapped with the Hornsea, Dogger Bank, and East Anglia zones before dispersal out of the North Sea or cessation of recording. The tags remained on the birds for between 6 to 132 days, which enabled tracking of the longest functioning tag to north-west Africa during autumn 2012.

5.11.2.28 The overall distribution of foraging locations during chick-rearing was broadly similar in all three years, although at higher density further out to sea in 2012 (Figure 5.7) (this is potentially in response to the poorer climatic conditions affecting prey during the 2012 breeding season). Most locations were within 200 km of Bempton Cliffs, with the highest density of locations mostly within 50-100 km. The mean foraging range was less than 50 km (maximum foraging range was within approximately 300-400 km), whilst the average foraging trip length was less than 150 km (maximum trip length ranged from approximately 1,200 - 1,700 km). Foraging trip duration was highly variable, on average lasting approximately eight hours.

5.11.2.29 It is evident from Figure 5.7 and the annual reports (Langston *et al.*, 2013) that the operational footprint of Hornsea Three may provide disturbance to a limited extent to foraging gannets from the pSPA. The distance of Hornsea Three from the colony is, however, well above the mean foraging range measured by Langston *et al.* (2013), and so it is unlikely that it forms a notably important area for breeding gannet in comparison with waters closer to the colony.

5.11.2.30 The tracking data presented by Langston *et al.* (2013) suggest that the Hornsea Three area does not represent an important foraging area for gannets from FFC pSPA which may form part of the population present at Hornsea Three. It also shows that gannet have an extensive foraging range with the 95% density contour on maps in Figure 5.7 representing on average nearly 17,200 km^2. The Hornsea Three array area is 696 km^2 and therefore, if it was located completely within the 95% density contour would represent only 4% of the area covered by the 95% density contour. As such, it is considered that the large foraging range of gannets offers sufficient alternative foraging opportunities and therefore a 2% mortality rate is considered appropriate in the breeding season. In non-breeding seasons, gannet are not constrained to breeding colonies as they will not be provisioning young and as such are able to exploit foraging opportunities over an even larger area. As such, a mortality rate of 1% is considered appropriate for all non-breeding seasons.

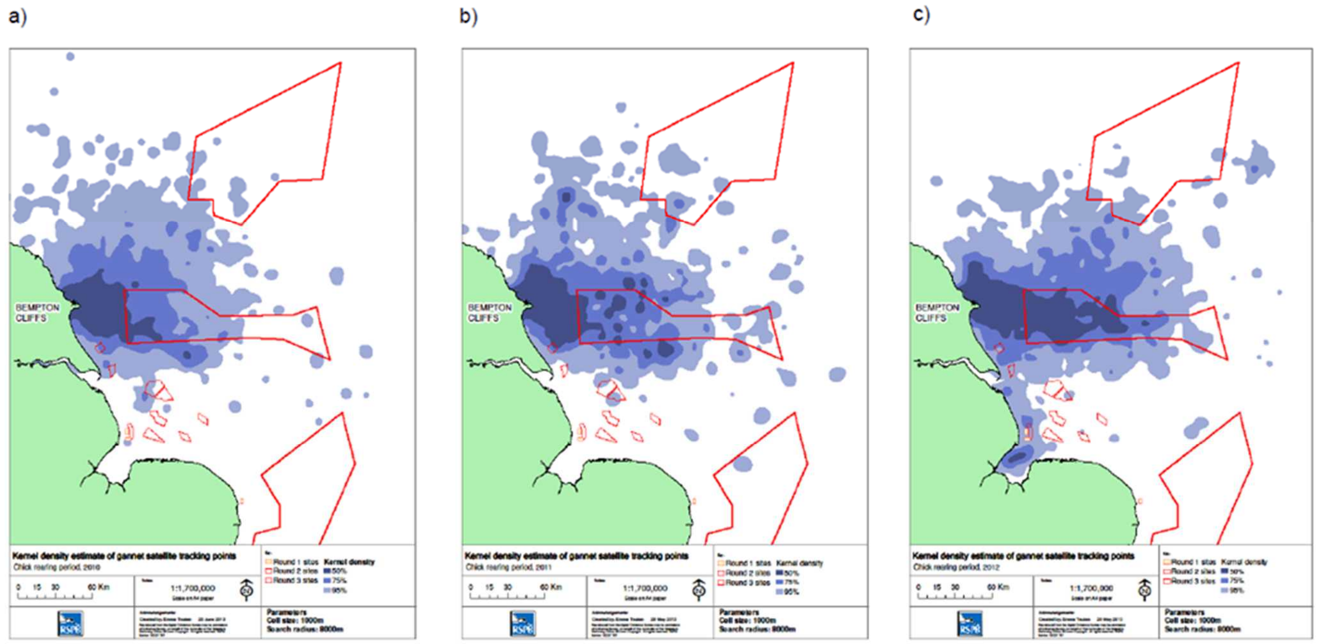

Figure 5.7: Gannet foraging Kernel Density Estimation (kernel density tool, ArcGIS Desktop 10) from satellite-tagged birds from Bempton Cliffs breeding colony in 2010 (left), 2011 (middle) and 2012 (right) during the chick-rearing period, showing the 50%, 75% and 95% density contours. From Langston *et al.* (2013).

Breeding season

5.11.2.31 The mean peak gannet population estimate calculated for the Hornsea Three array area plus 2 km buffer during the breeding season (April to August) was 1,333 birds.

5.11.2.32 Based on a displacement rate range of 30-70% and a mortality rate of 2% (due to the large foraging range of the species providing sufficient alternative foraging opportunities), 8-19 individuals may be lost as a result of displacement (Table 1.9 in annex 5.2: Analysis of Displacement Impacts on Seabirds). This predicted level of mortality does not surpass 1% of baseline mortality of the regional breeding population (1% of baseline mortality = 20 individuals).

5.11.2.33 The impact of displacement on gannet during the breeding season is predicted to be of local spatial extent, long term duration, continuous and of low to medium reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Post-breeding season

5.11.2.34 During the post-breeding season (September to November) the mean peak population estimate calculated for the Hornsea Three array area plus 2 km buffer was 984 individual gannet. Based on a displacement rate range of 30-70% and a mortality rate of 1% (due to the very large distributional range of the species providing sufficient alternative foraging opportunities), three to seven individuals may be lost as a result of displacement (Table 1.10 in annex 5.2: Analysis of Displacement Impacts on Seabirds). This predicted level of mortality does not surpass 1% of baseline mortality of the regional post-breeding population (1% of baseline mortality = 370 individuals).

5.11.2.35 The impact of displacement on gannet during the post-breeding season is predicted to be of local spatial extent, long term duration, continuous and of high reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Pre-breeding season

5.11.2.36 In the pre-breeding period (December to March), the mean peak population estimate calculated for the Hornsea Three array area plus 2 km buffer was 406 birds. Applying a displacement rate range of 30-70% and a mortality rate of 1%, this would result in the loss of one to three birds per year. This predicted level of mortality does not surpass 1% of baseline mortality of the regional pre-breeding population (1% of baseline mortality = 201 individuals) (Table 1.11 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.37 The impact of displacement on gannet during the pre-breeding season is predicted to be of local spatial extent, long term duration, continuous and of high reversibility involving a small number of individuals representing a small proportion of the regional population.. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

5.11.2.38 Gannet is considered to be of international conservation value as a result of Hornsea Three being in mean maximum foraging range of FFC pSPA. As a result of an increasing regional and national population trend, and despite a low productivity rate, the species' recoverability is considered to be high. Behaviourally, gannet was considered to be of high vulnerability by Wade *et al.* (2016) to displacement (from structures).

5.11.2.39 In summary, gannet is deemed to be of high vulnerability, high recoverability and international value. The sensitivity of the VOR is therefore, considered to be medium.

Significance of the effect

5.11.2.40 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be negligible. The effect will, therefore, be of **negligible or minor adverse** significance, which is not significant in EIA terms.

Puffin

Population structure within Hornsea Three and the former Hornsea Zone

5.11.2.41 The mean-maximum foraging range estimate for puffin is 105.4 km (± 46 km) while the maximum foraging range is 200 km (Thaxter *et al.,* 2012). The foraging ranges derived by Thaxter *et al.* (2012) were considered to have only a low level of associated confidence due to being supported by a limited number of studies.

5.11.2.42 Hornsea Three is located approximately 149 km from FFC pSPA, the closest puffin breeding colony. Hornsea Three is therefore beyond the mean-maximum foraging range of this species from FFC pSPA but is just inside of foraging range if the standard deviation associated if the mean-maximum foraging range is used. This therefore suggests that potential connectivity between Hornsea Three and breeding individuals from the FFC pSPA is unlikely. This is consistent with Webb *et al.* (1985) that reported few observations of puffin bringing fish back to their chicks from beyond 30 km offshore from what is now FFC pSPA (Brown and Grice, 2005). These observations occurred at a time when the number of breeding puffins at FFC pSPA was over seven times higher than the size of the colony today. The population from which puffins present at Hornsea Three may originate is therefore considered to be composed of young immatures and non-breeding birds during the breeding season.

5.11.2.43 In the non-breeding season the population at Hornsea Three is considered to be composed of a mixture of adults and immatures from colonies on the east coast of the UK with smaller proportions from colonies further afield.

Magnitude of impact

5.11.2.44 The displacement rate considered appropriate for puffin is 50% across all seasons. The mortality rate considered appropriate for puffin in the breeding season is 10% with a 1% mortality rate applied in the non-breeding season (see section 5.9.2). However, Hornsea Three is located in an area of the North Sea that does not support high densities of puffins in any season (see Figure 1.42 in annex 5.1: Baseline Characterisation Report) with this supported by the results of site-specific surveys with densities in the breeding season no higher than 0.3 birds/km^2. Therefore it is considered unlikely that the mortality rate from displacement will be as high as 10% and a range of mortality rates (2-10%) is applied in the breeding season.

Breeding season

5.11.2.45 The mean peak puffin population estimate calculated for the Hornsea Three array area plus 2 km buffer during the breeding season (May to July) was 253 birds. Based on a displacement rate of 50% and a mortality rate range of 2-10% during the breeding season, between three and thirteen puffins may be lost as a result of displacement.

5.11.2.46 Assessed against the defined regional breeding population (1,960 birds) the predicted mortality from displacement surpasses the 1% baseline mortality figure of two birds (Table 1.13 in annex 5.2: Analysis of Displacement Impacts on Seabirds). The actual magnitude of displacement is considered to be towards the lower end of the range presented with Hornsea Three located in an area of the North Sea that does not support high densities of puffin in the breeding season (see Figure 1.42 in annex 5.1: Baseline Characterisation Report). In addition, based on the evidence available from survey results and the scientific literature, the regional reference population for the breeding season detailed above is considered to be unrealistic. The peak breeding season population estimate for puffins at Hornsea Three plus a 4 km buffer was 684 birds (the equivalent population for Hornsea Three array area plus 2 km buffer was 411 individuals). In order to achieve this peak estimate, nearly 35% of all birds from the FFC pSPA colony would have to be present, which is not ecologically and behaviourally likely. This suggests that either the puffin's mean maximum foraging range is larger than previously recorded, and/or a large number of birds that do not form part of the FFC pSPA breeding population are present during summer months. It is considered highly unlikely that breeding adult birds will be present at Hornsea Three during the breeding season (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA) and therefore any birds present will be either immature and non-breeding birds.

5.11.2.47 During the breeding season not all puffins attending colonies and adjacent waters are breeding adults. Puffins do not usually breed until they are five years old (Cramp and Perrins 1977 - 1994) and unlike gannets and gulls it is not easy to separate adults from immature birds from site-specific observations offshore. However, data from other studies indicate that during the breeding period at least 35% of all puffins present may be non-breeding or immature birds and therefore not part of the SPA breeding population (Harris and Wanless, 2011).

5.11.2.48 This is potentially an underestimate of actual proportions of non-breeders further offshore at Hornsea Three and Dogger Bank. Votier *et al.* (2008) observed that immature and non-breeding guillemots from Skomer Island, Wales spread out further than breeding adults and it is likely that this pattern is replicated by puffins. Boat-based surveys in the North Sea by Camphuysen (2005) found that most foraging was concentrated around the major colonies, and that within 20 km of land, 99% of puffins were adults in breeding plumage. In contrast, further offshore, many puffins still had traces of winter plumage, suggesting that they were non-breeders that spent less time ashore. A higher proportion of non-breeders is therefore likely to occur further offshore.

5.11.2.49 It is considered likely that at least half of all birds recorded in the breeding season are immature individuals. In addition, a further proportion are likely to be non-breeding adult birds. Therefore, mortality predicted during the breeding season is considered likely to result in considerably less than nine adult birds from the regional breeding population.

5.11.2.50 Ringing recoveries of immature birds from the Isle of May indicate that the majority of immature birds remain in the North Sea during the non-breeding season (Harris and Wanless, 2011) and therefore it is likely that these birds then remain in the North Sea in the following breeding season. However, the high proportions reported are potentially biased as birds that perish in the North Sea are more likely to be recovered than birds that may perish in wintering areas located around the coast of Greenland (for example). Furness (2015) suggests that only small proportions (maximum 2%) of immature puffins from colonies bordering the North Sea remain in the North Sea during winter. If it is assumed that immature birds from colonies in the North Sea remain in the North Sea into the following breeding season this would represent a breeding season immature population of 8,857 birds. This is likely to be a considerable under-estimate however, as immatures that have wintered in areas outside of the North Sea will return to the North Sea during the breeding season with increasing proportions of immature age classes visiting colonies in the years prior to age of first breeding in addition to a population of non-breeding birds. If the displacement mortality predicted in the breeding season (thirteen birds) is compared to the baseline mortality of this population (1,727 birds – calculated using the inverse of the highest immature survival rate from Horswill and Robinson (2015) to provide the lowest baseline mortality on a precautionary basis) it represents an increase of only 0.75%.

5.11.2.51 The impact of displacement on puffin during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Non-breeding season

5.11.2.52 During the non-breeding season (August to April) the peak puffin population estimate was 127 birds in the Hornsea Three array area plus 2 km buffer.

5.11.2.53 Based on a 50% displacement rate and 1% mortality rate during this period, it is predicted that one bird will be lost as a result of displacement. From a regional non-breeding population of 231,957 individuals this level of mortality does not surpass the 1% baseline mortality figure (baseline mortality = 21,804 individuals) (Table 1.13 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.54 The impact of displacement on puffin during the non-breeding season is predicted to be of local spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

<u>Sensitivity of the receptor</u>

5.11.2.55 Puffin is considered to be of international conservation value, with species recoverability considered to be low. Behaviourally, Wade *et al.* (2016) have rated puffin as being of moderate vulnerability to displacement.

5.11.2.56 In summary, puffin is deemed to be of moderate vulnerability, low recoverability and international value. The sensitivity of the VOR is therefore, considered to be medium to high.

<u>Significance of the effect</u>

5.11.2.57 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be negligible - low. The effect will, therefore, be no greater than **minor adverse** significance, which is not significant in EIA terms

Razorbill

<u>Population structure within the Hornsea Three and former Hornsea Zone</u>

5.11.2.58 There is not considered to be any connectivity between Hornsea Three and any breeding colonies of razorbill (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA) and therefore the population of razorbill in Hornsea Three during the breeding season is therefore considered to consist of predominantly young immatures and potentially non-breeding adults. During the non-breeding season the population is predicted to comprise a mixture of adults and immatures from colonies on the east coast of the UK with smaller proportions from colonies further afield during the non-breeding season.

<u>Magnitude of impact</u>

5.11.2.59 The displacement rate considered appropriate for razorbill is 40% across all seasons. The mortality rate considered appropriate for razorbill in the breeding season is 2-10% with a 2% mortality rate applied in the pre- and post-breeding seasons and a 1% mortality rate applied in the non-breeding season (see section 5.9.2). However, Hornsea Three is located in an area of the North Sea that does not support high densities of razorbills in any season (see Figure 1.43 in annex 5.1: Baseline Characterisation Report) with this supported by the results of site-specific surveys with densities in the breeding season no higher than 0.6 birds/km^2. Therefore it is considered unlikely that the mortality rate from displacement will be as high as 10% and a range of mortality rates (2-10%) is applied in the breeding season.

Breeding season

5.11.2.60 The mean peak razorbill population estimate calculated for the Hornsea Three array area plus 2 km buffer during the breeding season (April to July) was 630 birds. Based on a displacement rate of 40% and a mortality rate range of 2-10% during the breeding season, between 5 and25 razorbills may be lost as a result of displacement (Table 1.14 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.61 There is not considered to be any connectivity between Hornsea Three and any breeding colonies of razorbill (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). As such the population of razorbill present at Hornsea Three is considered to consist of non-breeding and immature birds. Furness (2015) suggests that only small proportions (maximum 10%) of immature razorbills from colonies bordering the North Sea remain in the North Sea during winter. If it is assumed that immature birds from colonies in the North Sea remain in the North Sea into the following breeding season this would represent a breeding season immature population of 6,772 birds. This is likely to be a considerable under-estimate however, as immatures that have wintered in areas outside of the North Sea will return to the North Sea during the breeding season with increasing proportions of immature age classes visiting colonies in the years prior to age of first breeding in addition to a population of non-breeding birds. If the displacement mortality predicted in the breeding season (5-25 birds) is compared to the baseline mortality of this population (2,506 birds – calculated using the inverse of the immature survival rate from Horswill and Robinson (2015)) it represents an increase of 0.2-1.0%.

5.11.2.62 The impact of displacement on razorbill during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Post-breeding season

5.11.2.63 During the post-breeding period (August to October), the mean peak population estimate calculated for the Hornsea Three array area plus 2 km buffer was 2,020 birds. Using a 2% mortality rate and 40% displacement, this would result in the loss of 16 birds as a result of displacement (Table 1.15 in annex 5.2: Analysis of Displacement Impacts on Seabirds). Based on the estimated current regional population at this time (591,874 birds) this equates to an increase in baseline mortality rate of less than 1% (Table 1.15 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.64 The impact of displacement on razorbill during the post-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Non-breeding season

5.11.2.65 During the non-breeding season (November to December), the mean peak razorbill population estimate calculated for Hornsea Three array area plus 2 km buffer was 3,649 birds. Based on a 1% mortality rate and 40% displacement rate during this period, it is predicted that 15 birds will be lost as a result of displacement. From a regional non-breeding population of 218,622 individuals this would not represent a change in over 1% baseline mortality (baseline mortality = 22,955 individuals) (Table 1.16 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.66 The impact of displacement on razorbill during the non-breeding season is predicted to be of local spatial extent, long term duration, continuous and of low to medium reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Pre-breeding season

5.11.2.67 The peak population estimate of razorbill in the pre-breeding season calculated for the Hornsea Three array area plus 2 km buffer was 1,236 birds. Based on a 2% mortality rate and 40% displacement rate during this period, it is predicted that ten birds will be lost as a result of displacement. From a regional pre-breeding population of 591,874 individuals this represents less than the 1% baseline mortality (baseline mortality = 62,147 individuals) (Table 1.17 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.68 The impact of displacement on razorbill during the post-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

5.11.2.69 Razorbill is considered to be of regional conservation value as a result of regionally important populations of this species being recorded in Hornsea Three offshore ornithology study area in the non-breeding season. With a regional and national population trend likely to be at least stable, the species recoverability is considered to be medium, and behaviourally Wade *et al.* (2016) has rated the species as being of high vulnerability to displacement.

5.11.2.70 In summary, razorbill is deemed to be of high vulnerability, high recoverability and regional value. The sensitivity of the VOR is therefore, considered to be low to medium.

Significance of the effect

5.11.2.71 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be negligible - low. The effect will, therefore, be of **negligible or minor adverse** significance, which is not significant in EIA terms.

Guillemot

Population structure within Hornsea Three and the former Hornsea Zone

5.11.2.72 There is not considered to be any connectivity between Hornsea Three and any breeding colonies of guillemot (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA) and therefore the population of guillemots present within Hornsea Three during the breeding season can be considered to consist of predominantly young immatures and potentially non-breeding adults. During the non-breeding season the population is predicted to comprise a mixture of adults and immatures from colonies on the east coast of the UK with smaller proportions from colonies further afield.

Magnitude of impact

5.11.2.73 The displacement rate considered appropriate for guillemot is 50% across all seasons. The mortality rate considered appropriate for guillemot in the breeding season is 2-10% with a 1% mortality rate applied in all other seasons (see section 5.9.2).

Breeding season

5.11.2.74 The mean peak guillemot population estimate calculated for Hornsea Three array area plus 2 km buffer during the breeding season (March to July) was 13,374 birds. Based on a displacement rate of 50% and a mortality rate range of 2-10% during the breeding season, a precautionary estimate of 134-669 guillemots over the duration of the lifetime of Hornsea Three may die as a result of displacement (Table 1.18 in annex 5.2: Analysis of Displacement Impacts on Seabirds).

5.11.2.75 Guillemot is a dispersive rather than a migratory species with birds overwintering in sea areas close to their breeding colonies, although immature birds do disperse further than adults (Wernham *et al.,* 2002). Furness (2015) suggests that only reasonably high proportions (up to 80%) of immature guillemots from colonies bordering the North Sea remain in the North Sea during winter. If it is assumed that immature birds from colonies in the North Sea remain in the North Sea into the following breeding season this would represent a breeding season immature population of 560,761 birds. However, this population is likely to under-estimate the population of guillemot that may interact with Hornsea Three as it does not account for non-breeding adult birds. If the displacement mortality predicted in the breeding season (669 birds) is compared to the baseline mortality of this population (46,543 birds – calculated using the inverse of the highest immature survival rate from Horswill and Robinson (2015) to provide the lowest baseline mortality on a precautionary basis) it represents an increase of 0.29-1.44%.

5.11.2.76 The impact of displacement on guillemot during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Non-breeding season

5.11.2.77 During the non-breeding season (August to February) the mean peak guillemot population estimate calculated for Hornsea Three array area plus 2 km buffer was 17,772 birds.

5.11.2.78 Based on a 1% mortality rate and 50% displacement rate during this period, a precautionary estimate of 89 birds will be lost as a result of displacement. From a regional winter population of 1,617,306 individuals (Table 1.19 in annex 5.2: Analysis of Displacement Impacts on Seabirds), this would not surpass the 1% threshold of baseline mortality (baseline mortality = 98,656 individuals).

5.11.2.79 The impact of displacement on guillemot during the non-breeding season is predicted to be of local spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Sensitivity of the receptor

5.11.2.80 Guillemot is considered to be of regional conservation value as a result of regionally important populations of this species being recorded in the Hornsea Three offshore ornithology study area in the non-breeding season. The species is deemed to be of high vulnerability to displacement (Wade *et al.*, 2017), and with an increase in regional and national populations over the last decade (+40% and +5% respectively), guillemot has medium recoverability potential (Table 5.12).

5.11.2.81 In summary, guillemot is deemed to be of high vulnerability, medium recoverability and national value. The sensitivity of the VOR is therefore, considered to be medium.

Significance of the effect

5.11.2.82 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be low. The effect will, therefore, at most be of **minor adverse** significance, which is not significant in EIA terms.

Summary of displacement impacts during the operation and maintenance phase

5.11.2.83 A summary of physical displacement impacts in the operation and maintenance phase is presented in Table 5.22. The significance of impacts ranges from negligible or minor adverse to minor adverse with no impacts considered to be significant in EIA terms.

Table 5.22: Summary of the impact of physical displacement from an area around turbines and other ancillary structures during the operation and maintenance phase of the development.

VOR	Sensitivity	Magnitude				Significance
		Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season	
Fulmar	Medium	Low	Negligible	Negligible	Negligible	Negligible or minor adverse
Gannet	Medium	Negligible	Negligible		Negligible	Negligible or minor adverse
Puffin	Medium to high	Low		Negligible		Minor adverse
Razorbill	Low to medium	Low	Negligible	Negligible	Negligible	Negligible or minor adverse
Guillemot	Low to medium	Low		Low		Minor adverse

The impact of indirect effects, such as changes in habitat or abundance and distribution of prey resulting in impacts on seabirds.

5.11.2.84 The physical presence of foundation and potential scour protection, as well as potential changes in commercial fishing activities may impact upon the availability of prey species.

5.11.2.85 The indirect impacts on seabird prey resource and habitats are detailed in volume 2, chapter 2: Benthic Ecology and volume 2, chapter 3: Fish and Shellfish Ecology. Principal impacts on these resources and habitats are likely to be from the presence of foundations include potential changes to the wave climate, creation of hard substrate around turbine foundations and array/export cables, increases in sedimentation in the water column and noise and vibration from operational turbines.

5.11.2.86 Detailed assessments of the following potential operation and maintenance phase impacts have been undertaken in chapter 3: Fish and Shellfish Ecology for key seabird prey species (including cod, sprat, herring, mackerel and sandeel species) and include:

- Long term habitat loss due to presence of turbine foundations and scour/cable protection;
- Underwater noise as a result of operational turbines and maintenance vessel traffic;
- Temporary habitat loss and disturbance from maintenance operations (e.g. jack up operations and cable reburial);
- Accidental release of pollutants (e.g. from accidental spillage/leakage);
- Introduction of turbine foundations and scour/cable protection (hard substrates and structural complexity); and
- Electromagnetic fields (EMF) emitted by array and export cables.

5.11.2.87 Details of the fish and shellfish ecology assessment are summarised in Table 5.23. Evidence, modelling and justifications for these assessments are provided in volume 2, chapter 3: Fish and Shellfish Ecology and so justifications for this assessment will not be repeated in this chapter.

5.11.2.88 Potential reduction in fishing activity within the vicinity of turbines could have a positive benefit on prey stocks as could the aggregation of fish and shellfish around the introduced hard substrates, although this is likely to be localised.

5.11.2.89 The VORs fulmar, gannet, puffin, razorbill, guillemot, Sandwich tern, kittiwake, lesser black-backed gull and great black-backed gull, are included in the assessment of indirect effects, such as changes in habitat or abundance and distribution of prey in the operation and maintenance phase.

Table 5.23: Significance of effects of operation and maintenance impacts on fish and shellfish ecology (volume 2, chapter 3: Fish and Shellfish Ecology).

Potential impact	Species	Significance of effect
Long term habitat loss	Sandeel and herring	Minor adverse
	All other fish and shellfish species	Minor adverse
Underwater noise	All fish and shellfish species	Negligible
Introduction of turbine foundations and scour/cable protection	All fish and shellfish species	Minor adverse
Electromagnetic fields (EMF)	All fish and shellfish species	Minor adverse
Temporary habitat loss and disturbance	All fish and shellfish species	Negligible
Accidental release of pollutants	All fish and shellfish species	Negligible

All receptors

Magnitude of impact

5.11.2.90 Any changes to the distribution of prey species and habitat during operation and maintenance for seabirds is likely to be negligible or, for common scoter no change when considering the size of Hornsea Three array area and the Hornsea Three offshore cable corridor in relation to each species' total foraging range. The assessments in the benthic and fish chapters predicted either negligible or minor adverse effects for these impacts (volume 2, chapter 3: Fish and Shellfish Ecology). It is also possible that the attraction of birds to the base of structures to forage may result in a small increase in flight activity around rotors, and therefore birds at risk of collision, which may cancel out any benefits. The impact for all VORs therefore is predicted to be of local spatial extent, long term duration, continuous and of high reversibility. It is predicted that the impact will affect the receptor indirectly. The impact magnitude is therefore, considered to be negligible or, for common scoter (as explained in paragraphs 5.11.1.11 - 5.11.1.17), no change on all receptors.

Sensitivity of the receptor

5.11.2.91 As described previously, Wade *et al.* (2016) ranked each seabird species based on habitat flexibility. The vulnerability of the VORs ranged from very low (fulmar, gannet, lesser black-backed gull and great black-backed gull) to high (red-throated diver and common scoter) (Wade *et al.* 2016.)

5.11.2.92 Each VOR is deemed to be of very low to high vulnerability, low to high recoverability and regional to international value. The sensitivities of the receptors are therefore, considered to range from low to medium or medium, with the exception of puffin, which was considered to be medium to high, and common scoter and red-throated diver, considered to be high.

Significance of the effect

5.11.2.93 An indirect impact of negligible magnitude on a low to medium sensitivity receptor is predicted to produce a **negligible or minor adverse** effect. An indirect impact of negligible magnitude on a medium to high or high sensitivity receptor (puffin and red-throated diver respectively) is predicted to produce at worst, a **minor adverse** effect on the regional (puffin) or local (red-throated diver) population. The effects on all of these receptors are not significant in EIA terms.

Summary of indirect disturbance impacts in the operation and maintenance phase

5.11.2.94 A summary of operation and maintenance indirect disturbance impacts on each VOR is presented in Table 5.24. The significance of impacts ranges from negligible to minor adverse with no impacts considered to be significant in EIA terms.

Table 5.24: Summary of the impact of indirect effects, such as changes in habitat or abundance and distribution of prey.

VOR	Sensitivity	Magnitude	Significance
Common scoter	High	No change	Negligible
Red-throated diver	High	Negligible	Minor adverse
Fulmar	Medium	Negligible	Negligible or minor adverse
Gannet	Low	Negligible	Negligible or minor adverse
Puffin	Medium to high	Negligible	Minor adverse
Razorbill	Low to medium	Negligible	Negligible or minor adverse
Guillemot	Low to medium	Negligible	Negligible or minor adverse
Sandwich tern	Medium	Negligible	Negligible or minor adverse
Kittiwake	Low to medium	Negligible	Negligible or minor adverse
Lesser black-backed gull	Low	Negligible	Negligible or minor adverse
Great black-backed gull	Low	Negligible	Negligible or minor adverse

Collision with rotating turbine blades resulting in mortality of birds.

Collision risk impact assessment - seabirds

5.11.2.95 Hornsea Three has committed to a significantly increased lower blade tip height than previously assessed offshore wind farms in the UK, in an effort to reduce collision risk impacts on birds. This adopted measure (see Table 5.8) will significantly reduce the number of collisions for all seabird species when compared to the scenario that would occur if a lower blade tip height were to be used.

5.11.2.96 Although it is evident that there are a number of areas of uncertainty relative to estimating collision risk at offshore wind farms (e.g. natural variability in bird populations, assumptions made in relation to the geometry of turbines and bird shape, etc.), a quantitative impact assessment is presented in this chapter with this considered to be the most appropriate approach to inform assessment. This assessment is informed by the site-specific density data with the output being the estimated annual additional mortality for each VOR deemed sensitive to collision risk.

5.11.2.97 The Basic Band model (annex 5.3: Collision Risk Modelling) assumes a uniform distribution of 'at-risk' flights between lowest and highest levels of the rotors, thereby likely overestimating risk for species that predominantly fly at lower heights (e.g. gulls and terns).

5.11.2.98 The Extended Band model uses modelled flight height distributions to allow comparison of the impact of varying the height of wind turbines, and to account for the fact that collision risk is not distributed evenly within the rotor swept area. Full details of the CRM protocol followed for the assessment of Hornsea Three VORs is presented in section 5.9.3.

5.11.2.99 It is acknowledged that migratory passage movements may be 'missed' by aerial survey methods. Therefore for migratory waterbirds, the SOSS Migration Assessment Tool (MAT) for migratory species is used, which assesses theoretical biannual passage movements based on estimated flyway populations. For migratory seabirds, a generic 'migratory front' is defined for a species which is then used to calculate the number of birds from a relevant seasonal BDMPS population that has the potential to interact with Hornsea Three during spring and autumn migration. The interacting populations are then incorporated into CRM to provide a mortality estimate for each species.

5.11.2.100 For all VORs identified for CRM Band (2012) model results are presented in annex 5.3: Collision Risk Modelling. The full SOSS MAT model data is presented in appendix D of annex 5.3: Collision Risk Modelling.

Annual and seasonal collision mortality estimates

5.11.2.101 The predicted annual mortality estimates for each species are presented below, with the model type (Band Options 1, 2 or 3) also detailed.

5.11.2.102 A seasonal breakdown of predicted collisions for each species is presented in Table 5.25.

Table 5.25: Seasonal breakdown of collision risk mortality using the maximum design scenario turbine layout and parameters representing the mean estimate (density data) or maximum likelihood scenario (flight height data).[a]

Species	Band model Option	Avoidance rate (%)	Annual mortality rate at appropriate avoidance rate[b]	Number of collisions			
				Breeding season mortality	Post-breeding season mortality	Non-breeding season mortality	Pre-breeding season mortality
Gannet	1	98.9	17	8	5		4
	2	98.9	37	18	12		8
	3	98	15	7	5		3
Arctic skua	2	98	0		0		0
	3	98	0		0		0
Great skua	2	98	0		0		0
	3	98	0		0		0
Little gull	2	99.2	0		0		0
	3	98	0		0		0
Kittiwake	1	99.2	33	17	11		6
	2	99.2	173	88	55		29
	3	98	83	42	26		14
Lesser black-backed gull	1	99.5	14	12	1	0	1
	2	99.5	17	15	2	0	1
	3	98.9	12	10	1	0	1
Great black-backed gull	1	99.5	32	8		24	
	2	99.5	66	16		50	
	3	98.9	52	12		40	
Common tern	2	98	1		0		0
	3	98	0		0		0
Arctic tern	2	98	0		0		0
	3	98	0		0		0

a The grey cells denote where no mortality estimates were calculated due to inappropriate model type for the data available and/or a season (1) in which a species has no population that interacts with Hornsea Three, or (2) not defined for the species considered.

b All mortality estimates presented are rounded to a whole number (i.e. whole bird). Mortality estimates have been summated across seasons using the actual value, the resultant decimal value only then rounded to a whole number. The latter rounded value may differ to the less accurate summation of whole numbers presented for each season.

5.11.2.103 Collision risk estimates have been calculated using the upper and lower confidence metrics associated with survey density data, flight height data and avoidance rate. Further information on the approach to capturing uncertainty is provided in annex 5.3: Collision Risk Modelling. It is considered that the collision risk estimates calculated using the mean estimate (density data and avoidance rate) or maximum likelihood value (flight height data) are those on which any assessment should be based, however, within the following species sections consideration has been given to the range of collision risk estimates calculated incorporating the variability metrics. This approach often means that the upper confidence metrics are those discussed as the collision risk estimates calculated when applying these data are those which may adversely alter the conclusions of the assessment, however, it is important to also be mindful of the collision risk estimates calculated when applying the lower confidence metrics.

Gannet

Magnitude of impact

5.11.2.104 An annual mortality rate of 37 collisions/annum is predicted for gannet using Band Option 2 at an avoidance rate of 98.9% with 15 collisions/annum predicted when using Band Option 3 at a 98% avoidance rate and 17 collisions/annum when using Band Option 1 at a 98.9% avoidance rate (Table 5.26).

5.11.2.105 The variability associated with the collision risk estimates has also been considered in relation to baseline survey density data (all Options), flight height data (Options 2 and 3 only) and avoidance rate (Options 1 and 2 only). Annex 5.3: Collision Risk Modelling presents the variability associated with each of these aspects of CRM.

Table 5.26: Gannet seasonal collision risk results expressed as change in regional population baseline mortality based on collision risk estimates calculated using the mean estimate of relevant parameters

CRM option (Avoidance rate)	Season	Collision mortality	Baseline mortality of regional population (individuals/annum)	Increase in baseline mortality (%)
Band Option 1 (98.9%)	Breeding	8	2,024	0.40
	Post-breeding	5	36,960	0.01
	Pre-breeding	4	20,119	0.02
	Total	17	-	-
Band Option 2 (98.9%)	Breeding	18	2,024	0.88
	Post-breeding	12	36,960	0.03
	Pre-breeding	8	20,119	0.04
	Total	37	-	-
Band Option 3 (98%)	Breeding	7	2,024	0.37
	Post-breeding	5	36,960	0.01
	Pre-breeding	3	20,119	0.02
	Total	15	-	-

Breeding season

5.11.2.106 The breeding season for gannet accounts for approximately 50% of annual collisions. When using Option 3 at a 98% avoidance rate (7 collisions) this represents a 0.37% change in baseline mortality (2,024 individuals) of the regional breeding population (24,988 individuals). When using Option 2 at a 98.9% avoidance rate (18 collisions) this represents a 0.88% change in baseline mortality of the regional breeding population. When using Option 1 at a 98.9% avoidance rate (8 collisions) this represents a 0.40% increase in baseline mortality.

5.11.2.107 The degree of variability associated with the density data and avoidance rates used in collision risk modelling for gannet is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional breeding population (see monthly collision risk values presented in Tables A.1, A.3 and A.5 in Annex 5.3: Collision Risk Modelling). The greatest degree of variability in the collision risk estimates for gannet is caused by the flight height data (see monthly collision risk values presented in Tables A.2, A.4 and A.6 in Annex 5.3: Collision Risk Modelling), with the 1% threshold of baseline mortality for the regional breeding population of gannet surpassed when considering the variability associated with flight height data when using Options 1 and 2.

5.11.2.108 However, the collision risk estimates predicted using Option 2 (and Option 3) use flight height data that is not necessarily representative of the behaviour of birds at Hornsea Three with this illustrated by the site-specific data for Hornsea Three collected as part of the boat-based survey programme for the applications for the Hornsea Projects One and Two offshore wind farms. The PCH value calculated using site-specific data (1.4%) is much lower than that derived from generic flight height data (4.0%). Further to this, the assessment presented above assumes that the population present at Hornsea Three is composed of adults only. Site-specific age class data indicates that approximately 30-60% of birds present at Hornsea Three will be immature birds with this representing a considerable reduction in the magnitude of impact predicted on the regional breeding population.

5.11.2.109 The impact is predicted to be of regional spatial extent, long term duration, continuous, low to medium reversibility with a very slight change from baseline conditions (due to a small number of collisions). It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Post-breeding season

5.11.2.110 The post-breeding season for gannet accounts for approximately 28% of annual collisions. When using Option 3 at a 98% avoidance rate (5 collisions) this represents a 0.01% change in baseline mortality (36,960 individuals) of the regional post-breeding population (957,502 individuals). When using Option 2 at a 98.9% avoidance rate (12 collisions) this represents a 0.03% change in baseline mortality of the regional post-breeding population.

5.11.2.111 The degree of variability associated with the density data, flight height data and avoidance rates used in collision risk modelling for gannet is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional post-breeding population (see monthly collision risk values presented in Tables A.1, to A.6 in Annex 5.3: Collision Risk Modelling).

5.11.2.112 The impact is predicted to be of regional spatial extent, long term duration, continuous, low to medium reversibility with a very slight change from baseline conditions (due to a small number of collisions). It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Pre-breeding season

5.11.2.113 The pre-breeding season for gannet accounts for approximately 23% of annual collisions. When using Option 3 at a 98% avoidance rate (4 collisions) this represents a 0.02% change in baseline mortality (20,119 individuals) of the regional post-breeding population (910,273 individuals). When using Option 2 at a 98.9% avoidance rate (9 collisions) this represents a 0.04% change in baseline mortality of the regional post-breeding population.

5.11.2.114 The degree of variability associated with the density data, flight height data and avoidance rates used in collision risk modelling for gannet is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional pre-breeding population (see monthly collision risk values presented in Tables A.1, to A.6 in Annex 5.3: Collision Risk Modelling).

5.11.2.115 The impact is predicted to be of regional spatial extent, long term duration, continuous, low to medium reversibility with a very slight change from baseline conditions (due to a small number of collisions). It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

<u>Sensitivity of the receptor</u>

5.11.2.116 As a proposed qualifying feature of FFC pSPA, where Hornsea Three is within mean maximum foraging range, gannet is afforded international conservation value. It was ranked high in terms of vulnerability to collisions by Wade *et al.* (2016) although moderate vulnerability by Langston (2010). High vulnerability is considered appropriate within this assessment.

5.11.2.117 Gannet is deemed to be of high vulnerability, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be medium.

<u>Significance of the effect</u>

5.11.2.118 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be negligible - low. The effect will, therefore, be of **negligible or minor to minor adverse** significance, which is not significant in EIA terms.

Arctic skua

<u>Magnitude of impact</u>

5.11.2.119 An annual mortality rate of less than one collision per annum is predicted for Arctic skua using Band Option 2 at an avoidance rate of 98%, with while less than one collision per annum is predicted when using Band Option 3 at a 98% avoidance rate.

5.11.2.120 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

<u>Sensitivity of the receptor</u>

5.11.2.121 Arctic skua is considered to be of international conservation value due to the likelihood of a large proportion of the UK SPA populations passing down the east coast on migration. Recoverability, based on population trends and reproduction rates, are considered to be low.

5.11.2.122 Skuas are rated as being of relatively high vulnerability to collisions by Wade *et al.* (2016) as they spend a large proportion of their time in flight, albeit, not as frequently at potential collision height compared to gull species.

5.11.2.123 Very little empirical data on behaviour around wind farms is available specifically for skuas, although evidence in Krijgsveld *et al.* (2010) and Christensen *et al.* (2004) suggests that they may act in a similar manner to gulls and in general do not obviously avoid wind farms. Within the operational Horns Rev Offshore Wind Farm, skuas were observed chasing terns at various heights on a number of occasions, and this behaviour may put birds at risk of collision (assuming the parasitized species are present in the wind farm to pursue) (Petersen *et al.,* 2006). Vulnerability is therefore considered to be high.

5.11.2.124 In summary, Arctic skua is deemed to be of high vulnerability, low recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of the effect

5.11.2.125 Overall, the sensitivity of the receptor is considered to be high and the impact magnitude is deemed to be of no change. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Great skua

Magnitude of impact

5.11.2.126 An annual mortality rate of less than one collisions/annum are predicted for great skua using Band Option 2 at an avoidance rate of 98%, with less than one collisions/annum predicted when using Band Option 3 at a 98% avoidance rate.

5.11.2.127 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

Sensitivity of the receptor

5.11.2.128 Great skua is considered to be of international conservation value due to the likelihood of a large proportion of the UK SPA populations passing down the east coast on migration. Recoverability, based on population trends and reproduction rates, is considered to be medium.

5.11.2.129 Skuas are rated as being of relatively high vulnerability to collisions by Wade *et al.* (2016) as they spend a large proportion of their time in flight, albeit, not as frequently at potential collision height compared to gull species. As detailed for Arctic skua, very little empirical data on behaviour around wind farms is available and on a precautionary basis vulnerability is therefore considered to be high.

5.11.2.130 In summary, great skua is deemed to be of high vulnerability, medium recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of the effect

5.11.2.131 Overall, the sensitivity of the receptor is considered to be high and the impact magnitude is deemed to be of no change. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Common tern

Magnitude of impact

5.11.2.132 Only a small number of common terns were recorded during aerial surveys (see annex 5.1: Baseline Characterisation Report). The CRM undertaken was therefore that as described for migratory seabirds (see appendix C of annex 5.3: Collision Risk Modelling).

5.11.2.133 An annual mortality of one collision per annum is predicted for common tern using Band Option 2 at an avoidance rate of 98%, with less than one collisions/annum predicted when using Band Option 3 at a 98% avoidance rate.

5.11.2.134 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

Post-breeding season

5.11.2.135 The post-breeding season for common tern accounts for less than one collision per annum using Option 3 at a 98% avoidance rate. This represents a negligible change in baseline mortality (16,955 individuals) of the regional post-breeding population (144,911 individuals).

5.11.2.136 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

Pre-breeding season

5.11.2.137 The pre-breeding season for common tern accounts for less than one collision per annum using Option 3 at a 98% avoidance rate. This represents a negligible change in baseline mortality (16,955 individuals) of the regional pre-breeding population (144,911 individuals).

5.11.2.138 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

Sensitivity of the receptor

5.11.2.139 Common tern is listed on Annex 1 of the EU Birds Directive and on a precautionary basis is afforded an international conservation value. Recoverability is considered to be medium. Vulnerability to collisions was rated as moderate by Wade *et al.* (2016), as although the species spends much time in flight, little of it will be at risk height.

5.11.2.140 In summary, common tern is deemed to be of moderate vulnerability, medium recoverability and International value. The sensitivity of common tern is therefore, considered to be medium.

Significance of the effect

5.11.2.141 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be of no change. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Arctic tern

Magnitude of impact

5.11.2.142 Only a small number of arctic terns were recorded during aerial surveys (see annex 5.1: Baseline Characterisation Report). The CRM undertaken was therefore that as described for migratory seabirds (see appendix C of annex 5.3: Collision Risk Modelling).

5.11.2.143 An annual mortality of less one collision per annum is predicted for Arctic tern using Band Option 2 at an avoidance rate of 98%, with less than one collisions/annum predicted when using Band Option 3 at a 98% avoidance rate.

5.11.2.144 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

Sensitivity of the receptor

5.11.2.145 Arctic tern is listed on Annex 1 of the EU Birds Directive and on a precautionary basis is afforded an international conservation value. Recoverability is considered to be medium. Vulnerability to collisions was rated as moderate by Wade *et al.* (2016), as although the species spends much time in flight, little of it will be at risk height.

5.11.2.146 In summary, Arctic tern is deemed to be of moderate vulnerability, medium recoverability and International value. The sensitivity of common tern is therefore, considered to be medium.

Significance of the effect

5.11.2.147 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be of no change. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terns.

Kittiwake

Magnitude of impact

5.11.2.148 An annual mortality of 173 collisions/annum is predicted for kittiwake using Band Option 2 at an avoidance rate of 99.2%, with 102 collisions/annum predicted when using Band Option 3 at a 98% avoidance rate and 33 collisions/annum when using Band Option 1 at a 99.2% avoidance rate (Table 5.27).

Table 5.27: Kittiwake seasonal collision risk results expressed as change in regional population baseline mortality based on collision risk estimates calculated using the mean estimate of relevant parameters [a]

CRM option (Avoidance rate)	Season	Collision mortality	Baseline mortality of regional population (individuals/annum)	Increase in baseline mortality (%)
Band Option 1 (99.2%)	Breeding	17	14,893	0.11
	Post-breeding	11	121,171	0.01
	Pre-breeding	6	91,661	0.01
	Total	33	-	-
Band Option 2 (99.2%)	Breeding	88	14,893	0.59
	Post-breeding	55	121,171	0.05
	Pre-breeding	29	91,661	0.03
	Total	173	-	-
Band Option 3 (98%)	Breeding	42	14,893	0.28
	Post-breeding	26	121,171	0.02
	Pre-breeding	14	91,661	0.02
	Total	83	-	-

a collision risk estimates calculated using the mean estimate/maximum likelihood scenario are shown with estimates calculated using confidence intervals presented in brackets

Breeding season

5.11.2.149 The breeding season for kittiwake accounts for approximately 51% of annual collisions. When using Option 3 at a 98% avoidance rate (42 collisions) this represents a 0.28% change in baseline mortality (14,893 individuals) of the regional breeding population (102,002 individuals). When using Option 2 at a 99.2% avoidance rate (88 collisions) this represents a 0.59% change in baseline mortality of the regional breeding population. When using Option 1 at a 99.2% avoidance rate (17 collisions) this represents a 0.11% change in baseline mortality of the regional breeding population

5.11.2.150 The degree of variability associated with the density data, flight height data and avoidance rates used in collision risk modelling for kittiwake is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional breeding population (see monthly collision risk values presented in Tables A.7, to A.12 in Annex 5.3: Collision Risk Modelling). The regional breeding population against which impacts are assessed is composed of breeding adults only and there will, in addition, be immature birds and non-breeding adult birds present at Hornsea Three that supplement this regional population. The assessment here <u>does not discriminate between adult and immature birds and breeding and non-breeding adults</u>, with all birds observed during surveys being included in CRM. Comparing this predicted collision rate (for all birds) with a regional population composed <u>only of breeding adult birds</u> is, therefore, highly precautionary and <u>significantly over-estimates</u> the likely change in baseline mortality.

5.11.2.151 The impact is predicted to be of regional spatial extent, long term duration, continuous and low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Post-breeding season

5.11.2.152 The post-breeding season for kittiwake accounts for approximately 34% of annual collisions. When using Option 3 at a 98% avoidance rate (35 collisions) this represents a 0.03% change in baseline mortality (121,171 individuals) of the regional breeding population (829,937 individuals). When using Option 2 at a 99.2% avoidance rate (70 collisions) this represents a 0.06% change in baseline mortality of the regional breeding population.

5.11.2.153 The degree of variability associated with the density data, flight height data and avoidance rates used in collision risk modelling for kittiwake is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional post-breeding population (see monthly collision risk values presented in Tables A.7, to A.12 in Annex 5.3: Collision Risk Modelling).

5.11.2.154 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Pre-breeding season

5.11.2.155 The pre-breeding season for kittiwake accounts for approximately 16% of annual collisions. When using Option 3 at a 98% avoidance rate (217 collisions) this represents a 0.02% change in baseline mortality (91,661 individuals) of the regional breeding population (627,816 individuals). When using Option 2 at a 99.2% avoidance rate (34 collisions) this represents a 0.04% change in baseline mortality of the regional breeding population.

5.11.2.156 The degree of variability associated with the density data, flight height data and avoidance rates used in collision risk modelling for kittiwake is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional pre-breeding population (see monthly collision risk values presented in Tables A.7, to A.12 in Annex 5.3: Collision Risk Modelling).

5.11.2.157 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

<u>Sensitivity of the receptor</u>

5.11.2.158 Kittiwake was rated as being relatively high vulnerability to collision impacts by Wade *et al.* (2016), due to the proportion of flights likely to occur at potential risk height and percentage of time in flight, including at night. From previous studies in Flanders that have recorded mortality rates and collision rates, estimated micro-avoidance rates were, however, high for smaller gulls (Everaert, 2006; 2008; 2011; Everaert *et al.*, 2002; Everaert and Kuijken, 2007). Studies have also shown that rates are consistently above 98% for flights at rotor height (GWFL, 2011). The recently published report for Marine Scotland (Cook *et al.,* 2014) considers that a 99.2% avoidance rate is appropriate for the 'Basic' Band Model.

5.11.2.159 FFC pSPA is the closest breeding colony for kittiwake to Hornsea Three. However, Hornsea Three is outside of the mean-maximum (± 1 SD) foraging range of kittiwake (60 km) from the pSPA as reported by Thaxter *et al.* (2012). Preliminary results from the FAME project which has tracked breeding kittiwake from the FFC pSPA colony does however suggest that there may be connectivity between the FFC pSPA and Hornsea Three as presented in annex 5.1: Baseline Characterisation Report.

5.11.2.160 Kittiwake is deemed to be of high vulnerability, low recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of the effect

5.11.2.161 Overall, the sensitivity of the receptor is considered to be high and the impact magnitude is deemed to be low (breeding season). Consequently, the effect could be either minor or moderate adverse significance. Where an assessment concludes a significance that falls between two categories the EIA methodology states that expert judgement should be used in order to determine the significance of the impact (section 5.9). The assessment presented in the above sections is based on conservative assumptions, including the use of a breeding regional population that is based only on breeding adult birds (excluding immature and non-breeding adult birds) whereas the predicted collision rate is based on the observed birds at Hornsea Three which will include immature and non-breeding adults. Notwithstanding this, the predicted mortality rate still represents a very small proportion of the relevant regional populations and, in all cases, represents less than 1% of baseline mortality for those relevant populations.

5.11.2.162 On this basis it is judged that the impact is of **minor adverse** significance, which is not significant in EIA terms.

Little gull

Magnitude of impact

5.11.2.163 As little gull is generally only found along the eastern coast of the UK during autumn passage, the most appropriate reference populations are considered to be the southern North Sea flyway population, given as 30,000 to 75,000 birds by Stienen *et al.* (2007), and also the Hornsea Mere population, with a five-year mean of 3,312 birds (Frost *et al.,* 2017) which peaks around July / August, coinciding with the moult period for adult and sub-adult birds. Surveys by RPS in 2009 determined that Hornsea Mere is used as a pre-roost aggregation site, before birds headed 1 to 2 km offshore to spend the night. The 'population' at Hornsea Mere, at least in 2008, appeared to be in a constant state of flux involving the incoming and outgoing of different individuals despite the appearance of a relatively smooth increase from mid-August to the end of August followed by a relatively rapid decline through September.

5.11.2.164 The Flamborough Front (see section 1.3.2 in annex 5.1: Baseline Characterisation Report) offers a range of foraging opportunities for little gulls, numbers of which are likely to vary hugely in time and space. Birds utilising Hornsea Mere may travel considerable distances to find suitable feeding habitat.

5.11.2.165 Only a small number of little gulls were recorded during aerial surveys. The CRM undertaken was therefore that as described for migratory seabirds (appendix C of annex 5.3: Collision Risk Modelling).

5.11.2.166 An annual mortality rate of less than one collision per annum is predicted for little gull using Band Option 2 at an avoidance rate of 99.2%, with less than one collision per annum predicted when using Band Option 3 at a 98% avoidance rate. The predicted collision mortality therefore represents less than 0.01% of the southern North Sea flyway population (30,000 – 75,000 individuals) and 0.02% of the Hornsea Mere population (3,312 individuals).

5.11.2.167 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

Sensitivity of the receptor

5.11.2.168 Little gull is listed on both Annex 1 of the EU Birds Directive and Schedule 1 of the Wildlife and Countryside Act and is therefore considered to be of International conservation value. Recoverability is considered to be medium. Although not assessed specifically by Wade *et al.* (2016), the vulnerability of the species to collisions is likely to be similar to other small gull species. Krijgsveld *et al.* (2011) found little gulls to be relatively abundant within the Egmond aan Zee Offshore Wind Farm, compared to buffer areas outside. However, as described for kittiwake, micro avoidance rates of small gulls are likely to be high, and during boat-based surveys at Hornsea Project Two all little gulls were recorded below 22.5 metres. Vulnerability is therefore considered to be moderate.

5.11.2.169 In summary, little gull is deemed to be of moderate vulnerability, medium recoverability and International value. The sensitivity of the receptor is therefore, considered to be medium**.**

Significance of the effect

5.11.2.170 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be of no change. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Lesser black-backed gull

Magnitude of impact

5.11.2.171 An annual mortality rate of 15 collisions/annum is predicted for lesser black-backed gull using Band Option 2 at an avoidance rate of 99.5% with 10 collisions /annum predicted when using Band Option 3 at a 98.9% avoidance rate and 12 collision/annum predicted when using Band Option 1 at a 99.5% avoidance rate (Table 5.28).

Breeding season

5.11.2.172 The breeding season for lesser black-backed gull accounts for approximately 86% of annual collisions. When using Option 3 at a 98.9% avoidance rate (10 collisions) this represents a 1.90% change in baseline mortality (523 individuals) of the regional breeding population (4,544 individuals). When using Option 2 at a 99.5% avoidance rate (15 collisions) this represents a 2.84% change in baseline mortality of the regional breeding population. When using Option 1 at a 99.5% avoidance rate (12 collisions) this represents a 2.33% change in baseline mortality of the regional breeding population.

5.11.2.173 Although this represents over a 1% increase in baseline mortality of the regional population using all three of the Band model Options, the collision rate is low. The regional population does not include birds from outside of the region (e.g. from large Dutch colonies such as Texel) which are likely to forage occasionally within the site (see results of satellite tag studies of lesser black-backed gulls from Texel at http://www.sovon.nl, and also submitted documents for Galloper Wind Farm application (GWFL, 2011) or non-breeding and immature birds which may form a large proportion of the population present at Hornsea Three. Site-specific age class data from boat-based surveys conducted to support the applications for the Hornsea Project One and Two offshore wind farms indicates that at least 35% of birds recorded in the breeding season were immature or juvenile birds. A lower proportion of the birds aged during Hornsea Three aerial surveys undertaken during the breeding season were identified as immatures (14%) however, a total of only 57 birds were aged (of 261 birds recorded in total) meaning this may not be representative of the age structure present at Hornsea Three. Therefore the impact on the regional breeding population is likely to be an overestimate.

5.11.2.174 The degree of variability associated with the density data, flight height data and avoidance rates used in collision risk modelling for lesser black-backed gull is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional breeding population (see monthly collision risk values presented in Tables A.13, to A.18 in Annex 5.3: Collision Risk Modelling).

5.11.2.175 The impact is predicted to be of regional spatial extent, long term duration, continuous and low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Table 5.28: Lesser black-backed gull seasonal collision risk results expressed as change in regional population baseline mortality based on collision risk estimates calculated using the mean estimate of relevant parameters [a b].

CRM option (Avoidance rate)	Season	Collision mortality	Baseline mortality of regional population (individuals/annum)	Increase in baseline mortality (%)
Band Option 1 (99.5%)	Breeding	**12**	**523**	**2.33**
	Post-breeding	1	24,036	0.01
	Non-breeding	0	4,521	0.00
	Pre-breeding	1	22,711	0.00
	Total	14	-	-
Band Option 2 (99.5%)	**Breeding**	**15**	**523**	**2.84**
	Post-breeding	2	24,036	0.01
	Non-breeding	0	4,521	0.00
	Pre-breeding	1	22,711	0.01
	Total	17	-	-
Band Option 3 (98.9%)	**Breeding**	**10**	**523**	**1.90**
	Post-breeding	1	24,036	0.00
	Non-breeding	0	4,521	0.00
	Pre-breeding	1	22,711	0.00
	Total	12	-	-

a collision risk estimates calculated using the mean estimate/maximum likelihood scenario are shown with estimates calculated using confidence intervals presented in brackets

b Rows in **bold** indicates those seasons in which collision mortality is above 1% of the baseline mortality of the regional population.

Post-breeding season

5.11.2.176 The post-breeding season for lesser black-backed gull accounts for up to two collisions (Option 2 at a 99.5% avoidance rate). This represents a negligible change in baseline mortality (24,036 individuals) of the regional post-breeding population (209,007 individuals).

5.11.2.177 The degree of variability associated with the density data, flight height data and avoidance rates used in collision risk modelling for lesser black-backed gull is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional post-breeding population (see monthly collision risk values presented in Tables A.13, to A.18 in Annex 5.3: Collision Risk Modelling).

5.11.2.178 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

Non-breeding season

5.11.2.179 No lesser black-backed gulls were recorded at Hornsea Three during the non-breeding season defined for the species (November to February). As such, there is no change in the baseline mortality (4,521 individuals) of the regional non-breeding population (39,314 individuals).

5.11.2.180 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

Pre-breeding season

5.11.2.181 The pre-breeding season for lesser black-backed gull accounts for approximately 5% of annual collisions. One collision is predicted when using any of the three Band model Options with this representing up to a 0.01% change in baseline mortality (22,711 individuals) of the regional breeding population (197,483 individuals).

5.11.2.182 The degree of variability associated with the density data, flight height data and avoidance rates used in collision risk modelling for lesser black-backed gull is considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional pre-breeding population (see monthly collision risk values presented in Tables A.13, to A.18 in Annex 5.3: Collision Risk Modelling).

5.11.2.183 In non-breeding seasons, a large mixed population of lesser black-backed gulls is likely to be present in the North Sea region as they migrate to and from wintering areas. Such individuals are likely to be from the *Larus fuscus graellsii / intermedius* subspecies' populations that form large colonies along continental Europe spreading north up to Norway.

5.11.2.184 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Sensitivity of the receptor

5.11.2.185 Lesser black-backed gull was ranked the second most vulnerable marine bird species to collision impacts by Wade *et al.* (2016), mainly due to the high proportion of flights at potential collision heights, and the percentage of time in flight, including at night.

5.11.2.186 In summary, lesser black-backed gull is deemed to be of very high vulnerability, medium recoverability and regional value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of the effect

5.11.2.187 Overall, the sensitivity of the receptor is considered to be medium and the impact magnitude is deemed to be no greater than low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Great black-backed gull

Magnitude of impact

5.11.2.188 An annual mortality of 66 collisions/annum is predicted for great black-backed gull using Band Option 2 at an avoidance rate of 99.5%, with 52 collisions/annum are predicted when using Band Option 3 at a 98.9% avoidance rate and 32 collisions/annum when using Band Option 1 at a 99.5% avoidance rate (Table 5.29).

Table 5.29: Great black-backed gull seasonal collision risk results expressed as change in regional population baseline mortality based on collision risk estimates calculated using the mean estimate of relevant parameters.

CRM option (Avoidance rate)	Season	Collision mortality	Baseline mortality of regional population (individuals/annum)	Increase in baseline mortality (%)
Band Option 1 (99.5%)	Breeding	8	2,380	0.32
	Non-breeding	24	6,398	0.38
	Total	32	-	-
Band Option 2 (99.5%)	Breeding	16	2,380	0.66
	Non-breeding	50	6,398	0.79
	Total	66	-	-
Band Option 3 (98.9%)	Breeding	12	2,380	0.52
	Non-breeding	40	6,398	0.62
	Total	52	-	-

Breeding season

5.11.2.189 The breeding season for great black-backed gull accounts for approximately 24% of annual collisions. When using Option 3 at a 98.9% avoidance rate (12 collisions) this represents a 0.52% change in baseline mortality (2,380 individuals) of the regional breeding population (34,000 individuals). When using Option 2 at a 99.5% avoidance rate (16 collisions) this represents a 0.66% change in baseline mortality of the regional breeding population. When using Option 1 at a 99.5% avoidance rate (8 collisions) this represents a 0.32% change in baseline mortality of the regional breeding population.

5.11.2.190 The degree of variability associated with the avoidance rates used in collision risk modelling for great black-backed gull are considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional breeding population (see monthly collision risk values presented in Tables A.19, A.21 and A.23 in Annex 5.3: Collision Risk Modelling). The greatest degree of variability in the collision risk estimates for great black-backed gull is caused by either the density data or the flight height data depending on the Band (2012) Option used (see monthly collision risk values presented in Tables A.19, to A.24 in Annex 5.3: Collision Risk Modelling), with the 1% threshold of baseline mortality for the regional breeding population of great black-backed gull surpassed when considering collision risk estimates calculated using Options 2 and 3. However, the collision risk estimates predicted using Option 2 (and Option 3) use flight height data that is not necessarily representative of the behaviour of birds at Hornsea Three with this illustrated by the site-specific data for Hornsea Three collected as part of the boat-based survey programme for the applications for the Hornsea Projects One and Two offshore wind farms. The PCH value calculated using site-specific data (7.3%) is much lower than that derived from generic flight height data (17.6%).

5.11.2.191 Further to this, the assessment presented above assumes that the population present at Hornsea Three is composed of adults only. Site-specific age class data from boat-based surveys conducted to support the applications for the Hornsea Project One and Two offshore wind farms indicates that approximately 80% of birds recorded in the breeding season were immature or juvenile birds. This is supported by age class data collected during aerial surveys of Hornsea Three with 91% of birds recorded in the breeding season identified as immature birds (although only 43 birds were aged during the breeding season). This therefore supports the conclusion that the majority of birds at Hornsea Three in the breeding season are immature or non-breeding birds and represents a considerable reduction in the magnitude of impact predicted on the national breeding population.

5.11.2.192 The impact is predicted to be of regional spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Non-breeding season

5.11.2.193 The non-breeding season for great black-backed gull accounts for approximately 76% of annual collisions When using Option 3 at a 98.9% avoidance rate (40 collisions) this represents a 0.62% change in baseline mortality (6,398 individuals) of the regional breeding population (91,399 individuals). When using Option 2 at a 99.5% avoidance rate (50 collisions) this represents a 0.79% change in baseline mortality of the regional breeding population. When using Option 1 at a 99.5% avoidance rate (24 collisions) this represents a 0.38% change in baseline mortality of the regional breeding population.

5.11.2.194 The degree of variability associated with the avoidance rates used in collision risk modelling for great black-backed gull are considered to represent a negligible change in resulting collision risk estimates in terms of the effect on the regional non-breeding population (see monthly collision risk values presented in Tables A.19, A.21 and A.23 in Annex 5.3: Collision Risk Modelling). The greatest degree of variability in the collision risk estimates for great black-backed gull is caused by the flight height data (see monthly collision risk values presented in Tables A.20, A.22 and A.24 in Annex 5.3: Collision Risk Modelling), with the 1% threshold of baseline mortality for the regional breeding population of great black-backed gull surpassed when considering collision risk estimates calculated using Options 2 and 3. However, as already discussed the proportion of birds at collision height from generic data is considered unlikely to accurately reflect the behaviour of birds at Hornsea Three and thus the collision risk estimates calculated using Options 2 and 3 are likely to be over-estimates.

5.11.2.195 The impact is predicted to be of regional spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

<u>Sensitivity of the receptor</u>

5.11.2.196 Great black-backed gull was rated the seabird species most vulnerable to collision impacts by Wade *et al.* (2016), mainly due to the high proportion of flights at potential collision heights, and the percentage of time in flight, including at night.

5.11.2.197 In summary, great black-backed gull is deemed to be of very high vulnerability, medium recoverability and national value. The sensitivity of the receptor is therefore, considered to be medium.

<u>Significance of the effect</u>

5.11.2.198 Overall, the sensitivity of the receptor is considered to be high sensitivity and the impact magnitude is deemed to be negligible – low. The effect will, therefore, be of **minor adverse** significance, which is not significant in EIA terms.

Migratory waterbirds

<u>Magnitude of impact</u>

5.11.2.199 For the purposes of CRM, a list of 12 species were selected based on a relatively high proportion of birds occurring at locations (e.g. SPAs) close to Hornsea Three (appendix D of annex 5.3: Collision Risk Modelling Report), only one of which has been recorded within the aerial surveys, golden plover.

5.11.2.200 The CRM has predicted low numbers of collisions with proposed turbines for most species, although slightly higher numbers i.e. 23 – 25 individuals per annum of dark-bellied brent geese, golden plover, lapwing and dunlin are predicted to collide (appendix D of annex 5.3: Collision Risk Modelling Report). It can be concluded, however, that in relation to flyway, regional and SPA populations, the additional mortality due to turbine collisions is likely to be negligible for all species based on known population sizes e.g. Holt *et al.* (2012).

5.11.2.201 The impact is predicted to be of local spatial extent, long term duration, continuous and high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be no change.

<u>Sensitivity of the receptors</u>

5.11.2.202 Although migratory non-seabird species have not been significantly studied in the offshore environment, vulnerability to collisions is likely to be generally low, since most migration will occur on a broad front and also above rotor height, although during periods of poor weather this risk may increase. Recoverability of populations of migrants may vary considerably, with smaller wader species with a relatively favourable conservation status (e.g. golden plover) faring better than larger, rarer species with lower reproductive rates (e.g. taiga bean goose). On a precautionary basis and purposes of this assessment these species are assumed to have high sensitivity.

Significance of the effect

5.11.2.203 Overall, the sensitivity of these receptors is considered to be high and the impact magnitude is deemed to be of no change. The effect will, therefore, be of **negligible** significance, which is not significant in EIA terms.

Summary of collision risk impacts in the operation and maintenance phase

5.11.2.204 A summary of collision impacts in the operation and maintenance phase on each VOR is presented in Table 5.30. The significance of impacts ranges from negligible to minor adverse with no impacts considered to be significant in EIA terms.

Table 5.30: Summary of the impact of collisions with rotating turbine blades may result in direct mortality of an individual[a].

VOR	Sensitivity	Magnitude				Significance
		Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season	
Gannet	Medium	Low	Negligible		Negligible	Minor or Negligible or minor adverse
Arctic skua	High	No change (Annual)				Negligible
Great skua	High	No change (Annual)				Negligible
Common tern	Medium		No change		No change	Negligible
Arctic tern	Medium	No change (Annual)				Negligible
Kittiwake	High	Negligible	Negligible		Negligible	Minor adverse
Little gull	Medium	No change (Annual)				Negligible
Lesser black-backed gull	Medium	Low	No change	No change	Negligible	Minor adverse
Great black-backed gull	Medium	Low		Low		Negligible or minor adverse
Migratory waterbirds	High	No change (Annual)				Negligible
a Grey cells indicate not relevant for the species.						

The impact of barrier effects caused by the physical presence of turbines and ancillary structures may prevent clear transit of birds between foraging and breeding sites, or on migration.

5.11.2.205 Barrier effects may occur due to the potential disruption of bird flight lines, which then imposes an extra energetic cost to daily movements or migratory routes (Speakman *et al*., 2009; Masden *et al*., 2010). 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 Hornsea Three. The effect refers to the disruption of preferred flight lines, so that some individuals may choose to re-navigate to alternative routes. Such re-navigation has the potential to lead to increased energetic costs and could affect birds on annual migration or species on foraging excursions from breeding colonies.

5.11.2.206 Hornsea Three is within mean maximum foraging range of gannet (229 km; Thaxter *et al.* 2012) from the nearest breeding colony (Bempton Cliffs within FFC pSPA). However, Hornsea Three is unlikely to provide a barrier to foraging gannets from the colony given the species extensive foraging range and efficient flying capabilities.

5.11.2.207 Hornsea Three is unlikely to provide a barrier to foraging kittiwakes with limited connectivity identified between FFC pSPA and Hornsea Three, as with other gull species (great black-backed, lesser black-backed and little gull) it is expected that birds will continue to pass through Hornsea Three and are at more risk to collision than barrier effects (see collision assessment in paragraphs 5.11.2.148 to 5.11.2.161).

5.11.2.208 Hornsea Three lies outside of the mean-maximum foraging range of guillemot, razorbill, and puffin from the seabird colonies of Flamborough Head and Bempton Cliffs and so is unlikely to provide a barrier to breeding auks on foraging excursions.

5.11.2.209 Due to the similar magnitude of effect likely to be predicted for certain groups of receptors, receptors are grouped in the following assessment sections based on their likely usage of Hornsea Three.

All receptors

Magnitude of impact

5.11.2.210 For seabird species which are within mean maximum foraging range of breeding colonies, these generally forage widely (e.g. fulmar and gannet). As such, turbines associated with Hornsea Three are unlikely to form a significant barrier to movement from any colony, with the closest being at Flamborough Head, at about 149 km away. The impact is therefore predicted to be of local spatial extent, long term duration, intermittent and low to medium reversibility within the context of the regional or national populations. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low at a regional level.

5.11.2.211 For breeding species which are outside of the mean maximum foraging range of breeding colonies (e.g. most gull and auk species), by definition it is highly unlikely that there will be any barrier effect at all. The impact magnitude is therefore, considered to be negligible at a regional level.

5.11.2.212 For migratory species (skuas, terns and little gull), the impact is predicted to be of local spatial extent, short term duration, intermittent and medium to high reversibility within the context of the flyway or European breeding populations. It is predicted that the impact will affect the receptor directly. Because of the species' apparent tolerance of turbines the impact magnitude is therefore, considered to be negligible for all species at an international level during the migratory periods.

<u>Sensitivity of the receptor</u>

5.11.2.213 The vulnerability of a species to barrier effects is most likely to be reflected in the species' reaction to the presence of turbines as considered by Maclean *et al.* (2009). The vulnerability of Hornsea Three VORs to barrier effects range from very low to high.

5.11.2.214 Migratory seabird species included in the impact assessment have been assigned, on a precautionary basis, an international conservation value.

5.11.2.215 Evidence from studies at operational wind farms (Everaert, 2006; Everaert and Kuijken, 2007; Lawrence *et al.*, 2007; Krijgsveld *et al.*, 2011) has shown that gulls, terns and skuas are unlikely to see turbines as a barrier to movement, with some evidence of attraction by little gulls in Krijgsveld *et al.* (2011).

5.11.2.216 All species except gannet, little gull and great skua have shown indications of national declines in breeding numbers and so recoverability is considered medium. For little gull, the species is considered to be increasing in numbers at an international scale (Wetlands International, 2006), albeit at an unknown level, and so recoverability is rated as medium to high. Great skua has shown an upward population trend in recent years although evidence suggests that growth rate is slowing (http://jncc.defra.gov.uk/page-2879) this species is also deemed to have a medium-high recoverability.

5.11.2.217 The overall sensitivity for migratory species is therefore considered to be low.

<u>Significance of the effect</u>

5.11.2.218 .An impact of low magnitude on low sensitivity receptors during the migratory periods will produce a **negligible or minor adverse** effect on the national population, which is considered to be not significant in EIA terms.

Summary of barrier effect impacts in the operation and maintenance phase

5.11.2.219 A summary of barrier effect impacts in the operation and maintenance phase on each VOR is presented in Table 5.31. The significance of impacts is considered to be negligible or minor adverse for all VORs with no impacts considered to be significant in EIA terms.

Table 5.31: Summary of the impact of barrier effects caused by the physical presence of turbines and ancillary structures may prevent clear transit of birds between foraging and breeding sites, or on migration.

Species	Sensitivity	Magnitude	Significance
Fulmar	Low	Low	Negligible or minor adverse
Gannet	Low	Low	Negligible or minor adverse
Arctic skua	Low	Negligible	Negligible or minor adverse
Great skua	Low	Negligible	Negligible or minor adverse
Puffin	Low	Negligible	Negligible or minor adverse
Razorbill	Low	Negligible	Negligible or minor adverse
Guillemot	Low	Negligible	Negligible or minor adverse
Common tern	Low	Negligible	Negligible or minor adverse
Arctic tern	Low	Negligible	Negligible or minor adverse
Kittiwake	Low	Negligible	Negligible or minor adverse
Little gull	Low	Negligible	Negligible or minor adverse
Lesser black-backed gull	Low	Negligible	Negligible or minor adverse
Great black-backed gull	Low	Negligible	Negligible or minor adverse

The impact of attraction to lit structures by migrating birds in particular may cause disorientation, reduction in fitness and possible mortality of seabirds

5.11.2.220 Some species of birds are often attracted to structures such as oil rigs during the hours of darkness, as they may provide opportunities for extended feeding periods, shelter and resting places or navigation aids for migrating birds. Any benefits of lighting, however, may be outweighed by increased risks of collision with gas flares, or in the case of turbines, rotating blades. Turbines are not likely to be extensively lit, compared to oil rigs for example, and so any benefits relating to increased provision of foraging opportunities during hours of darkness are likely to be negligible.

5.11.2.221 The complexity of this issue arises from the fact that disturbance effects of lighting may derive from changes in orientation, disorientation and attraction or repulsion from the altered light environment, which in turn may affect foraging, migration and communication (Longcore and Rich, 2004). Birds may collide with each other or a structure, or become exhausted as a result. Conversely, for unlit turbines at night or during foggy conditions, it is possible that the risk of collision may be greater because moving rotors may not be detectable (Trapp, 1998).

5.11.2.222 Migrating birds are likely to be particularly susceptible to any adverse effects of lighting. Around two thirds of all bird species migrate during darkness, when collision risk is expected to be higher than during daylight (Hüppop *et al.*, 2006).

5.11.2.223 The evidence for this impact is however mixed. ICES (2011) state that birds are somewhat less inclined to avoid turbines at night, but in contrast extended periods of infra-red monitoring at night using a Thermal Animal Detection System (TADS) at Nysted provided unexpected evidence that no movements of birds were detected below 120 m during the hours of darkness, even during periods of heavy seabird migration (Desholm, 2005). Welcker *et al.* (2017) found nocturnal migrants do not have a higher risk of collision with wind energy facilities than do diurnally active species, but rather appear to circumvent collision more effectively.

5.11.2.224 In terms of attraction to lit structures, the worst-case scenario for Hornsea Three would involve 300 turbines and the maximum number of ancillary structures. For maximum visibility, each structure would be fitted with lighting requirements for aviation and shipping.

All receptors

Magnitude of impact

5.11.2.225 The species that are likely to be present in largest numbers (kittiwake, gannet and guillemot) are unlikely to be active at night, either returning to colonies or roosting on the sea surface. In addition, auks and gannet have been shown to avoid wind farms to some degree, and it is therefore possible that this will continue at night, although auks have been found in close proximity to lit oil rigs. Fulmars are unlikely to be found in large aggregations and so any impacts would occur on a relatively small proportion of birds within Hornsea Three at any time. Since gulls are visual foragers that may follow lit trawlers and other vessels, it is unlikely that birds, at least those local to the area, would be disoriented by lit turbines to a significant degree.

5.11.2.226 It is therefore most likely that a significant impact would only occur on any species if large numbers of migrants pass through the site in a single event, leading to mass disorientation or collisions. Certain migratory species (skuas, little gull and terns) may theoretically all move at night and therefore be at risk, although all of these species are given the lowest ranking for nocturnal activity rate by Wade *et al.* (2016). As reported above in the Barrier Effects section (paragraph 5.11.2.205 onwards), precise numbers of birds moving through the site are unknown, but in relation to national or international populations, proportions travelling through Hornsea Three during hours of darkness are likely to be low (see Wade *et al.* (2016) for determination of nocturnal activity rates), particularly as most flights would be below potential collision height. Moreover, there is no evidence from any existing offshore wind farms to suggest mass collision events as a result of the navigational and aviation lighting that is typical for offshore wind farms. As previously referenced, Welcker *et al.* (2017) found nocturnal migrants do not have a higher risk of collision with wind energy facilities than do diurnally active species, but rather appear to circumvent collision more effectively.

5.11.2.227 As such, the impact is therefore predicted to be of local spatial extent, short term duration, intermittent and of low to medium reversibility within the context of any international, national or regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low for all receptors.

Sensitivity of the receptors

5.11.2.228 The attraction to lit structures and therefore any resulting impacts are likely to depend much on each species' presence within Hornsea Three during the hours of darkness, as well as the proportion of flights likely to occur at potential collision height. Based on nocturnal activity rates advocated in Garthe and Hüppop (2004) and King *et al.* (2009), gulls are likely to have moderate levels of nocturnal activity. Garthe and Hüppop (1996) reported that in the southern North Sea, gulls (including kittiwake) frequently forage at fishing vessels during the night. However, Kotzerka *et al.* (2010) reported that kittiwake foraging trips mainly occurred during daylight and birds were mostly inactive during the night, and so risks may be lower for this species despite the proportion of flights at risk heights being higher than for some other species.

5.11.2.229 Gannets have been shown to rarely fly at night, although may do so slightly more during the migratory periods, and their activity rate was rated as low (Wade *et al.*, 2016). A moderate number of flights are likely to be at risk height (Johnston *et al.*, 2014). Fulmar was given a relatively high nocturnal activity rate (4 out of 5) (Wade *et al.*, 2016), which is likely to be due to the long duration of foraging trips undertaken by the species. Very few flights are likely to be at risk height (Wade *et al.* 2016).

5.11.2.230 Auks were attributed a very low nocturnal activity rate score, as were skuas and terns, which is likely to be due to foraging requirements related to visibility rather than smell or obtaining discards, and their relatively short foraging durations. Few flights from these species are likely to be at risk height (Johnston *et al.*, 2014, Wade *et al.* 2016).

5.11.2.231 Based on previously reported conservation status and recoverability levels for each species, in combination with vulnerability, the sensitivity of all receptors is considered to be low, with species generally either having low nocturnal activity rates at potential collision height and high conservation status (e.g. guillemot, terns, skuas, kittiwake) or high nocturnal activity rates at potential collision height and low conservation status (e.g. great black-backed gull), or a similar combination.

Significance of the effect

5.11.2.232 An impact of low magnitude on low sensitivity receptors during the migratory periods will produce a **negligible or minor adverse** effect, which is considered to be not significant in EIA terms for all receptors. This evaluation is supported by literature evidence that those species that are most active at night are unlikely to be affected by lit turbines and other structures, whereas those species that may have been sensitive on account of their conservation status or recoverability are unlikely to be present on site at night.

Summary of the impact of attraction to lit structures during the operation and maintenance phase

5.11.2.233 A summary of the impact of attraction to lit structures is provided in Table 5.32. The significance of all impacts for all VORs are negligible to minor adverse with no impacts considered to be significant in EIA terms.

Table 5.32: Summary of the impact of attraction to lit structures by migrating birds.

Species	Sensitivity	Magnitude	Significance
Fulmar	Low	Low	Negligible or minor adverse
Gannet	Low	Low	Negligible or minor adverse
Arctic skua	Low	Low	Negligible or minor adverse
Great skua	Low	Low	Negligible or minor adverse
Puffin	Low	Low	Negligible or minor adverse
Razorbill	Low	Low	Negligible or minor adverse
Guillemot	Low	Low	Negligible or minor adverse
Common tern	Low	Low	Negligible or minor adverse
Arctic tern	Low	Low	Negligible or minor adverse
Kittiwake	Low	Low	Negligible or minor adverse
Little gull	Low	Low	Negligible or minor adverse
Lesser black-backed gull	Low	Low	Negligible or minor adverse
Great black-backed gull	Low	Low	Negligible or minor adverse

The impact of disturbance as a result of activities associated with maintenance of operational turbines, cables and other infrastructure may result in disturbance or displacement of seabird species

5.11.2.234 Disturbance to birds due to operational offshore wind farms is considered to be of a lower intensity than during construction/decommissioning phases, and limited to maintenance activities as well as vessel and helicopter trips to and from the site and accommodation platforms, and also post-construction monitoring survey activity. The maximum design scenario for the wind farm considered for operation and maintenance disturbance is outlined in Table 5.8.

5.11.2.235 In many cases operation and maintenance disturbance may be indistinguishable from displacement, as birds of particular species may be susceptible to both impacts. A bird that has already been displaced from the wind farm may not be affected by operation and maintenance disturbance. Conversely, operation and maintenance disturbance may exacerbate the impact of displacement if it occurs in an area where birds have been displaced to (e.g. supply vessels en route to and from Hornsea Three). As it is not easy to predict the long-term displacement reactions of birds to turbines, the impacts of operation and maintenance disturbance have been considered in isolation.

5.11.2.236 The operation and maintenance of Hornsea Three may be managed on site using an offshore accommodation platform (with the use of crew boats and/or helicopters) or a floatel (with the use of crew boats and/or helicopters). Regular maintenance of turbines will occur throughout the year. Periodic inspection of the cable will be undertaken by remotely operated vehicles and/or geophysical survey to check that cables have not been exposed due to seabed movements, in which case remedial burial work or other cable protection methods will be required.

All receptors

Magnitude of impact

5.11.2.237 It is expected that there will be daily boat movements within the offshore Hornsea Three area during operation and maintenance, with up to 20 crew vessels predicted on the site. Operational vessels are likely to be much less intrusive to seabird species than those associated with construction activities. Impacts are therefore likely to be of a lower magnitude than disturbance during construction, with birds likely to be affected in a smaller radius around the activity, compared to piling activities during construction for example.

5.11.2.238 The ultimate consequence of disturbance may be increased mortality to an extent similar (although likely more restricted in spatial extent) to displacement impacts, with birds during the breeding season more likely to be susceptible to such impacts. As such, the impact is predicted to be of local spatial extent, long term duration, and intermittent and low to medium reversibility within the context of any international, national or regional population. It is predicted that the impact will affect the receptor directly. If it is assumed that the magnitude of loss is similar to identified displacement impacts (Table 5.22) although reduced in spatial scale it is considered to be negligible for all species.

Sensitivity of the receptors

5.11.2.239 The overall sensitivity of receptors is considered to be of the same levels as those relating to construction disturbance in the Construction Phase impact assessment (see paragraph 5.11.1.3 onwards). Although scientific evidence on the effects of wind farm maintenance activities is lacking, there is no reason to suggest that any receptor will react differently to operation and maintenance activity as opposed to construction phase activity.

Significance of the effect

5.11.2.240 An impact of negligible magnitude on low to medium sensitivity receptors will produce a **negligible or minor adverse** effect on regional populations for all receptors, which is considered to be not significant in EIA terms. For common scoter and red-throated diver which are deemed to be of medium-high sensitivity, an impact of negligible magnitude will produce a **minor adverse** effect, which is considered to be not significant in EIA terms.

Summary of disturbance impacts in the operation and maintenance phase

5.11.2.241 A summary of operation and maintenance disturbance impacts on each VOR is presented in Table 5.33. The significance of impacts ranges from negligible or minor adverse to minor adverse with no impacts considered to be significant in EIA terms.

Table 5.33: Summary of the impact of disturbance as a result of activities associated with maintenance of operational turbines, cables and other infrastructure may result in disturbance or displacement of bird species.

Species	Sensitivity	Magnitude	Significance
Common scoter	Medium to high	Negligible	Minor adverse
Red-throated diver	Medium to high	Negligible	Minor adverse
Fulmar	Low	Negligible	Negligible or minor adverse
Gannet	Low	Negligible	Negligible or minor adverse
Puffin	Medium	Negligible	Negligible or minor adverse
Razorbill	Low to medium	Negligible	Negligible or minor adverse
Guillemot	Medium	Negligible	Negligible or minor adverse
Sandwich tern	Medium	Negligible	Negligible or minor adverse

The impact of pollution including accidental spills and contaminant releases associated with maintenance or supply/service vessels which may affect species' survival rates or foraging activity

5.11.2.242 During the operation phase, each turbine will undergo a routine service every year. As part of this process, hydraulic fluids, gearbox oils and lubricants will be replaced and solid consumables such as filters will be disposed of.

5.11.2.243 Maintenance of the turbines may involve a range of processes, from an exchange of major components up to complete removal of a faulty turbine and replacement using jack-up or crane barges. Scour protection may need to be added to turbine foundations and removal or replacement of other structures such as substations and accommodation platforms may occur.

5.11.2.244 The most likely solution for a break in the subsea cables is to splice in a new section of cable, adding scour protection if required.

5.11.2.245 Maintenance vessels and machinery present will contain a fuel supply and lubricants which, in the event of an incident such as a collision, may be released into the surrounding sea. Details on the potential worst-case spills are presented in paragraph 5.11.1.128 onwards including Table 5.8, for the Construction Phase.

5.11.2.246 This assessment considers the impact of pollution which may affect species' survival rates or foraging activity at Hornsea Three and therefore is of minimal importance to species actively migrating when only briefly transiting Hornsea Three. In the absence of a pathway for effect for migrant seabirds, the VORs considered for this potential impact are those species using The Hornsea Three offshore ornithology study area and The Hornsea Three offshore cable corridor i.e. common scoter, red-throated diver, fulmar, gannet, puffin, razorbill, guillemot, Sandwich tern, kittiwake, lesser black-backed gull and great black-backed gull.

Magnitude of impact

5.11.2.247 As outlined above, it is expected that there will be daily boat movements within Hornsea Three during operation and maintenance, with up to 20 crew vessels on site. In general, maintenance vessels are likely to have lower volumes of potential pollution sources than their construction equivalents, except in the event of turbine replacement. With a lower intensity of activity than during construction, impacts are therefore likely to be of a lower likelihood and magnitude. In addition, PEMMP commitments are part of the mitigation measures adopted as part of design. This will reduce likelihood of event and also reduce the consequence of any spills.

5.11.2.248 Given the likely limited size of potential pollution incidents (based on the volumes of any chemicals carried by one vessel) and the designed-in measures, the impact is therefore predicted to be of local spatial extent, short term duration, intermittent and high reversibility within the context of the regional populations. It is predicted that the impact will affect the receptor both directly and indirectly. The impact magnitude is therefore, considered to be no change at a regional population scale (Table 5.7), for all species.

Sensitivity of the receptor

5.11.2.249 The overall level of sensitivity of receptors is considered to be the same as those relating to pollution impacts in the Construction Phase impact assessment (see paragraph 5.11.1.128 onwards including Table 5.8). A summary of sensitivity for each receptor is provided in Table 5.34 below.

Significance of the effect

5.11.2.250 Based on an impact magnitude for all receptors being no change irrespective of the sensitivity of the receptor a **negligible** effect on the regional population is predicted which is not significant in EIA terms.

Summary of accidental pollution impacts in the operation and maintenance phase

5.11.2.251 A summary of operation and maintenance pollution impacts on each VOR is presented in Table 5.34. The significance of impacts for all VORS is negligible with no impacts considered to be significant in EIA terms.

Table 5.34: Summary of impacts of pollution including accidental spills and contaminant releases associated with maintenance or supply/service vessels which may affect species' survival rates or foraging activity.

Species	Sensitivity	Magnitude	Significance
Common scoter	Medium to high	No change	Negligible
Red-throated diver	Medium to high	No change	Negligible
Fulmar	Low	No change	Negligible
Gannet	Medium to high	No change	Negligible
Puffin	Medium to high	No change	Negligible
Razorbill	Medium to high	No change	Negligible
Guillemot	Medium to high	No change	Negligible
Sandwich tern	Medium	No change	Negligible
Kittiwake	Low to medium	No change	Negligible
Lesser black-backed gull	Low	No change	Negligible
Great black-backed gull	Low	No change	Negligible

Future monitoring

5.11.2.252 The proposed approach to monitoring for offshore ornithology is discussed in the In Principle Monitoring Plan. An Ornithological Monitoring Plan will be produced which will identify the monitoring objectives for key ornithological receptors that will be associated with the assumptions made within assessments potentially relating to flight heights, demographics and proportion of SPA breeding birds at Hornsea Three, foraging ranges, avoidance rates and consequences of displacement.

5.11.3 Decommissioning phase

5.11.3.1 The impacts of the offshore decommissioning of Hornsea Three have been assessed on birds present in the offshore environment. The potential effects arising from the decommissioning of Hornsea Three are listed in Table 5.8 along with the maximum design scenario against which each decommissioning phase impact has been assessed.

5.11.3.2 A description of the potential effect on offshore ornithological receptors caused by each identified impact is given below.

The impact of decommissioning activities such as increased vessel activity and underwater noise may result in direct disturbance or displacement from important foraging and habitat areas of seabirds.

5.11.3.3 A degree of temporary disturbance and displacement is likely to occur throughout the decommissioning phase. The magnitude and significance of any impacts is likely to be of a similar or identical scale to those presented for the construction phase above (from paragraph 5.11.1.11. onwards). The magnitude and significance for each relevant receptor is presented in Table 5.35 below but, overall, the long term effect of this would be to return the area to its former state and the impact on regional or national populations of concern would be neutral with no impact over the long term.

Table 5.35: Summary of the impact of decommissioning activities such as underwater noise and vessel traffic that may result in direct disturbance or displacement from accessing important foraging and habitat areas (highest magnitude shown).

Species	Sensitivity	Magnitude	Significance
Common scoter	High	No change	Negligible
Red-throated diver	High	Negligible	Minor adverse
Gannet	Low	Low	Negligible or minor adverse

Species	Sensitivity	Magnitude	Significance
Puffin	Medium to high	Low	Minor adverse
Razorbill	Low to medium	Low	Negligible or minor adverse
Guillemot	Medium	Low	Minor adverse
Sandwich tern	Medium	Negligible	Negligible or minor adverse

The impact of indirect effects, such as changes in habitat or abundance and distribution of prey resulting in potential impacts on seabirds

5.11.3.4 Indirect impacts will likely be similar or identical to those described for the construction phase e.g. physical disturbance, smothering and re-mobilisation of contaminants affecting prey species. Given the likely low sensitivity of the prey species, including sandeels within the wind farm and cable array footprint to disturbance (see volume 2, chapter 3: Fish and Shellfish Ecology; volume 2, chapter 2: Benthic Subtidal and Intertidal Ecology) and the low magnitude of indirect effects likely to occur on foraging seabirds, the significance of the impact overall would be minor adverse at worst.

Table 5.36: Summary of impact of indirect effects, such as changes in habitat or abundance and distribution of prey.

Species	Sensitivity	Magnitude	Significance
Common scoter	High	Negligible	Minor adverse
Red-throated diver	High	Negligible	Minor adverse
Fulmar	Low	Negligible	Negligible or minor adverse
Gannet	Low	Low	Negligible or minor adverse
Puffin	Medium to high	Low	Minor adverse
Razorbill	Low to medium	Low	Negligible or minor adverse
Guillemot	Medium	Low	Minor adverse
Sandwich tern	Medium	Negligible	Negligible or minor adverse
Kittiwake	Low	Low	Negligible or minor adverse
Lesser black-backed gull	Low to medium	Negligible	Negligible or minor adverse
Great black-backed gull	Low	Negligible	Negligible or minor adverse

The impact of pollution including accidental spills and contaminant releases associated with removal of infrastructure and supply/service vessels may lead to direct mortality of birds or a reduction in foraging capacity

5.11.3.5 The impacts of pollution during the decommissioning activities are expected to be the same or similar as during construction. A summary of these impacts on each species is presented in Table 5.37, which reflects those predicted during the construction phase.

Table 5.37: Summary of the impact of pollution including accidental spills and contaminant releases associated with removal of infrastructure, rigs and supply/service vessels may lead to direct mortality of birds or a reduction in foraging capacity.

Species	Sensitivity	Magnitude	Significance
Common scoter	Medium to high	No change	Negligible
Red-throated diver	Medium to high	No change	Negligible
Fulmar	Low	No change	Negligible
Gannet	Medium to high	No change	Negligible
Puffin	Medium to high	No change	Negligible
Razorbill	Medium to high	No change	Negligible
Guillemot	Medium to high	No change	Negligible
Sandwich tern	Medium	No change	Negligible
Kittiwake	Low to medium	No change	Negligible
Lesser black-backed gull	Low	No change	Negligible
Great black-backed gull	Low	No change	Negligible

5.12 Cumulative Effect Assessment methodology

Screening of other projects and plans into the Cumulative Effect Assessment

5.12.1.1 The Cumulative Effect Assessment (CEA) takes into account the impact associated with Hornsea Three together with other projects and plans. The projects and plans selected as relevant to the CEA are based upon the results of a screening exercise undertaken as part of the 'CEA long list' of projects (see volume 4, annex 5.2: Cumulative Effects Screening Matrix and annex 5.3: Location of Schemes). Each project on the CEA long list has been considered on a case by case basis for scoping in or out of this chapter's assessment based upon data confidence, effect-receptor pathways and the spatial/temporal scales involved.

5.12.1.2 In undertaking the CEA for Hornsea Three, it is important to bear in mind that other projects and plans under consideration will have differing potential for proceeding to an operational stage and hence a differing potential to ultimately contribute to a cumulative impact alongside Hornsea Three. For example, relevant projects and plans that are already under construction are likely to contribute to cumulative impact with Hornsea Three (providing effect or spatial pathways exist), whereas projects and plans not yet approved or not yet submitted are less certain to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors. For this reason, all relevant projects and plans considered cumulatively alongside Hornsea Three have been allocated into 'Tiers', reflecting their current stage within the planning and development process. This allows the CEA to present several future development scenarios, each with a differing potential for being ultimately built out. Appropriate weight may therefore be given to each Tier in the decision making process when considering the potential cumulative impact associated with Hornsea Three (e.g. it may be considered that greater weight can be placed on the Tier 1 assessment relative to Tier 2).

5.12.1.3 A description of each tier is included below:

- Tier 1: Hornsea Three considered alongside:
  - Other project/plans currently under construction; and/or
  - Those with consent, and, where applicable (i.e. for low carbon electricity generation projects), that have been awarded a Contract for Difference (CFD) but have not yet been implemented; and/or
  - Those currently operational that were not operational when baseline data was collected, and/or those that are operational but have an on-going impact.
- Tier 2: All projects/plans considered in Tier 1, as well as:
  - Those project/plans that have consent but, where relevant (i.e. for low carbon electricity generation projects) have no CFD; and/or
  - Submitted but not yet determined.
- Tier 3: All projects/plans considered in Tier 2, as well as those on relevant plans and programmes likely to come forward but have not yet submitted an application for consent (the PINS programme of projects and the adopted development plan including supplementary planning documents are the most relevant sources of information, along with information from the relevant planning authorities regarding planned major works being consulted upon, but not yet the subject of a consent application). Specifically, this Tier includes all projects where the developer has advised PINS in writing that they intend to submit an application in the future, those projects where a Scoping Report is available and/or those projects which have published a PEIR.

5.12.1.4 Offshore wind farms seek consent for a project design envelope, using the worst case scenario within that envelope for assessments. Typically the worst case scenario is characterised by the maximum number of the smallest turbine scenario representing the worst case in impact terms. It is common place that the final design for a project (the ‘as-built; scenario) represents a scenario that has effects of lesser magnitude to those that were originally assessed with the turbine scenario often composed of fewer larger turbines.. In addition, the maximum design scenario quoted in the application (and the associated Environmental Statement) are often refined during the determination period of the application.

5.12.1.5 For example, it is noted that the Applicant for Hornsea Project One considered an overall maximum number of turbines of 332 in the Environmental Statement, but has gained consent for 240 turbines. In addition, it is now known that Hornsea Project One 'as built' consists of 174 turbines. Similarly, Hornsea Project Two has gained consent for an overall maximum number of turbines of 300, as opposed to 360 considered in the Environmental Statement. A similar pattern of reduction in the project envelope from that assessed in the Environmental Statement, through to the consented project and then to the 'as built' project is also seen across other offshore wind farms of relevance to this CEA. This process of refinement can result in a reduction to other project parameters as well as turbine numbers, for example, the number of cables and offshore substations to be installed. The CEA presented in this chapter has been undertaken on the basis of information presented in the Environmental Statements for the other projects, plans and activities. Given that this broadly represents a maximum design scenario, the level of cumulative impact on offshore ornithology would be highly likely be reduced from those presented here.

5.12.1.6 The specific projects scoped into this CEA and the Tiers into which they have been allocated, are outlined in Table 5.38. The range of projects considered within the CEA is dependent on the particular impact as well as each species’ population distribution and behaviour (e.g. foraging range). In general the initial scope of projects has considered all operational, in-construction or planned wind farms along the east coast of Britain, as well as non-UK projects in the North Sea, within potential foraging range.

5.12.1.7 Following PINS guidance received in the Hornsea Project One Second Scoping Opinion, projects will, however, not be considered within the ornithological CEA where its influence on an ornithological receptor, which is also predicted to be significantly affected by Hornsea Three, is considered to be captured within the baseline (i.e. from data collected during baseline surveys for Hornsea Three), as this would lead to effective double-counting of an impact. This takes into account any time-lag for effects to be displayed at a population level (e.g. reductions in productivity, increased mortality), which is particularly relevant for seabird species that breed only after a number of years, and then often intermittently.

5.12.1.8 Although some non-UK offshore wind farms may be within the potential zone of influence for particular ornithological receptors (but less likely to contribute to cumulative impacts due to distances from Hornsea Three), compatible data on these projects are largely unavailable and so these could not be included within a detailed quantitative assessment. It has been assumed, for the purposes of this assessment, that any contribution from these projects to cumulative mortality will be negligible.

5.12.1.9 Owing to the evolution of the methods used to determine impacts of offshore wind farm projects on birds in the UK over the last decade, there is considerable variation in style and detail of presentation of results and subsequent assessment in other project Environmental Statements and technical reports. In many cases, particularly with the older, smaller Round 1 and 2 projects, no attempt has been made to separate, for example, mortality due to collisions between seasons, or between SPA and non-SPA birds. Instead total annual mortality (if this has been estimated) has been assessed against an undetermined population as a 'worst-case' scenario, which would likely overestimate actual impacts on, for example, individual SPA populations, if it is assumed all mortality is to this population.

5.12.1.10 For some impacts, particularly disturbance-displacement related, often a qualitative assessment was deemed sufficient, and there is no reference to displacement rates and/or mortality rates particular to that project.

5.12.1.11 The projects that are included within the cumulative assessment for each species are based on the availability of data, and are presented in the individual impact sections below. For collision impacts this includes all projects for which CRM has been undertaken, but excludes those where collision risk estimates have not been quantified. Projects without appropriate data have been considered, where possible, qualitatively, acknowledging that they may contribute to a cumulative impact. For displacement, an analytical approach has been used which seeks to calculate displacement mortality, comparable with those produced for Hornsea Project Two. This approach follows that used during the examination process for previous projects within the North Sea (e.g. Dogger Bank Creyke Beck A and B). These approaches are discussed further within the relevant sections for each impact.

5.12.1.12 It should be recognised that as some projects are currently within the application process, figures presented will be subject to refinement as a result of consultation and agreements with stakeholders. The figures presented should be seen as being both preliminary and precautionary, and of lower confidence than would otherwise have been the case. As a general rule, projects which presented updated data on or prior to early-2017 have been included in the CEA, this will continue to be updated as the assessment is completed.

5.12.1.13 The guidelines by King *et al.* (2009) recommend that only regulated projects subject to EIA should be included and that unregulated or unplanned activities are usually integrated into baseline results and not required for consideration. A quantitative approach to assessing the potential impacts of other (non-wind) offshore activities was, however, not possible, and a qualitative approach was instead considered. Other activities that may have a direct or indirect impact on birds include the following types of project:

- Marine aggregate and disposal;
- Cable and pipeline construction;
- Commercial fisheries; and
- Oil and gas exploration and production.

5.12.1.14 Activities that were considered to be recorded in the baseline, and where no recent changes have occurred, or future changes are predicted, have been omitted. For activities such as commercial fishing, for example, numbers and distribution of vessels may alter upon commencement of construction of Hornsea Three, hence its inclusion in the CEA.

Table 5.38: List of other projects and plans considered within the CEA.

Tier	Phase	Project/Plan	Distance from Hornsea Three (km)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation and maintenance phase with Hornsea Three operation and maintenance phase
1	***Offshore wind farms***						
	Consent and awarded CfD	Aberdeen Demo	444	Up to 100MW with no more than 11 turbines	2019	No	Yes
		Hornsea Project Two	7	360 turbines assessed in the Environmental Statement (although 300 turbines actually consented).	2018-2019	No	Yes
		Moray East	548	1116MW up to 137 turbines	Not known	Not known	Yes
		Neart na Gaoithe	372	448MW (64x7MW turbines)	Unknown	Yes	Yes
		Triton Knoll	100	288 turbines consented, of which 90 to be constructed.	2018 – 2021	No	Yes
	Under construction	Beatrice	564	588MW - 88 turbines	2017-2019	No	Yes
		Blyth Demo	258	Consented: 99MW (up to 15) In Construction: 41.5MW (5x8MW)	2019	No	Yes
		East Anglia One	152	714MW (102x7MW)	2017 – 2019	No	Yes
		Galloper	195	Up to 336MW (56x6MW turbines)	2019	No	Yes
		Hornsea Project One	7	240 turbines consented, with 174 turbines to be constructed.	2017 – 2019	No	Yes
		Hywind Scotland Pilot Park	438	30MW (5x6MW turbines)	2019	No	Yes
		Race Bank	114	206 turbines consented, of which 91 turbines to be constructed.	2017 - 2018	No	Yes
		Rampion Wind Farm	388	400MW (116x3.45MW)	2017 - 2018	No	Yes
	Operation and maintenance	Dudgeon	87	168 turbines consented, of which 67 turbines were constructed.	2015 – 2017	No	Yes
		Greater Gabbard	198	504MW (140x3.6MWturbines)	N/A	No	Yes
		Gunfleet Sands Demo	245	12MW (2x6MW)	N/A	No	Yes
		Gunfleet Sands I	240	108MW (30x3.6MW)	N/A	No	Yes
		Gunfleet Sands II	239	64.8MW (18x3.6MW)	N/A	No	Yes
		Humber Gateway	128	Up to 219MW (73x3MW turbines)	N/A	No	Yes
		Kentish Flats	272	90MW (30x3MW Vestas turbines). Fully commissioned Dec 2005	N/A	No	Yes
		Kentish Flats Extension	273	49.5MW (15x3.3MW Vestas turbines)	N/A	No	Yes
		Lincs / LID61	139	270MW (75x3.6 MW)	N/A	No	Yes
		London Array	230	630MW (175x3.6MW)	N/A	No	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three (km)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation and maintenance phase with Hornsea Three operation and maintenance phase
		Lynn and Inner Dowsing Wind Farms	147	194 MW(54x 3.6MW Siemens monopiles). Commissioned March 2009. 5km off the coast of Skegness.	N/A	No	Yes
		Methil (Samsung) Demo	412	1x7MW turbine Operated by Scottish Enterprise, round/type - Demonstration/Lease	N/A	No	Yes
		Scroby Sands	132	60MW (30x2MW turbines)	N/A	No	Yes
		Sheringham Shoal	109	316.8MW (88x3.6MW) Sheringham, Greater Wash 17-23 km off North Norfolk	N/A	No	Yes
		Teesside	224	1.5km NE Teesmouth. 62.1MW (27x2.3 MW) Commissioned July 2013.	N/A	No	Yes
		Thanet	260	300MW (100x3 MW monopile turbines) UK, offshore wind, Round 2. 12 km off Foreness Point, Kent Fully commissioned Sep 2010	N/A	No	Yes
		Westermost Rough	132	210MW (35x6MW)	N/A	No	Yes
2	***Offshore wind farms***						
	Consent and no CfD	Dogger Bank Creyke Beck A	76	300 turbines assessed in the Environmental Statement (although 200 turbines actually consented).	2021 – 2024	Yes	Yes
		Dogger Bank Creyke Beck B	99	300 turbines assessed in the Environmental Statement (although 200 turbines actually consented).	2021 – 2024	Yes	Yes
		Dogger Bank Teesside A	107	Up to 1.2GW	2023 - 2026	Yes	Yes
		Sofia (formerly Dogger Bank Teesside B)	95	300 turbines assessed in the Environmental Statement (although 200 turbines actually consented).	2023 - 2026	Yes	Yes
		East Anglia Three	103	Up to 1200MW (up to 172 turbines of up to 7 - 12MW capacity)	2020 – 2022	Yes	Yes
		Inch Cape	384	Up to 784MW (95-110 turbines of up to 7 - 8MW capacity)	Unknown	Yes	Yes
		Kincardine Offshore Wind Farm	422	48MW (8x6MW turbines)	2019	No	Yes
		Methil Demonstration Project - 2B Energy	411	Demonstrator site	Not known	Not known	Yes
		SeaGreen Alpha	383	Up to 525MW (75x7MW)	Unknown	Yes	Yes
		Seagreen Bravo	367	Up to 525MW (75x7MW)	Unknown	Yes	Yes

Tier	Phase	Project/Plan	Distance from Hornsea Three (km)	Details	Date of Construction (if applicable)	Overlap of construction phase with Hornsea Three construction phase	Overlap of operation and maintenance phase with Hornsea Three operation and maintenance phase
	Cables						
	Application	Viking Link Interconnector	13	High voltage (up to 500 kV) Direct Current (DC) electricity interconnector	2018	No	Yes
3	**Offshore wind farms**						
	Planning	Hornsea Project Four	36	1,000 MW	Unknown	Yes	Yes
		East Anglia One North	141	600 MW - 800 MW	Assumed after 2020	Yes	Yes
		East Anglia Two	158	Up to 800MW	2022 – 2024	Yes	Yes
		Moray West	554	750MW Up to 90 turbines	2022-2024	Yes	Yes
		Norfolk Boreas	53	Up to 1800MW	Assumed after 2020	Yes	Yes
		Norfolk Vanguard	73	Seeking consent for up to 257 turbines.	2020 – 2022	Yes	Yes
		Seagreen Charlie	366	Not known	After 2022	Yes	Yes
		Seagreen Delta	355	Not known	After 2022	Yes	Yes
		Seagreen Echo	345	Not known	After 2022	Yes	Yes
		Seagreen Foxtrot	383	Not known	After 2022	Yes	Yes
		Seagreen Golf	355	Not known	After 2022	Yes	Yes
		Thanet Extension		340 MW – 34 turbines	2021	Yes	Yes

5.12.2 Maximum design scenario

5.12.2.1 The maximum design scenarios identified in Table 5.39 have been selected as those having the potential to result in the greatest effect on an identified receptor or receptor group. The cumulative impact presented and assessed in this section have been selected from the details provided in the Hornsea Three project description (volume 1, chapter 3: Project Description), as well as the information available on other projects and plans, in order to inform a 'maximum design scenario'. Effects of greater adverse significance are not predicted to arise should any other development scenario, based on details within the project Design Envelope (e.g. different turbine layout), to that assessed here be taken forward in the final design scheme. Other aspects, namely indirect impacts associated with prey redistribution and availability, pollution incidents, lighting and barrier effects are very difficult to quantify, and although it is acknowledged that cumulative impacts are possible, the magnitude of these impacts is not considered to be significant at a population level for any VOR, and is therefore not considered further within the CEA for offshore ornithology.

Table 5.39: Maximum design scenario considered for the assessment of potential cumulative impacts on offshore ornithology.

Potential impact	Maximum design scenario	Justification
Construction phase		
The impact of construction activities such as increased vessel activity and underwater noise, may result in direct disturbance or displacement from important foraging and habitat areas of birds.	**Maximum design scenario: Construction vessels** Maximum design scenario as described for construction phase assessed cumulatively with the full development of the following projects: Tier 1: • Hornsea Project Two Tier 2 • Dogger Bank Creyke Beck A • Dogger Bank Creyke Beck B • Dogger Bank Teesside A • Sofia (formerly Dogger Bank Teesside B) • East Anglia Three Tier 3 • Norfolk Vanguard	**Maximum design scenario: Construction vessels** Maximum design scenario provides for the greatest number of potential vessels associated with the construction phase and hence the highest likelihood of potential disturbance / displacement to bird species, as a result of multiple activities taking place over a 11 year offshore construction period. Maximum design scenario also reflects season and location with respect to a species abundance and vulnerability to an impact in the zone of influence. **Maximum design scenario: Construction activity** Maximum Design Scenario provides for the greatest disturbance/displacement effects to bird species due to construction activities (magnitude and duration).
Operation and maintenance phase		
The impact of physical displacement from an area around turbines (300) and other ancillary structures (up to twelve offshore transformer substations, up to three offshore accommodation platforms and four offshore HVAC booster substations) during the operation phase of the development may result in effective habitat loss and reduction in survival or fitness rates.	Maximum design scenario as described for operation and maintenance phase assessed cumulatively with all projects in each Tier included in Table 5.38.	Provides for the maximum amount (spatial extent) of habitat loss due to physical displacement effects. For sensitive species, the wind farm as a whole will be avoided, whereas for others only individual turbines will be avoided while within the wind farm. Edge-weighted layout will potentially maximise area of sea rendered unavailable to birds.
Mortality from collision with rotating turbine blades	Maximum design scenario as described for operation and maintenance phase assessed cumulatively with all projects in each Tier included in Table 5.38.	Greatest rotor swept area plus parameters that maximise collision risk and therefore mortality rates for all species as the surface area available for collision increases. This is the turbine layout with the largest combined rotor swept area and collision probability, the latter at its highest when turbines are at maximum rotor speed and at the lowest tip height.

5.13 Cumulative Effect Assessment

5.13.1.1 A description of the significance of cumulative effects upon offshore ornithological receptors arising from each identified impact is given below.

5.13.2 Construction phase

5.13.2.1 Any potential cumulative impacts on the VORs will only occur if the construction phases of wind farm projects within a particular spatial extent (for example foraging range during breeding season or the North Sea in winter) are coincidental or sequential, leading to a short- to mid-term impact.

5.13.2.2 Although it is difficult to quantify, numbers affected are likely to be lower than those predicted in the cumulative displacement assessment in the following Operation and Maintenance Impacts section, since the number of projects relevant to the assessment is smaller, and the duration and extent of impacts are unlikely to be as large. With species likely to be of similar vulnerability to construction and displacement impacts, the levels of magnitude and significance predicted by operation and maintenance displacement can be used as a basis for construction disturbance effects.

The impact of construction activities such as increased vessel activity and underwater noise, may result in direct disturbance or displacement from important foraging and habitat areas of birds

5.13.2.3 In section 5.11 the potential impact of construction activities that may result in direct disturbance or displacement from important foraging and habitat areas of birds, was assessed for common scoter, red-throated diver, gannet and auks

Tier 1

<u>Magnitude of impact</u>

5.13.2.4 Hornsea Project Two is the only Tier 1 project predicted to overlap with the construction of Hornsea Three. Disturbance events during construction activities (including piling of foundations) will disturb and displace birds for the duration of the construction period. As construction activities will be focused at specific locations within the Hornsea Three array area, it is expected to lead to a displacement impact of lesser magnitude than that predicted during operation and maintenance. Any impacts resulting from disturbance and displacement from construction activities are considered likely to be short-term, temporary and reversible in nature, lasting only for the duration of construction activity, with birds expected to return to the area once construction activities have ceased. The installation of the offshore components of Hornsea Three will occur over a maximum duration of 11 years, assuming a two phase construction scenario (Table 5.8). A gap of three years may occur between the same activity in different phases with in consequence the construction period considered of medium term duration as birds may return to areas when activities are not currently occurring.

5.13.2.5 At this stage, the likely origin and routing of vessels involved in the construction of Hornsea Three or any of the Dogger projects is not known. However, for the purposes of this assessment it is considered that construction vessels involved in construction and cable laying activities associated with the Dogger Bank projects would be unlikely to originate in the Greater Wash area and are, therefore, unlikely to affect areas within the Greater Wash known to support relatively high densities of common scoter and red-throated diver. given the distance between the Dogger Bank projects and ports adjacent to the Greater Wash pSPA.

5.13.2.6 In section 5.11, the assessment of this impact for Hornsea Three alone was predicted to be at most of low magnitude for the VORs, on the basis that the extent of disturbance is limited, as construction activities will take place only within a small area of the site at any time (i.e. local spatial extent and intermittent with respect to any one area). The other projects under consideration have also typically predicted effects of negligible magnitude for this impact.

5.13.2.7 The impact is predicted to be of local spatial extent, medium term duration, intermittent and low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be at most low dependent upon on the VOR.

<u>Sensitivity of receptor</u>

5.13.2.8 The sensitivity of all VORs to cumulative disturbance/displacement due to construction activity is considered to be the same as predicted in Table 5.18 when assessing this impact for Hornsea Three alone.

5.13.2.9 For the receptors assessed, common scoter, red-throated diver, gannet and auks, are deemed to be of very low to very high vulnerability, low to high recoverability and regional to international value. The sensitivity of the receptor is therefore, considered to be low for gannet, medium for guillemot, low to medium for razorbill, medium to high for puffin and, high for common scoter and red-throated diver.

<u>Significance of Effect</u>

5.13.2.10 Overall, the sensitivity of the receptors is considered to be low to high and the impact magnitude is deemed to be at most low. The effect will, therefore, be at most of **minor adverse** significance, which is not significant in EIA terms.

Tier 2

<u>Magnitude of impact</u>

5.13.2.11 In addition to the Tier 1 projects considered above, those Tier 2 projects predicted to overlap with the construction of Hornsea Three are Dogger Bank Creyke Beck A&B, Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B), East Anglia Three. An assessment of the effects of Norfolk Vanguard has yet to be made, but the Environmental Statement for East Anglia Three considered the likely magnitude of the effects of construction activities to be of negligible magnitude for all species.

5.13.2.12 The impact is predicted to be of local spatial extent, medium term duration, intermittent and with low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be at most low dependent on the VOR.

Sensitivity of receptor

5.13.2.13 The sensitivity of all ornithological receptors to cumulative disturbance/displacement due to construction activity is considered to be the same as predicted in Table 5.18 when assessing this impact for Hornsea Three alone.

5.13.2.14 For the receptors assessed, common scoter, red-throated diver, gannet and auks, are deemed to be of very low to very high vulnerability, low to high recoverability and regional to international value. The sensitivity of the receptor is therefore, considered to be low for gannet, low to medium for razorbill, medium for guillemot, medium to high for puffin and, high for common scoter and red-throated diver.

Significance of Effect

5.13.2.15 Overall, the sensitivity of the receptors is considered to be low to high and the impact magnitude is deemed to be at most low. The effect will, therefore, be at most of **minor adverse** significance, which is not significant in EIA terms.

5.13.3 Operation and maintenance phase

The impact of physical displacement from the Hornsea Three array area during the operational and maintenance phase of the development may result in effective habitat loss and reduction in survival or fitness rates.

Methodology for cumulative effect assessment - displacement

5.13.3.1 Predicted displacement effects for Hornsea Three alone during the operation and maintenance phase are discussed in depth in section 5.9.2 above. With respect to this cumulative assessment of displacement effects, suitable information was obtained from each relevant project's Environmental Statement chapter, Technical Report or other submitted documents.

5.13.3.2 Recently published interim guidance by JNCC *et al.* (2017) state that displacement impacts for each relevant species should be assessed based on a wide range of potential displacement and mortality rates in a 'matrix'. While some recent Environmental Statements use this matrix approach (e.g. Hornsea Project One, Aberdeen European Offshore Wind Deployment Centre, Dogger Bank Creyke Beck Projects A and B, Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B), and Seagreen Alpha and Bravo), many older projects do not. Instead of discounting data from all projects without a matrix approach, their data has been considered here where possible.

5.13.3.3 For Hornsea Three, the mean peak/peak population estimates were calculated for Hornsea Three array area plus 2 km buffer, following JNCC *et al.* (2017). As described in paragraph 5.11.2.8 for example, gulls (e.g. kittiwake) have a low sensitivity to disturbance/displacement, and so any displacement impacts are unlikely to extend further than the wind farm itself, whereas a moderate vulnerability species such as guillemot may show displacement up to a buffer of 1 km. Predicted displacement mortality is not expected to occur on a year on year basis; it is considered more likely to relate to a singular event following which seabirds will respond to by either redistribution or habituation.

5.13.3.4 No species where JNCC *et al.* (2017) recommend a 4 km buffer (divers and scoters) are relevant in this assessment of the Hornsea Three array area, none of these species having been identified as VORs for the latter area..

Methodology

5.13.3.5 In the large majority of projects that are now operational, no attempt was made to quantify either the number of birds displaced by the wind farm, or the resultant mortality levels. Instead a qualitative assessment is usually conducted and as such these projects cannot be included as part of the quantitative assessment. For certain other projects, 100% displacement has been assumed, but the resultant mortality rate is not considered and in some (e.g. Beatrice), the impact on productivity rather than mortality is considered the more appropriate metric. These projects are also excluded from the quantitative assessment.

5.13.3.6 Some applications are still within the planning process at the time of writing. It is therefore considered that the figures provided in such cases have not been finalised. The levels of mortality predicted are therefore subject to change, and so the confidence level in their results is low.

5.13.3.7 As part of the Hornsea Project One and Hornsea Project Two and Dogger Bank Creyke Beck A and B, Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B) examination processes, Natural England raised concerns relating to the potential cumulative displacement of auks from projects within the North Sea. The cumulative assessment has therefore focussed on the three auk species, puffin, razorbill and guillemot. These species are amongst the most sensitive of species exposed to displacement effects and are widespread over the majority of the annual cycle in the North Sea. The impact of displacement from Hornsea Three alone has also extended to fulmar and gannet (see section 5.11.2). While both species are considered prone to displacement from operational wind farm areas, the consequences of displacement on these two species are considered to be trivial. They both have vast foraging areas in all seasons and have particularly high degrees of habitat flexibility (Wade *et al.*, 2016). On this basis, no quantitative cumulative displacement assessment is attempted for these two species.

5.13.3.8 Two data sources have been used to determine the potential levels of displacement and mortality from wind farms included in the cumulative effect assessment:

- Population data held in individual wind farm project Environmental Statements and Habitats Regulations Assessments consisting of population estimates for individual project areas rather than raw survey data; and
- Density data provided in the Natural England seabird Sensitivity Mapping for English Territorial Waters (WWT Consulting and MacArthur Green, 2013).

5.13.3.9 The latter dataset has been compiled from the JNCC's European Seabirds at Sea databased from boat surveys; Wildfowl and Wetlands Trust (Consulting) Ltd.'s aerial survey database and several publically available boat based survey datasets from surveys for offshore wind farms and comprises predicted densities at a resolution of 3 km x 3 km grid cells.

5.13.3.10 For the data from WWT Consulting and MacArthur Green (2013), GIS has been used to derive mean densities for common guillemot, razorbill, and puffin and for individual wind farm project areas. GIS has also been used to calculate the development area plus a 2 km buffer for each wind farm project. Numbers of birds present within the footprint of each project (and project + buffer) has then been calculated through simply multiplying area (in km^2) by mean density. The Natural England data is presented for both breeding and non-breeding seasons, with no further division into a post-breeding dispersion season.

5.13.3.11 For data from individual projects, monthly population estimates have been collated where available. For some projects data is not available for the relevant buffer area and the data has been scaled up or down based on data from other project areas.

5.13.3.12 Upon obtaining mean-peak population estimates for the individual projects the numbers of birds affected through displacement and subsequent mortality has been calculated using the displacement and mortality rates agreed for Hornsea Project Two.

5.13.3.13 For earlier Round 1 and 2 projects monthly population data is not available and it has not been possible to derive specific apportioned displacement and mortality values. For these projects a combination of both the Natural England data and available project data has been used to derive representative values. This has been undertaken by comparing known project population estimates against those from the Natural England dataset and deriving appropriate scaling factors that can then be applied to projects for which the population estimate data is lacking.

Puffin

Tier 1

Magnitude of impact

Breeding season

5.13.3.14 Using the same assumptions as for Hornsea Three alone (50% displacement and 2-10% mortality), the predicted cumulative mortality of puffin due to the displacement predicted to arise from Hornsea Three and Tier 1 projects in the breeding season is up to 105-108 birds (see Table 5.40).

5.13.3.15 It is considered likely that a significant proportion of the population of puffin present at Hornsea Three during the breeding season is composed of immature birds (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). In addition, a further proportion are likely to be non-breeding adult birds. Therefore, mortality predicted during the breeding season is considered likely to result in considerably less than 105-108 adult birds from the regional breeding population.

5.13.3.16 The impact of displacement mortality on puffin during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Non-breeding season

5.13.3.17 Using the same assumptions as for Hornsea Three alone (50% displacement and 1% mortality), the precautionary predicted cumulative mortality of puffin due to the displacement predicted to arise from Hornsea Three and Tier 1 projects in the non-breeding season is 45 birds (see Table 5.40), which represents a small proportion of the regional non-breeding season population of 231,957 individuals. The impact magnitude of this effect would not exceed 1% of the baseline mortality (21,804 individuals) within this population.

5.13.3.18 The impact of displacement mortality on puffin during the non-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Sensitivity of receptor

5.13.3.19 Puffin is considered to be of international conservation value, with species recoverability considered as low. Behaviourally, Wade *et al.* (2016) have rated puffin as being of moderate vulnerability to displacement.

5.13.3.20 In summary, puffin is deemed to be of moderate vulnerability, low recoverability and international value. The sensitivity of the VOR is, therefore, considered to be medium.

Significance of Effect

5.13.3.21 The sensitivity of puffin is considered to be medium and the impact magnitude is deemed to be low (breeding season). The effect is predicted, therefore, to be of **minor adverse** significance, which is not significant in EIA terms.

Tiers 1 and 2

Magnitude of impact

Breeding season

5.13.3.22 Using the same assumptions as for Hornsea Three alone (50% displacement and 2-10% mortality), the precautionary predicted cumulative mortality of puffin due to the displacement predicted to arise from Tier 1 and Tier 2 projects in the breeding season is 116-119 (Table 5.40).

Non-breeding season

5.13.3.23 Using the same assumptions as for Hornsea Three alone (50% displacement and 1% mortality), the precautionary predicted cumulative mortality of puffin due to the displacement predicted to arise from Tier 1 and Tier 2 projects in the non-breeding season is 68 (see Table 5.40), which represents a small proportion of the regional non-breeding season population of 231,957 individuals. The magnitude of this effect would not exceed 1% of the baseline mortality (21,804 individuals) within this population.

5.13.3.24 The impact of displacement mortality on puffin during the non-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Sensitivity of receptor

5.13.3.25 Puffin is considered to be of international conservation value, with species recoverability considered as low. Behaviourally, Wade *et al.* (2016) have rated puffin as being of moderate vulnerability to displacement.

5.13.3.26 In summary, puffin is deemed to be of moderate vulnerability, low recoverability and international value. The sensitivity of the VOR is, therefore, considered to be medium.

Significance of effect

5.13.3.27 The sensitivity of puffin is considered to be medium and the impact magnitude is deemed to be low (breeding season). The effect is predicted, therefore, to be of **minor adverse** significance, which is not significant in EIA terms.

Table 5.40: Puffin cumulative mortality as a result of displacement (all birds).[a]

Offshore wind farm	Breeding season (50% displacement, 10% mortality)	Non-breeding season (50% displacement, 1% mortality)
Hornsea Three[b]	3-13	1
Tier 1		
Aberdeen		0
Beatrice		12
Blyth Demonstration	12	1
Dudgeon	0	0
East Anglia ONE		0
Galloper		0
Greater Gabbard		0
Hornsea Project One	54	6
Hornsea Project Two	23	10
Humber Gateway	1	0
Hywind		0
Lincs and LID6	0	0
London Array		0
Moray East		3
Neart na Gaoithe		11
Race Bank	0	0
Sheringham Shoal	0	0
Teesside	2	0
Thanet		0
Triton Knoll	1	0
Westermost Rough	3	0
Tier 1 total	**105-108**	**45**
Tier 2		
Dogger Bank Creyke Beck A	2	1
Dogger Bank Creyke Beck B	5	4
Dogger Bank Teesside A	2	1

Offshore wind farm	Breeding season (50% displacement, 10% mortality)	Non-breeding season (50% displacement, 1% mortality)
Sofia (formerly Dogger Bank Teesside B)	2	2
East Anglia Three		1
Inch Cape		13
Kincardine		0
Seagreen A		0
Seagreen B		0
Tier 2 total	**10**	**22**
Total	**116-119**	**68**

a The numbers presented in cumulative displacement and collision tables are rounded to the nearest whole number. Underlying calculations are based on real numbers (i.e. all decimal places).
b a 2-10% mortality rate range is presented for Hornsea Three

Razorbill

Population structure

5.13.3.28 In the breeding season, it is considered that impacts associated with projects throughout the North Sea may act cumulatively with Hornsea Three. As such, the population of razorbill that is predicted to be exposed to cumulative displacement impacts in the breeding season will be composed of a proportion of breeding adults, immature birds and non-breeding adults. It is not known how many immature or non-breeding razorbill are present in the North Sea during the breeding season and it is therefore difficult to calculate a population against which impacts can be assessed. In addition, different projects, depending on their proximity to breeding colonies will impact differing proportions of breeding adult, immature or non-breeding adult birds. For example, at projects such as Hornsea Three that are located beyond the foraging range of razorbill from any breeding colony the population affected will consist of immature and non-breeding birds whereas at projects such as Humber Gateway that are located closer to breeding colonies, the population is likely to consist of adult breeding birds, immature birds and non-breeding adult birds.

5.13.3.29 Paragraph 5.11.2.61 describes a process by which to calculate the immature population present at Hornsea Three using the population of razorbill present in the North Sea during the non-breeding season and assuming that these birds remain in the North Sea into the breeding season. This however, is likely to be a considerable under-estimate as a large proportion of immature razorbill winter outside of the North Sea, returning in the breeding season. At breeding colonies in the North Sea the total number of breeding adult birds is 90,304 (Furness, 2015). Furness (2015) indicates that the non-breeding component of a razorbill population will represent 43% of the total population. This would therefore mean that there are an additional 68,124 immature birds associated with breeding colonies in the North Sea. However, the use of these populations is not appropriate in a cumulative context as this would not capture the complexity of the population structure present in the North Sea, as it ignores the distribution of different age classes. Given the complexities of the population affected by cumulative impacts no attempt has been made to compare the predicted impact against a relevant population and instead a qualitative assessment is provided for the breeding season.

5.13.3.30 During non-breeding seasons the population affected by cumulative displacement impacts is predicted to comprise a mixture of adults and immatures from colonies on the east coast of the UK with smaller proportions from colonies further afield during the non-breeding season.

Tier 1

Magnitude of impact

Breeding season

5.13.3.31 Using the same assumptions as for Hornsea Three alone (40% displacement and 2-10% mortality) the precautionary predicted cumulative mortality of razorbill due to the displacement predicted to arise from Hornsea Three and Tier 1 projects in the breeding season is 336-356 (Table 5.41). Such predicted mortality is not however expected to occur on a year on year basis; it is considered more likely to relate to a singular event following which seabirds will respond by either redistribution or habituation. Displacement from an area is unlikely to result in direct mortality on individual birds, instead the impact of displacement will have fitness consequences in terms of productivity and mortality which will vary depending on the age of the birds impacted.

5.13.3.32 Hornsea Three contributes 1.5 - 7.0% of the Tier 1 cumulative total with the birds experiencing displacement impacts at Hornsea Three considered to be either immature or non-breeding birds. In the breeding season these birds are considered likely to be less susceptible to displacement impacts as they are not constrained to certain areas as are breeding birds. As stated above in the project alone assessment Hornsea Three is located in an area of the North Sea that does not support high densities of razorbill and therefore it is unlikely to represent an important area for the species. This is equally applicable to a number of other projects considered cumulatively. For projects located in areas that support only low densities of razorbill or those projects that are outside of the foraging range of razorbill from breeding colonies, it is considered that a mortality rate of 10% over-estimates the likely level of impact.

5.13.3.33 The cumulative impact predicted for razorbill in Table 5.41 has been considered sustainable in previous assessments (Natural England, 2015d) and as a long-lived species, razorbill is considered to be able to adapt to changes in the environment exhibiting a moderate level of habitat flexibility (Wade *et al.,* 2016).

5.13.3.34 The impact of displacement mortality on razorbill during the breeding season is therefore predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Post-breeding season

5.13.3.35 During the post-breeding season, using a displacement rate of 40% and a mortality rate of 2% the precautionary predicted cumulative mortality of razorbill due to the displacement predicted to arise from Hornsea Three and Tier 1 projects in the post-breeding season is 168 birds (Table 5.41). This represents a small proportion of the regional population (591,874 individuals) and does not represent an increase in baseline mortality (62,147 individuals) of greater than 1%.

5.13.3.36 The impact of displacement mortality on razorbill during the post-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Non-breeding season

5.13.3.37 During the non-breeding season, using a displacement rate of 40% and a mortality rate of 1% the precautionary predicted cumulative mortality of razorbill due to the displacement predicted to arise from Hornsea Three and Tier 1 projects in the non-breeding season is 39 birds (Table 5.41). This represents a small proportion of the regional population (218,622 individuals) and does not represent an increase in baseline mortality (22,955 individuals) of greater than 1%.

5.13.3.38 The impact of displacement mortality on razorbill during the non-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Pre-breeding season

5.13.3.39 During the pre-breeding season, using a displacement rate of 40% and a mortality rate of 2% the precautionary predicted cumulative mortality of razorbill due to the displacement predicted to arise from Hornsea Three and Tier 1 projects in the pre-breeding season is 59 birds (Table 5.41). This represents a small proportion of the regional population (591,874 individuals) and does not represent an increase in baseline mortality (62,147 individuals) of greater than 1%.

5.13.3.40 The impact of displacement mortality on razorbill during the pre-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Sensitivity of receptor

5.13.3.41 Razorbill is considered to be of regional conservation value as a result of regionally important populations of this species being recorded in Hornsea Three offshore ornithology study area in the breeding season. With a regional and national population trend likely to be at least stable, the species recoverability is considered medium, and behaviourally Wade *et al.* (2016) has rated it as being of high vulnerability to displacement.

5.13.3.42 In summary, razorbill is deemed to be of high vulnerability, medium recoverability and regional value. The sensitivity of the VOR is therefore, considered to be low to medium.

Significance of Effect

5.13.3.43 The sensitivity of razorbill is considered to be low to medium and the impact magnitude is deemed to be low (breeding season). The predicted displacement mortality is based on conservative assumptions, including the use of precautionary displacement and mortality rates In addition, it is considered unlikely that all projects included in Tier 2 will be brought forward or, if constructed, they are unlikely to be built out to the maximum design scenario assumptions made in the respective impact assessments.

5.13.3.44 On this basis it is judged that the cumulative impact of Hornsea Three together with Tier 1 projects is likely to be of **minor significance**, which is not significant in EIA terms.

Tiers 1 and 2

Magnitude of impact

Breeding season

5.13.3.45 Using the same assumptions as for Hornsea Three alone (40% displacement and 10% mortality) the precautionary predicted cumulative mortality of razorbill due to the displacement predicted to arise from Tier 1 and Tier 2 projects in the breeding season is 776-796 (Table 5.41). Displacement from an area is unlikely to result in direct mortality on individual birds, instead the impact of displacement will have fitness consequences in terms of productivity and mortality which will vary depending on the age of the birds impacted.

5.13.3.46 Hornsea Three contributes 0.6 - 3.1% of the Tier 1 cumulative total with the birds experiencing displacement impacts at Hornsea three considered to be either immature or non-breeding birds. In the breeding season, these birds are considered likely to be less susceptible to displacement impacts as they are not constrained to certain areas unlike breeding birds. As stated above in the project alone assessment, Hornsea Three is located in an area of the North Sea that does not support high densities of razorbill and therefore it is unlikely to represent an important area for the species. This is equally applicable to a number of other projects considered cumulatively. For projects located in areas that support only low densities of razorbill or those projects that are outside of the foraging range of razorbill from breeding colonies, it is considered that a mortality rate of 10% over-estimates the likely level of impact.

5.13.3.47 The cumulative impact predicted for razorbill in Table 5.41 has been considered sustainable in previous assessments (Natural England, 2015d) and as a long-lived species, razorbill is considered to be able to adapt to changes in the environment exhibiting a moderate level of habitat flexibility (Wade *et al.,* 2016).

5.13.3.48 The impact of displacement mortality on razorbill during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Post-breeding season

5.13.3.49 During the post-breeding season, using a displacement rate of 40% and a mortality rate of 2% the precautionary predicted cumulative mortality of razorbill due to the displacement predicted to arise from Tier 1 and Tier 2 projects in the breeding season is 232 (Table 5.41). This represents a small proportion of the regional population (591,874 individuals) and does not represent an increase in baseline mortality (62,147 individuals) of greater than 1%.

5.13.3.50 The impact of displacement mortality on razorbill during the post-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Non-breeding season

5.13.3.51 During the non-breeding season, using a displacement rate of 40% and a mortality rate of 1% the precautionary predicted cumulative mortality of razorbill due to the displacement predicted to arise from Tier 1 and Tier 2 projects in the non-breeding season is 71 (Table 5.41). This represents a small proportion of the regional population (218,622 individuals) and does not represent an increase in baseline mortality (22,955 individuals) of greater than 1%.

Table 5.41: Razorbill cumulative mortality as a result of displacement (all birds).

Offshore wind farm	Breeding season (40% displacement, 10% mortality)	Post-breeding season (40% displacement, 2% mortality)	Non-breeding season (40% displacement, 1% mortality)	Pre-breeding season (40% displacement, 2% mortality)
Hornsea Three[a]	5-25	16	15	10
Tier 1				
Aberdeen	6	1	0	0
Beatrice	35	7	2	7
Blyth Demonstration	5	1	0	1
Dudgeon	10	3	3	3
East Anglia ONE	1	0	1	3
Galloper	2	0	0	3
Greater Gabbard	0	0	2	1
Hornsea Project One	44	38	6	14
Hornsea Project Two	100	34	3	13
Humber Gateway	1	0	0	0
Hywind	3	0	0	0
Lincs and LID6	2	0	0	0
London Array	1	0	0	0
Moray East	97	9	0	1
Neart na Gaoithe	13	44	2	0

Offshore wind farm	Breeding season (40% displacement, 10% mortality)	Post-breeding season (40% displacement, 2% mortality)	Non-breeding season (40% displacement, 1% mortality)	Pre-breeding season (40% displacement, 2% mortality)
Race Bank	1	0	0	0
Sheringham Shoal	4	11	1	0
Teesside	1	0	0	0
Thanet	0	0	0	0
Triton Knoll	2	2	3	1
Westermost Rough	4	1	1	1
Tier 1 total	**336-356**	**168**	**39**	**59**
Tier 2				
Dogger Bank Creyke Beck A	50	13	7	33
Dogger Bank Creyke Beck B	62	17	9	41
Dogger Bank Teesside A	33	2	4	15
Sofia (formerly Dogger Bank Teesside B)	46	5	6	24
East Anglia Three	27	5	5	12
Inch Cape	57	23	3	0
Kincardine	1	0	0	0
Seagreen A	128	0	0	0
Seagreen B	35	0	0	0
Tier 2 total	**440**	**64**	**32**	**125**
Total	**776-796**	**232**	**71**	**185**
a a 2-10% mortality rate range is presented for Hornsea Three				

5.13.3.52 The impact of displacement mortality on razorbill during the non-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Pre-breeding season

5.13.3.53 During the pre-breeding season, using a displacement rate of 40% and a mortality rate of 2% the precautionary predicted cumulative mortality of razorbill due to the displacement predicted to arise from Tier 1 and Tier 2 projects in the pre-breeding season is 185 (Table 5.41). This represents a small proportion of the regional population (591,874 individuals) and does not represent an increase in baseline mortality (62,147 individuals) of greater than 1%.

5.13.3.54 The impact of displacement mortality on razorbill during the pre-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of high reversibility involving a small number of individuals representing a small proportion of the regional population. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be negligible.

Sensitivity of receptor

5.13.3.55 Razorbill is considered to be of regional conservation value as a result of nationally important populations of this species being recorded in Hornsea Three offshore ornithology study area in the breeding season. With a regional and national population trend likely to be at least stable, the species recoverability is considered medium, and behaviourally Wade *et al.* (2016) has rated it as being of high vulnerability to displacement.

5.13.3.56 In summary, razorbill is deemed to be of high vulnerability, medium recoverability and regional value. The sensitivity of the VOR is therefore, considered to be low to medium.

Significance of effect

5.13.3.57 The sensitivity of razorbill is considered to be low to medium and the impact magnitude is deemed to be low (breeding season). The predicted displacement mortality is based on conservative assumptions, including the use of precautionary displacement and mortality rates In addition, it is considered unlikely that all projects included in Tier 2 will be brought forward or, if constructed, they are unlikely to be built out to the maximum design scenario assumptions made in the respective impact assessments.

5.13.3.58 On this basis it is judged that the cumulative impact of Hornsea Three together with Tier 2 projects is likely to be of **minor significance**, which is not significant in EIA terms.

Guillemot

Population structure

5.13.3.59 In the breeding season, it is considered that impacts associated with projects throughout the North Sea may act cumulatively with Hornsea Three. As such, the population of guillemot that is predicted to be exposed to cumulative displacement impacts in the breeding season will be composed of a proportion of breeding adults, immature birds and non-breeding adults. It is not known how many immature or non-breeding guillemot are present in the North Sea during the breeding season and it is therefore difficult to calculate a population against which impacts can be assessed. In addition, different projects, depending on their proximity to breeding colonies will impact differing proportions of breeding adult, immature or non-breeding adult birds. For example at projects such as Hornsea Three that are located beyond the foraging range of guillemot from any breeding colony, the population affected will consist of immature and non-breeding birds whereas at projects such as Humber Gateway that are located closer to breeding colonies, the population is likely to consist of adult breeding birds, immature birds and non-breeding adult birds.

5.13.3.60 Guillemot is a dispersive rather than a migratory species with birds overwintering in sea areas close to their breeding colonies, although immature birds do disperse further than adults (Wernham *et al.,* 2002). Furness (2015) suggests that only reasonably high proportions (up to 80%) of immature guillemots from colonies bordering the North Sea remain in the North Sea during winter. At breeding colonies in the UK North Sea the total number of breeding adult birds is 1,175,332 (Furness, 2015). Furness (2015) indicates that the non-breeding component of a guillemot population will represent 43% of the total population. This would therefore mean that there are an additional 869,746 immature birds associated with breeding colonies in the North Sea. It is possible that not all immature birds associated with UK North Sea breeding colonies will be present in the North Sea during the breeding season, although immature birds from elsewhere (breeding colonies in UK western waters and foreign colonies may be present). However, it is considered a precautionary assumption to assume that immature birds associated with colonies in the North Sea that are present in the North Sea during the non-breeding season will remain in the North Sea into the following breeding season. This would therefore represent a breeding season immature population of 560,761 birds. Combining these breeding adult and immature populations would therefore provide a North Sea population of 2,045,078 individuals. However, this population is likely to under-estimate the population of guillemot that may interact with Hornsea Three as it does not account for non-breeding adult birds.

5.13.3.61 The use of these population is however, not appropriate in a cumulative context as the impacts predicted for each project affect different components of the population. Any assessment using this as a discrete population against which impacts would be equally distributed would therefore not capture the complexity of the population structure present in the North Sea, as it ignores the distribution of different age classes. No attempt has therefore been made to compare the predicted impact against this total population.

5.13.3.62 During the non-breeding season the population affected by cumulative displacement impacts is predicted to comprise a mixture of adults and immatures from colonies on the east coast of the UK with smaller proportions from colonies further afield during the non-breeding season.

Tier 1

Magnitude of impact

Breeding season

5.13.3.63 Using the same assumptions as for Hornsea Three alone (50% displacement and 2-10% mortality) the precautionary predicted cumulative mortality of guillemot due to the displacement predicted to arise from Hornsea Three and Tier 1 projects in the breeding season is 2,582-3,117 (Table 5.42). This level of predicted mortality is not expected to occur on a year on year basis; it is considered more likely to relate to a singular event following which seabirds will respond to by either redistribution or habituation. Displacement from an area is unlikely to result in direct mortality on individual birds, instead the impact of displacement will have fitness consequences in terms of productivity and mortality which will vary depending on the age of the birds impacted.

5.13.3.64 Hornsea Three contributes 5.2 - 21.5% of the Tier 1 cumulative total with the birds experiencing displacement impacts at Hornsea Three considered to be either immature or non-breeding birds which, in the breeding season, are considered to be less susceptible to displacement impacts as they are not constrained to certain areas unlike breeding birds. As stated above in the project alone assessment, Hornsea Three is located in an area of the North Sea that does not support high densities of guillemot and therefore it is unlikely to represent an important area for the species. This is equally applicable to a number of other projects considered cumulatively. For projects located in areas that support only low densities of guillemot or those projects that are outside of the foraging range of razorbill from breeding colonies, it is considered that a mortality rate of 10% over-estimates the likely level of impact.

5.13.3.65 The cumulative impact predicted for guillemot in Table 5.42 has been considered sustainable in previous assessments (Natural England, 2015d) and as a long-lived species, guillemot is considered to be able to adapt to changes in the environment exhibiting a moderate level of habitat flexibility (Wade *et al.,* 2016).

5.13.3.66 The impact of displacement mortality on guillemot during the breeding season without considering the likely age structure of population affected is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be medium.

Non-breeding season

5.13.3.67 During the non-breeding season, the precautionary predicted cumulative mortality of guillemot due to the displacement predicted to arise from Hornsea Three and Tier 1 projects in the non-breeding season is 275 (Table 5.42), which represents a small proportion of the regional non-breeding population of 1,617,306 and does not represent an increase in baseline mortality (98,656 individuals) of greater than 1%.

5.13.3.68 The impact of displacement mortality on guillemot during the non-breeding season is predicted to be of local spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Sensitivity of receptor

5.13.3.69 Guillemot is considered to be an ornithological receptor of regional conservation value within the context of Hornsea Three. The species is deemed to be of high vulnerability to displacement (Wade *et al.*, 2016), and with an increase in regional and national populations over the last decade (+40% and +6% respectively), guillemot has medium recoverability potential.

5.13.3.70 In summary, guillemot is deemed to be of high vulnerability, medium recoverability and national value. The sensitivity of the VOR is therefore, considered to be medium.

Significance of effect

5.13.3.71 The sensitivity of guillemot is considered to be medium and the impact magnitude is deemed to be medium (breeding season). The predicted displacement mortality is based on conservative assumptions, including the use of precautionary displacement and mortality rates. In addition, it is considered unlikely that all projects included in Tier 1 will be built out to the maximum design scenario assumptions made in the respective impact assessments.

5.13.3.72 On this basis, at this stage, it is judged that the cumulative impact of Hornsea Three together with Tier 1 projects could be of **moderate** significance.. Previous assessments of cumulative displacement impacts for guillemot, that have predicted a similar impact magnitude have however, concluded that such an impact is not significant in the context of the North Sea population of guillemot (Natural England, 2015d).

<u>Tiers 1 and 2</u>

Magnitude of impact

Breeding season

5.13.3.73 Using the same assumptions as for Hornsea Three alone (50% displacement and 2-10% mortality) the precautionary predicted cumulative mortality of guillemot due to the displacement predicted to arise from Tier 1 and Tier 2 projects in the breeding season is 5,660-6,195 (Table 5.42). This level of predicted mortality is not expected to occur on a year on year basis; it is considered more likely to relate to a singular event following which seabirds will respond to by either redistribution or habituation. Displacement from an area is unlikely to result in direct mortality on individual birds, instead the impact of displacement will have fitness consequences in terms of productivity and mortality which will vary depending on the age of the birds impacted.

5.13.3.74 Hornsea Three contributes 2.4 - 10.8% of the Tier 1 cumulative total with the birds experiencing displacement impacts at Hornsea Three considered to be either immature or non-breeding birds which, in the breeding season, are considered to be less susceptible to displacement impacts as they are not constrained to certain areas unlike breeding birds. As stated above in the project alone assessment, Hornsea Three is located in an area of the North Sea that does not support high densities of guillemot and therefore it is unlikely to represent an important area for the species. This is equally applicable to a number of other projects considered cumulatively. For projects located in areas that support only low densities of guillemot or those projects that are outside of the foraging range of guillemot from breeding colonies, it is considered that a mortality rate of 10% over-estimates the likely level of impact.

5.13.3.75 The cumulative impact predicted for guillemot in Table 5.42 has been considered sustainable in previous assessments (Natural England, 2015a) and as a long-lived species, guillemot is considered to be able to adapt to changes in the environment exhibiting a moderate level of habitat flexibility (Wade *et al.*, 2016).

5.13.3.76 The impact of displacement mortality on guillemot during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be medium.

Non-breeding season

5.13.3.77 During the non-breeding season, the precautionary predicted cumulative mortality of guillemot due to the displacement predicted to arise from Tier 1 and Tier 2 projects in the non-breeding season is 411 (Table 5.42), which represents a small proportion of the regional winter population of 1,617,306 and does not represent an increase in baseline mortality (98,656 individuals) of greater than 1%.

5.13.3.78 The impact of displacement mortality on guillemot during the non-breeding season is predicted to be of local spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Sensitivity of receptor

5.13.3.79 Guillemot is deemed to be of high vulnerability, medium recoverability and national value. The sensitivity of the VOR is therefore, considered to be medium.

Table 5.42: Guillemot cumulative mortality as a result of displacement (all birds)

Offshore wind farm	Breeding season (50% displacement, 10% mortality)	Non-breeding season (50% displacement, 1% mortality)
Hornsea Three[a]	134-669	89
Tier 1		
Aberdeen	27	1
Beatrice	680	14
Blyth Demonstration	61	7
Dudgeon	17	3
East Anglia ONE	14	3
Galloper	15	3
Greater Gabbard	17	3
Hornsea Project One	492	40
Hornsea Project Two	387	66
Humber Gateway	5	1
Hywind	26	0
Lincs and LID6	29	4
London Array	10	2
Moray East	491	3
Neart na Gaoithe	88	19
Race Bank	18	4
Sheringham Shoal	19	4
Teesside	13	5
Thanet	1	1
Triton Knoll	21	4
Westermost Rough	17	2
Tier 1 total	**2,582-3,117**	**275**
Tier 2		
Dogger Bank Creyke Beck A	270	31
Dogger Bank Creyke Beck B	474	53
Dogger Bank Teesside A	164	11
Sofia (formerly Dogger Bank Teesside B)	261	19
East Anglia Three	31	7
Inch Cape	219	16
Kincardine	32	0
Seagreen A	825	0
Seagreen B	803	0
Tier 2 total	**3,078**	**137**
Total	**5,660-6,195**	**411**
a a 2-10% mortality rate range is presented for Hornsea Three		

Significance of effect

5.13.3.80 The sensitivity of guillemot is considered to be medium and the impact magnitude is deemed to be medium (breeding season). The predicted displacement mortality is based on conservative assumptions, including the use of precautionary displacement and mortality rates. In addition, it is considered unlikely that all projects included in Tier 2 will be brought forward or, if constructed, they are unlikely to be built out to the maximum design scenario assumptions made in the respective impact assessments.

5.13.3.81 On this basis, it is judged that the cumulative impact of Hornsea Three together with Tier 1 and 2 projects could be of **moderate significance**, which is potentially significant in EIA terms.

Collision with rotating turbine blades resulting in mortality of birds

Methodology for cumulative effect assessment – collision risk

5.13.3.82 Direct comparison of the collision risks predicted by the wind farms in the wider area is problematic due to the differing assumptions made in the calculations used in the different studies, and the limited amount of species data presented in Environmental Statement chapters (Maclean *et al.*, 2009). Nevertheless, a combined quantitative assessment of the cumulative impacts posed by Hornsea Three in conjunction with other projects has been undertaken, based on the information presented in other projects' supporting documentation available to date.

5.13.3.83 It is possible that migratory birds may pass through a number of project sites within the central North Sea each year and so the initial scope of the CEA for collision mortality has taken into account all relevant projects along the east coast of Britain plus other non-UK projects (Table 5.38). Due to a lack of compatible project information it has not been possible to include a quantitative assessment for each project. Suitable quantitative data from relevant projects are therefore presented in each species assessment below.

5.13.3.84 The CEA has been separated into seasonal mortality, based on relevant reference populations (Table 1.5 in volume 5, annex 5.1: Baseline Characterisation Report). Cumulative impacts of Hornsea Three and other relevant projects during the breeding season have been based on mean maximum foraging range given for each species (or other information e.g. tracking information). For regional breeding species (taken to be gannet, lesser black-backed gull and kittiwake), each species has a colony, which can be used to determine the scope of the CEA (i.e. the projects which overlap with foraging ranges of these species. In the case of gannet and lesser black-backed gull this is taken to be mean-maximum foraging range and for kittiwake this is based on information from tracking studies). This assumes that the majority of collisions involve individuals from that colony in the breeding season. However, it is also important to consider the populations of immature and non-breeding individuals that may be impacted by wind farms considered cumulatively with Hornsea Three to which a proportion of collision impacts will be attributable.

5.13.3.85 For the purposes of this assessment, the definition of cumulative effects is the effect of Hornsea Three, alongside the effect of other developments on a single VOR. Although further mortality will occur during the breeding season due to collisions from birds from other colonies with other projects outside of foraging range (e.g. kittiwakes at Scottish east coast projects), Hornsea Three will contribute zero collisions to this as it is outside of foraging range, and so these projects are not considered to require inclusion in a breeding season cumulative assessment.

5.13.3.86 During the non-breeding period, it is assumed that individuals present from each species will originate from a wider range of colonies, with intermixing throughout the North Sea, and so the most appropriate reference populations (e.g. east coast or flyway) have been taken forward to assessment, based on literature evidence available (Furness, 2015). A greater range of projects are included, reflecting the wider movements of birds (i.e. all east coast UK wind farm projects).

Confidence in collision risk data available from other projects

<u>Collision risk modelling</u>

5.13.3.87 The earliest collision risk assessments of offshore wind farms for Round 1 and 2 projects were generally undertaken by adapting the Band (2000) collision risk model (updated in Band *et al.*, 2007), developed on behalf of Scottish Natural Heritage to quantify mortality rates for birds at offshore wind farms. As flight data are collected in a fundamentally different way in the onshore and offshore environments, the boat survey data collected at these offshore sites required significant reinterpretation to become compatible with the model. This is a potential source of variability in interpretation and results between projects, particularly as a standard method of interpretation was not available at that time.

5.13.3.88 For these projects' models it was also assumed that for birds transiting through turbines at risk height, collision risk was distributed evenly within the rotor swept area (as per Option 1 or 2 of the Band model), which in the majority of cases overestimates the risk for most species which predominantly fly at lower altitudes (including some within the lower rotor swept area). As the probability of colliding with a rotor blade is lower at these lower altitudes, using the mean value instead will invariably overestimate risk, and therefore resultant mortality rates.

5.13.3.89 The most recent projects have run collision risk analyses using the Band model, updated for the offshore environment (Band, 2012; sometimes the draft version Band (2011)). The updates within Band (2012) mean that projects that have used the Band (2012) or Band (2011) models are likely to produce more realistic mortality rates than earlier projects that had to interpret the onshore Band models. This is particularly the case for those that undertook modelling using the Extended Option 3 or 4 variants.

5.13.3.90 In addition to the different models used to estimate collision mortality, different avoidance rates have been selected for impact assessment in different projects. This is the most sensitive parameter in the model, and so leads to a great deal of variability in results. Mortality estimates from other projects have been converted to a common currency in this assessment consistent with those avoidance rates recommended by Cook *et al.* (2014).

5.13.3.91 A process of caution is applied however when altering outputs (by updating prescribed avoidance rates) within projects considered within the CEA. This is particularly relevant for projects that have been consented, where values have already been accepted by decision-makers. In some other cases it is not clear in the collision modelling process, using different Band model versions, where precaution may have been built in. If this was at an earlier stage, then a higher avoidance rate may be acceptable, and so results should can be converted to a "common currency", where possible as advocated by Natural England and JNCC in their Relevant Representation for Hornsea Project One and subsequent consultation for Hornsea Project Two.

Consented and as-built scenarios

5.13.3.92 As well as different models being used for different projects, as some applications are still within the planning process at the time of writing, meaning that collision risk figures provided may not have been finalised. The levels of mortality predicted are therefore subject to change, and so the confidence level in their results is low. Therefore, whilst the modelling approach applied may lead to an assumption of high confidence, in reality given that the numbers used in this assessment are known to be subject to refinement (which we understand in the majority of cases will lead to a reduction in predicted mortality numbers) the confidence in these data is low. Furthermore, it is frequently the case that projects when constructed do not reflect the maximum design scenario assessed. In many cases, the as-built scenario will represent a significantly lower impact than that assessed as the maximum design scenario for the purpose of obtaining a consent.

5.13.3.93 In order to provide an appraisal of this likely over-estimation of the cumulative collision risk totals for each species, a simple analysis has been conducted comparing the turbine scenario used for CRM for projects considered cumulatively with the respective as-built turbine scenario. Table 5.44 identifies the assessed, consented and as-built or planned turbine scenarios for each of the projects considered cumulatively in addition to the possible change that may result if CRM was conducted utilising the as-built turbine scenario. If there is a difference between the assessed number of turbines and the consented number of turbines (i.e. those projects for which consideration in the assessment is quantitative) a simple correction factor representing the change in the number of turbines has been applied to the collision risk estimates for that project. Where differences arise between the assessed turbine scenario and the as-built/planned turbine scenario (i.e. those projects for which consideration in the assessment is qualitative) further analysis utilising the correction factors calculated by MacArthur Green (2017), has been applied in order to calculate the likely change in collision risk estimates for a project with this discussed qualitatively in the respective species sections. MacArthur Green (2017) presents an appraisal of the likely 'headroom' that exists in current cumulative collision risk estimates due to assessed turbine scenarios representing a higher collision risk to birds than as-built or planned turbine scenarios. The correction factors have only been applied here if the assessed turbine scenario presented in Table 5.44 matches that used by MacArthur Green (2017) (Table 5.45).

5.13.3.94 The correction factors presented in MacArthur Green (2017) can therefore be applied for nine projects that are included in Table 5.45. The exercise presented therefore does not account for considerable reductions that are likely to occur in the assessed collision risk estimates calculated for Hornsea Project Two, Moray East, Neart na Gaoithe, Seagreen Alpha and Seagreen Bravo due to these projects currently planning to deploy turbine scenarios that will meet the consented maximum project capacity but using fewer higher capacity turbines. Reductions in collision risk estimates are also likely for London Array, Beatrice, Blyth Demonstration, East Anglia One and Triton Knoll as these projects are currently planning or operating turbine scenarios that are below the consented maximum capacity for the project. Based on the changes that have occurred between assessment and construction for those projects in Tier 1, it is considered highly likely that the eventual as-built turbine scenarios for Tier 2 projects such as Dogger Bank Creyke Beck A&B, Dogger Bank Teesside A, Sofia (formerly Dogger Bank Teesside B) and Inch Cape will also contain fewer higher capacity turbines that will lead to reductions in the collision risk estimates incorporated into the cumulative assessments presented below.

5.13.3.95 The correction factors applied in Table 5.48, Table 5.51, Table 5.53 or Table 5.55 account only for changes between assessed and consented turbine scenarios and have not been corrected using the correction factors presented in MacArthur Green (2017).

Nocturnal activity factors

5.13.3.96 Appendix D of annex 5.3: Collision Risk Modelling presents a discussion on the nocturnal activity factors used for species included in CRM at Hornsea Three. Based on empirical evidence it is considered that the nocturnal activity factors that have historically been used for gannet and kittiwake in CRM (from Garthe and Hüppop, 2004) over-estimate the actual level of nocturnal activity exhibited by both gannet and kittiwake. CRM conducted for projects considered cumulatively are considered to have most certainly used the nocturnal activity factors from Garthe and Hüppop (2004) and therefore it is necessary to correct the collision risk estimates to account for this over-estimation. However, the over-estimation of nocturnal activity factors within collision risk modelling was discussed as part of the consenting process for East Anglia Three and, for projects in Scotland, Scottish Natural Heritage and Marine Scotland have advised the use of nocturnal activity factors lower than those derived from Garthe and Hüppop (2004) as part of scoping advice for a number of recent projects (e.g. see Scottish Government, 2017).

5.13.3.97 The correction factor to apply to the collision risk estimates for each project considered cumulatively will depend on the latitude at which a project is located. An analysis has been conducted in appendix D of annex 5.3: Collision Risk Modelling that calculates correction factors for four geographic areas into which each of the projects considered cumulatively have been assigned (Table 5.43). Two correction factors are presented, a minimum representing the minimum monthly change that can be applied cross all months and the total representing the total change in collision risk estimates in each area using a generic wind farm scenario. The 'total' correction factor may potentially under or over-estimate the collision risk for an individual project and therefore this is applied in the assessments for individual species in this section, as guidance only. The application of the 'minimum' correction factor is considered to be precautionary as this represents the minimum change that would occur across all months.

Table 5.43: Correction factors to apply to collision risk estimates for projects in each geographic region

Geographic region	Projects within region	% change in collision risk estimates	
		Minimum	Total
East Anglia and English Channel	East Anglia One East Anglia Three Galloper Greater Gabbard Kentish Flats Extension London Array Thanet	Gannet = -10.1 Kittiwake =- 9.2	Gannet = -19.4 Kittiwake = -16.2
Southern North Sea	Blyth Demonstration Dogger Bank Creyke Beck A & B Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B) Dudgeon Hornsea Project One Hornsea Project Two Humber Gateway Lincs Race Bank Sheringham Shoal Teesside Triton Knoll Westermost Rough	Gannet = -9.3 Kittiwake = -8.5	Gannet = -19.3 Kittiwake = -16.2
Firth of Forth	Aberdeen (EOWDC) Inch Cape Kincardine Methil Neart na Gaoithe Seagreen Alpha Seagreen Bravo	Gannet = -8.4 Kittiwake = -7.8	Gannet = -19.3 Kittiwake = -16.2
Moray Firth	Beatrice Hywind Moray East	Gannet = -7.6 Kittiwake = -7.1	Gannet = -19.2 Kittiwake = -16.1

Table 5.44: Assessed, consented and as-built/planned turbine scenarios for projects considered cumulatively for collision risk impacts

Tier	Phase	Offshore wind farm	Assessed turbine scenario	Assessed capacity (MW)	Consented capacity (MW)	Consented number of turbines	As-built turbine scenario/turbine scenario currently being considered	As built/currently planned capacity	Is there a difference between the assessed turbine scenario and either the consented of as-built/planned turbine scenarios (Yes/No)?	Implications for cumulative assessment	Consideration in assessment
1	Operation and maintenance	Dudgeon	168 x 3 MW	504	560	77	67 x 6 MW	402	Yes – consented number of turbines (77) lower than that assessed (168). In addition, constructed number of turbines lower than consented	Reduction of 54% - assessed vs consented number of turbines Potential additional 6% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative
		Greater Gabbard	140	Unavailable	-	-	140 x 3.6 MW	504	No – assessed scenario consistent with as-built scenario	-	-
		Humber Gateway	83 x 3.6 MW	298.8	300	83	73 x 3 MW	219	Yes – as-built number of turbines (73) lower than assessed (83) however capacity of as-built turbines lower than assessed	Reduction of 12% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Kentish Flats Extension	17 x 3 MW	51	-	-	15 x 3.3 MW	49.5	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 12% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Lincs	83 x 3 MW	249	250	83	75 x 3.6 MW	270	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 10% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		London Array	271 x 3 MW	813	1000	341	175 x 3.6 MW	630	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 35% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Sheringham Shoal	108 x 3 MW	324	316.8	108	88 x 3.6 MW	316.8	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 19% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Teesside	30	Unavailable	100	30	27 x 2.3 MW	62.1	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 10% in terms of number of turbines however the assessed turbine capacity is unknown and therefore it is not known if the reduction can be applied	Qualitative
		Thanet	60 x 5 MW	300	300	-	100 x 3 MW	300	Yes – as-built scenario has more turbines than assessed scenario	As-built scenario was assessed within the Environmental Statement but was not the maximum design scenario. As this scenario has ultimately been built the collision risk estimates used for Thanet represent the 100 x 3 MW turbine scenario	Quantitative
		Westermost Rough	50 x 3.6 MW	180	245	80	35 x 6 MW	210	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 30% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
	Under construction	Beatrice (gannet)	142 x 7 MW	994	750	125	84 x 7 MW	588	Yes – consented number of turbines (125) lower than that assessed (142). In addition, constructed number of turbines lower than consented	Reduction of 12% - assessed vs consented number of turbines Potential additional 29% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative

Tier	Phase	Offshore wind farm	Assessed turbine scenario	Assessed capacity (MW)	Consented capacity (MW)	Consented number of turbines	As-built turbine scenario/turbine scenario currently being considered	As built/currently planned capacity	Is there a difference between the assessed turbine scenario and either the consented of as-built/planned turbine scenarios (Yes/No)?	Implications for cumulative assessment	Consideration in assessment
		Beatrice (other species)	277 x 3.6 MW	817.2	750	125	84 x 7 MW	588	Yes – consented number of turbines (125) lower than that assessed (277). In addition, constructed number of turbines lower than consented	Reduction of 55% - assessed vs consented number of turbines Potential additional 15% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative
		Blyth Demonstration Project	15 x 8 MW	120	-	-	5 x 8 MW	40	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 67% - assessed vs consented number of turbines	Quantitative
		East Anglia One	325 x 3.6 MW	1170	1200	240	102 x 7 MW	714	Yes – consented number of turbines (240) lower than that assessed (325). In addition, project has committed to building only 102 turbines but using a different turbine scenario	Reduction of 26% - assessed vs consented number of turbines Potential additional 42% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative
		Galloper	140 x 3.6 MW	504	504	140	56 x 6.3 MW	352.8	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 60% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Hornsea Project One	240 x 5 MW	1200	1200	-	174 x 7 MW	1218	Yes – as-built scenario has fewer turbines than assessed scenario	Reduction of 28% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Hywind	5 x 6 MW	30	30	-	5 x 6 MW	30	No – assessed scenario consistent with as-built scenario	-	-
		Race Bank	206	Unavailable	580	-	91	-	Yes - as-built scenario has fewer turbines than assessed scenario	Reduction of 56% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
	Consent and awarded CfD	Aberdeen European Offshore Wind Deployment Centre	11 x 7 MW	77	100	-	11 x 8.4 MW	92.4	Yes – same number of turbines, however capacity of turbines higher for as-built scenario	Potential for an minor change in collision risk due to change in turbine scenario	Qualitative
		Hornsea Project Two	300 x 5 MW	1500	1800	300	92-231	1368	Yes – planned turbine scenario has fewer turbines than assessed scenario	Reduction of 23-69% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Moray Firth Project One (MORL)	339 (139 x 3.6, 100 x 5 and 100 x 5 MW)	1500.4	1116	186	100 x 9.5 MW	950	Yes – consented number of turbines (186) lower than that assessed (339). In addition, planned turbine scenario is lower than consented	Reduction of 45% - assessed vs consented number of turbines Potential additional 25% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative

Tier	Phase	Offshore wind farm	Assessed turbine scenario	Assessed capacity (MW)	Consented capacity (MW)	Consented number of turbines	As-built turbine scenario/turbine scenario currently being considered	As built/currently planned capacity	Is there a difference between the assessed turbine scenario and either the consented of as-built/planned turbine scenarios (Yes/No)?	Implications for cumulative assessment	Consideration in assessment
		Neart na Gaoithe	128 x 3.6 MW	460.8	450	75	56 x 8 MW	450	Yes – consented number of turbines (75) lower than that assessed (128). In addition, planned turbine scenario is lower than consented	Reduction of 41% - assessed vs consented number of turbines Potential additional 15% reduction if as built scenario vs assessed scenario taken into account	Quantitative Qualitative
		Triton Knoll	288 x 3.6 MW	1036.8	1200	288	90 x 9.5 MW	855	Yes – planned turbine scenario has fewer turbines than assessed scenario	Reduction of 69% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
2	Consent and no CfD	Dogger Bank Creyke Beck A and B	400 x 6 MW	2400	2400	400	-	-	No	Project was consented in 2015 and it is likely that a larger capacity turbine scenario, resulting in fewer turbines, will be constructed	-
		Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B)	400 x 6 MW	2400	2400	400	240-400	Unavailable	No	Project was consented in 2015 and it is likely that a larger capacity turbine scenario, resulting in fewer turbines, will be constructed	-
		East Anglia Three	172 x 7 MW	1204	-	-	172 x 7 MW	1204	No	-	-
		Inch Cape	213	Unavailable	-	-	72	Unavailable	Yes – planned turbine scenario has fewer turbines than assessed scenario	Reduction of 66% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Kincardine	8 x 6 MW	6 to 8	Up to 50 MW	-	7	Unavailable	Yes - planned turbine scenario has fewer turbines than assessed scenario	Reduction of 13% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Methil	1	Unavailable	-	-	2	Unavailable	Yes - planned turbine scenario has more turbines than assessed scenario	Increase of 100% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Seagreen Alpha	75 x 7 MW	525	525		35-60	525	Yes - planned turbine scenario has more turbines than assessed scenario	Reduction of 20-53% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative
		Seagreen Bravo	75 x 7 MW	525	525		35-60	525	Yes - planned turbine scenario has more turbines than assessed scenario	Reduction of 20-53% in terms of number of turbines however change in capacity of turbines may influence collision risk estimates	Qualitative

Table 5.45: Correction factors from MacArthur Green (2017) applied to collision risk estimates[a]

Offshore wind farm	Correction factors from MacArthur Green (2017)			
	Gannet	Kittiwake	Lesser black-backed gull	Great black-backed gull
Dudgeon	0.46		0.49	0.50
Galloper	0.43	0.42	0.43	0.41
Humber Gateway	0.50	0.39	0.42	0.45
Kentish Flats Extension	0.80	0.72	0.80	0.80
Lincs	1.01	1.04	1.03	1.02
Race Bank	0.53	0.59	0.57	0.57
Sheringham Shoal	0.97		0.98	0.97
Teesside	0.68	0.67	0.67	0.68
Westermost Rough	0.83	0.82	0.82	0.83
a grey boxes indicate those projects where collision risk estimates are unavailable therefore a correction factor is not necessary				

Gannet

5.13.3.98 Table 5.48 presents a seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for gannet.

Tier 1

Magnitude of impact

Breeding season

5.13.3.99 When considering all Tier 1 projects which are within foraging range, the combined breeding season mortality is estimated to be 100 gannets, of which Hornsea Three contributes approximately 7.4%. The mortality of these additional birds in the breeding season is equal to an increase in baseline mortality of 4.9% on the regional breeding population (24,988 individuals) using a baseline mortality rate of 0.081 (Horswill and Robinson, 2015).

5.13.3.100 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, continuous and of low to medium reversibility, it is predicted that the cumulative collision risk estimate in the breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.101 It is considered likely that a substantial proportion of all birds recorded in the breeding season are immature individuals. In addition, a further proportion are likely to be non-breeding adult birds. Site-specific age class data indicates that approximately 30-60% of birds present at Hornsea Three will be immature birds with this representing a considerable reduction in the magnitude of impact predicted on the regional breeding population. If the cumulative collision risk estimate is corrected to account for immature birds using the lowest proportion of immatures estimated from site-specific data, this would provide a cumulative total of 70 birds representing a 3.5% increase in the baseline mortality of the regional breeding population.

5.13.3.102 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 35.3%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

Table 5.46: Changes to collision risk estimates for gannet calculated when applying the turbine scenario correction factors from MacArthur Green (2017)[a].

Offshore wind farm	Breeding season		Post-breeding season		Pre-breeding season	
	No correction	Corrected	No correction	Corrected	No correction	Corrected
Dudgeon[b]	10	10	18	18	9	9
Galloper			28	12	11	5
Humber Gateway	2	1	1	0	1	1
Kentish Flats Extension			0	0	0	0
Lincs	2	2	1	1	2	2
Race Bank	34	18	12	6	4	2
Sheringham Shoal	14	14	3	3	0	0
Teesside	5	3	2	1	0	0
Westermost Rough	0	0	0	0	0	0
Tier 1						
Other Tier 1 projects	17		244		135	
Total	100	65	309	287	163	154
% change	35.3		7.2		5.5	
Tiers 1 and 2						

Offshore wind farm	Breeding season		Post-breeding season		Pre-breeding season	
Other Tier 1 and 2 projects	130		561		294	
Total	197	179	626	604	321	312
% change	9.4		3.6		2.8	

a grey boxes indicate that impacts in the relevant season from a project are not applicable to the regional population being considered

b The correction factor from MacArthur Green (2017) for Dudgeon has been applied to collision risk estimate calculated using the assessed turbine scenario and not the collision risk estimate presented in Table 5.52Table 5.51 which accounts for the reduction between the assessed and consented turbine scenario

5.13.3.103 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.48 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.47). When applying the ‘minimum’ correction factor the number of breeding season collisions for Tier 1 projects reduces by 9.3%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for gannet and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.47 when applying the ‘total’ correction factor.

Table 5.47: Correction to collision risk estimates for gannet to take account of the over-estimation of nocturnal flight activity

Season	Tier	Uncorrected collision risk estimate	Corrected collision risk estimate	
			Minimum	Total
Breeding	1	100	91	81
	All	197	179	159
Post-breeding	1	309	281	249
	All	626	570	506
Pre-breeding	1	163	148	131
	All	321	292	259

5.13.3.104 The impact of collision on gannet during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Post-breeding season

5.13.3.105 In the post-breeding season a total of 309 collisions are estimated to occur at Tier 1 projects with Hornsea Three making a small contribution (1.6%) of this total (Table 5.48). This level of additional mortality represents a 0.84% increase in baseline mortality (36,960 individuals) of the post-breeding BDMPS population of gannet (456,298 individuals).

5.13.3.106 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility, it is predicted that the cumulative collision risk estimate in the post-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.107 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 7.2%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.108 Applying the nocturnal activity correction factors presented in Table 5.43, the collision risk estimates presented in Table 5.48 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.47). When applying the ‘minimum’ correction factor the number of breeding season collisions for Tier 1 projects reduces by 9.3%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for gannet and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.47 when applying the ‘total’ correction factor

5.13.3.109 The impact of collision on gannet during the post-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Pre-breeding season

5.13.3.110 There are estimated to be 163 collisions at Tier 1 projects during the pre-breeding season with Hornsea Three contributing 2.0% of these collisions (Table 5.48). This total represents an increase of 0.81% in the baseline mortality (20,119 individuals) of the pre-breeding BDMPS population of gannet (248,385 individuals).

5.13.3.111 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the pre-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.112 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 5.5%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.113 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.48 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.47). When applying the 'minimum' correction factor the number of breeding season collisions for Tier 1 projects reduces by 9.0%.It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for gannet and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.47 when applying the 'total' correction factor

5.13.3.114 The impact of collision mortality on gannet during the pre-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the pre-breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Sensitivity of receptor

5.13.3.115 As a proposed qualifying feature of FFC pSPA, where Hornsea Three is within mean maximum foraging range, gannet is afforded international conservation value. It was ranked high in terms of vulnerability to collisions by Wade *et al.* (2016) although moderate vulnerability by Langston (2010). High vulnerability is considered appropriate within this assessment.

5.13.3.116 Gannet is deemed to be of high vulnerability, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of Effect

5.13.3.117 The sensitivity of gannet is considered to be high and the impact magnitude is deemed to be low. However, the predicted collision mortality rate is based on conservative assumptions, including:

- The use of precautionary avoidance rates;
- The use of precautionary nocturnal activity factors in CRM undertaken for projects considered cumulatively with this likely to reduce collision risk estimates by approximately 9.1-19.2%;
- Worst case assumptions about the effects on a breeding regional population that is based only on breeding adult birds (excluding immature and non-breeding adult birds) whereas predicted collision estimates are based on the observed birds at Hornsea Three which will include immature and non-breeding adults. This has differing effects at projects located at different distances from breeding colonies; and
- The assumption that all projects, if constructed, will be built out to the maximum design scenario assumptions made in the respective impact assessments. Analyses conducted for operational projects indicates a potential reduction of approximately 4.2% when all seasons are combined with further significant reductions likely at consented projects that are yet to be constructed (e.g. projects in the Hornsea zone, Dogger Bank zone and Scottish waters).

5.13.3.118 On this basis, at this stage, taking into account the precaution built into the assessments presented above, it is judged that the cumulative impact of Hornsea Three together with Tier 1 projects will be of **minor adverse** significance, which is not significant in EIA terms.

Tiers 1 and 2

Magnitude of impact

Breeding season

5.13.3.119 When Tier 2 projects are considered in the breeding season, a total of 197 collisions are estimated to occur with Hornsea Three contributing 3.8% of this total. The mortality of these additional birds in the breeding season represents a 9.7% increase on the baseline mortality (2,024 individuals) of the regional breeding population (24,988 individuals). However, as explained in paragraph 5.13.3.99 this is considered to over-estimate the effect on the regional breeding population as it is considered highly likely that the population of gannet present at Hornsea Three will be comprised of a significant proportion of immature and non-breeding birds. Site-specific age class data indicates that approximately 30-60% of birds present at Hornsea Three will be immature birds with this representing a considerable reduction in the magnitude of impact predicted on the regional breeding population. Therefore, mortality predicted during the breeding season is considered likely to result in considerably less than 197 adult birds from the regional breeding population.

5.13.3.120 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility, it is predicted that the cumulative collision risk estimate in the breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.121 It is considered likely that a substantial proportion of all birds recorded in the breeding season are immature individuals. In addition, a further proportion are likely to be non-breeding adult birds. Site-specific age class data indicates that approximately 30-60% of birds present at Hornsea Three will be immature birds with this representing a considerable reduction in the magnitude of impact predicted on the regional breeding population. At projects located further from breeding colonies (e.g. Dogger Bank Creyke Beck A&B) the proportion of breeding adult birds is likely to be very small compared to the proportions of immature and non-breeding birds. If the cumulative collision risk estimate is corrected to account for immature birds using the lowest proportion of immatures estimated from site-specific data, this would provide a cumulative total of 138 birds representing a 6.8% increase in the baseline mortality of the regional breeding population.

5.13.3.122 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 and Tier 2 reduces by 9.4%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.123 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.48 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.47). When applying the 'minimum' correction factor the number of breeding season collisions for Tier 1 projects reduces by 9.1%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for gannet and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.47 when applying the 'total' correction factor

5.13.3.124 The impact of collision mortality on gannet during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low to medium.

Post-breeding season

5.13.3.125 When Tier 2 projects are considered in the post-breeding season, a total of 626 collisions are estimated to occur with Hornsea Three contributing only 0.8% of this total. The mortality of these additional birds in the post-breeding season represents a 1.7% increase in baseline mortality (36,960 individuals) of the post-breeding BDMPS population of gannet (456,298 individuals).

5.13.3.126 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the post-breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.127 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 and Tier 2 reduces by 3.6%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.128 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.48 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.47). When applying the 'minimum' correction factor the number of breeding season collisions for Tier 1 projects reduces by 9.0%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for gannet and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.47 when applying the 'total' correction factor.

5.13.3.129 The impact of collision mortality on gannet during the post-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Pre-breeding season

5.13.3.130 In the pre-breeding season, an additional 158 collisions are estimated to occur at Tier 2 projects providing a total estimate of 321 collisions in the pre-breeding season of which Hornsea Three contributes 1.0%. A total of 321 collisions represents a 1.6% increase in baseline mortality (20,119 individuals) of the pre-breeding BDMPS population of gannet (248,385 individuals).

5.13.3.131 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the pre-breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.132 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 and Tier 2 reduces by 2.8%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.133 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.48 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.47). When applying the 'minimum' correction factor the number of breeding season collisions for Tier 1 projects reduces by 9.0%.It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for gannet and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.47 when applying the 'total' correction factor

5.13.3.134 The impact of collision mortality on gannet during the pre-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the pre-breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Sensitivity of receptor

5.13.3.135 As a proposed qualifying feature of FFC pSPA, where Hornsea Three is within mean maximum foraging range, gannet is afforded international conservation value. It was ranked high in terms of vulnerability to collisions by Wade *et al.* (2016) although moderate vulnerability by Langston (2010). High vulnerability is considered appropriate within this assessment.

5.13.3.136 Gannet is deemed to be of high vulnerability, high recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of effect

5.13.3.137 The sensitivity of gannet is considered to be high and the impact magnitude is deemed to be low to medium (breeding season). However, the predicted collision mortality rate is based on conservative assumptions, including:

- The use of precautionary avoidance rates;
- The use of precautionary nocturnal activity factors in CRM undertaken for projects considered cumulatively with this likely to reduce collision risk estimates by approximately 9.0-19.1%;
- Worst case assumptions about the effects on a breeding regional population that is based only on breeding adult birds (excluding immature and non-breeding adult birds) whereas predicted collision estimates are based on the observed birds at Hornsea Three which will include immature and non-breeding adults; and
- The assumption that all projects, if constructed, will be built out to the maximum design scenario assumptions made in the respective impact assessments. Analyses conducted for operational projects indicates a potential reduction of approximately 10.7% when all seasons are combined with further significant reductions likely at consented projects that are yet to be constructed (e.g. projects in the Hornsea zone, Dogger Bank zone and Scottish waters).

5.13.3.138 On this basis, at this stage, it is judged that the cumulative impact of Hornsea Three together with Tier 1 and 2 projects could be of **minor or moderate adverse** significance, which is potentially significant in EIA terms.

Table 5.48: Seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for gannet.

Offshore wind farm	Tier	Collision risk model	Option	Avoidance rate (%)	Annual collisions	Breeding	Post-breeding	Pre-breeding	Notes
Hornsea Three	-	Band (2012)	3	98	15	7	5	3	
Tier 1									
Aberdeen Demo	1	Band (2012)	2	98.9	9		5	0	
Beatrice	1	Band (2012)	3	98	37		19	4	Corrected to account for reduction in number of turbines (assessed vs consented turbine scenarios)
Blyth Demo	1	Band *et al.* (2007)	1	98.9	8	4	2	3	
Dudgeon	1	Band (2000)	1	98.9	37	10	18	9	Corrected to account for reduction in number of turbines (assessed vs consented turbine scenarios)
East Anglia One	1	Band (2012)	3	98	68		63	3	Corrected to account for reduction in number of turbines (assessed vs consented turbine scenarios)
Galloper	1	Band *et al.* (2007)	1	98.9	56		28	11	
Greater Gabbard	1	Band (2000)	1	98.9	28		8	9	
Hornsea Project One	1	Band (2012)	4	98	4	1	2	1	Collision risk estimates represent the actual turbine scenario to be used
Hornsea Project Two	1	Band (2012)	4	98	18	5	9	4	
Humber Gateway	1	Not available	1	98.9	4	2	1	1	
Hywind	1	Band (2012)	1	98.9	7		2	2	
Kentish Flats Extension	1	Band (2012)	1	98.9	0		0	0	
Lincs	1	Band (2000)	1	98.9	5	2	1	2	
London Array	1	Band (2000)	1	98.9	6		2	0	
Moray East	1	Band (2012)	3	98	16		5	1	Corrected to account for reduction in number of turbines (assessed vs consented turbine scenarios)
Neart na Gaoithe	1	Band (2012)	1	98.9	334		57	64	Corrected to account for reduction in number of turbines (assessed vs consented turbine scenarios)
Race Bank	1	Band (2000)	1	98.9	50	34	12	4	
Sheringham Shoal	1	Band (2000)	1	98.9	18	14	3	0	
Teesside	1	Band (2000)	1	98.9	7	5	2	0	
Thanet	1	Band (2000)	1	98.9	1		0	0	
Triton Knoll	1	Band (2000)	1	98.9	122	17	65	40	
Westermost Rough	1	Band *et al.* (2007)	1	98.9	1	0	0	0	
Tier 1 total					**848**	**100**	**309**	**163**	

Offshore wind farm	Tier	Collision risk model	Option	Avoidance rate (%)	Annual collisions	Breeding	Post-breeding	Pre-breeding	Notes
Tier 2									
Dogger Bank Creyke Beck A and B	2	Band (2012)	3	98	121	41	48	32	
Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B)	2	Band (2012)	3	98	136	56	39	41	
East Anglia Three	2	Band (2012)	3	98	48		33	10	
Inchcape	2	Band (2012)	1	98.9	365		29	5	
Kincardine	2	Band (2012)	3	98	30		13	0	
Methil	2	Band (2011/12)	1	98.9	1		0	0	
Seagreen Alpha	2	Band (2012)	3	98	494		91	33	
Seagreen Bravo	2	Band (2012)	3	98	332		64	37	
Tier 2 total					**1,527**	**97**	**317**	**158**	
Overall total					**2,374**	**197**	**626**	**321**	

Kittiwake

5.13.3.139 Table 5.51 presents a seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for kittiwake.

Tier 1

Magnitude of impact

Breeding season

5.13.3.140 Any collision mortality impact is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly.

5.13.3.141 When considering all Tier 1 projects which are within foraging range, the combined breeding season mortality is estimated to be 60 kittiwakes, of which Hornsea Three contributes approximately 70%. The mortality of these additional birds in the breeding season is equal to an increase in baseline mortality (14,892 individuals) of 0.40% on the regional breeding population (102,002 individuals) using a baseline mortality rate of 0.146 (Horswill and Robinson, 2015).

5.13.3.142 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.143 It is considered likely that a substantial proportion of all birds recorded in the breeding season are immature individuals (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). In addition, a further proportion are likely to be non-breeding adult birds. Analyses undertaken in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA suggest that 12-58% of birds at Hornsea Three in the breeding season will be immature birds. However, based on the information presented in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA it is considered that the true proportion of immatures at Hornsea Three may well be higher and that a proportion of 58% immatures is precautionary. Therefore if the cumulative collision risk estimate is corrected to account for immature birds, this would provide a cumulative total of 25 birds representing a 0.17% increase in the baseline mortality of the regional breeding population.

5.13.3.144 Hornsea Three is located a considerable distance (149 km) from the nearest breeding colony and therefore the proportion of immatures present at Hornsea Three may not be directly applicable to projects located closer to breeding colonies. However, immature and non-breeding birds are known to visit colonies prior to first breeding (Coulson, 2011) and the majority of collisions predicted in the breeding season occur at those projects with limited connectivity to breeding colonies (i.e. Hornsea Three and Triton Knoll) based on tracking data (see Figure 1.22 in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). The application of the immature proportion calculated for Hornsea Three is therefore still considered suitably precautionary. Therefore, mortality predicted during the breeding season is considered likely to result in considerably less than 60 adult birds from the regional breeding population.

5.13.3.145 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 2.6%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

Table 5.49: Changes to collision risk estimates for kittiwake calculated when applying the turbine scenario corrections factors from MacArthur Green (2017)[a]

Offshore wind farm	Breeding season		Post-breeding season		Pre-breeding season	
	No correction	Corrected	No correction	Corrected	No correction	Corrected
Galloper			20	9	20	8
Humber Gateway	2	1	2	1	1	1
Kentish Flats Extension			1	1	0	0
Lincs	1	1	1	1	1	1
Race Bank	1	1	17	10	4	2
Teesside			18	12	2	1
Westermost Rough	0	0	0	0	0	0
Tier 1						
Other Tier 1 projects	57		172		106	
Total	60	59	232	206	134	120
% change	2.6		11.2		11.0	
Tier 2						

Offshore wind farm	Breeding season		Post-breeding season		Pre-breeding season	
Other Tier 1 and 2 projects	144		613		418	
Total	148	146	673	647	446	431
% change	1.1		3.9		3.3	
a grey boxes indicate that impacts in the relevant season from a project are not applicable to the regional population being considered						

5.13.3.146 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.51 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.50).

Table 5.50: Correction to collision risk estimates for kittiwake to take account of the over-estimation of nocturnal flight activity.

Season	Tier	Uncorrected collision risk estimate	Corrected collision risk estimate	
			Minimum	Total
Breeding	1	60	59	57
	All	148	139	131
Post-breeding	1	232	215	199
	All	673	620	568
Pre-breeding	1	134	124	115
	All	446	410	376

5.13.3.147 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.51 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.50). When applying the ‘minimum’ correction factor the number of breeding season collisions for Tier 1 projects reduces by 2.6%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for kittiwake and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.50 when applying the ‘total’ correction factor.

5.13.3.148 The impact of collision on kittiwake during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Post-breeding season

5.13.3.149 In the post-breeding season a total of 232 collisions are estimated to occur at Tier 1 projects with Hornsea Three contributing approximately 11.3% of this total. This level of additional mortality represents an increase of 0.19% in baseline mortality (121,171 individuals) of the post-breeding BDMPS population of kittiwake (829,937 individuals).

5.13.3.150 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the post-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.151 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 11.2%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.152 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.51 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.50). When applying the ‘minimum’ correction factor the number of breeding season collisions for Tier 1 projects reduces by 7.6%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for kittiwake and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.50 when applying the ‘total’ correction factor.

5.13.3.153 The impact of collision on kittiwake during the post-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Pre-breeding season

5.13.3.154 There are estimated to be 134 collisions at Tier 1 projects during the pre-breeding season with Hornsea Three contributing approximately 10.4% of these collisions. This total represents a 0.15% increase in the baseline mortality (91,661 individuals) of the pre-breeding BDMPS population of kittiwake (627,816 individuals).

5.13.3.155 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the pre-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.156 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 11.0%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.157 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.51 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.50). When applying the 'minimum' correction factor the number of breeding season collisions for Tier 1 projects reduces by 7.7%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for kittiwake and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.50 when applying the 'total' correction factor.

5.13.3.158 The impact of collision on kittiwake during the pre-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the pre-breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Sensitivity of receptor

5.13.3.159 Kittiwake was rated as being relatively high vulnerability to collision impacts by Wade *et al.* (2016), due to the proportion of flights likely to occur at potential risk height and percentage of time in flight, including at night. From previous studies in Flanders that have recorded mortality rates and collision rates, estimated micro-avoidance rates were, however, high for smaller gulls (Everaert, 2006; 2008; 2011; Everaert *et al.*, 2002; Everaert and Kuijken, 2007).Studies have also shown that rates are consistently above 98% for flights at rotor height (GWFL, 2011). The recently published report for Marine Scotland (Cook *et al.*, 2014) considers that a 99.2% avoidance rate is appropriate for the 'Basic' Band Model.

5.13.3.160 FFC pSPA is the closest breeding colony for kittiwake to Hornsea Three. However, Hornsea Three is outside of the mean-maximum (± 1 SD) foraging range of kittiwake (60 km) from the pSPA as reported by Thaxter *et al.* (2012) (Figure 1.30). Preliminary results from the FAME project which has tracked breeding kittiwake from the FFC pSPA colony does however suggest that there may be some connectivity between the FFC pSPA and Hornsea Three as presented in annex 5.1: Baseline Characterisation Report.

5.13.3.161 Kittiwake is deemed to be of high vulnerability, low recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Table 5.51: Seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for kittiwake.

Offshore wind farm	Tier	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding	Post-breeding	Pre-breeding	Notes
Hornsea Project Three	-	Band (2012)	3	98	82	42	26	14	
Tier 1									
Aberdeen Demo	1	Band (2012)	2	99.2	14		4	0	
Beatrice	1	Band (2012)	3	98	20		2	2	Corrected to account for reduction in number of turbines
Blyth Demo	1	Band (2011)	1	99.2	4		2	1	
East Anglia One	1	Band (2012)	3	98	24		17	6	Corrected to account for reduction in number of turbines
Galloper	1	Band *et al.* (2007)	1	99.2	48		20	20	
Greater Gabbard	1	Band (2000)	1	99.2	20		5	13	
Hornsea Project One	1	Band (2012)	4	98	2	1	1	0	Collision risk estimates represent the actual turbine scenario to be used
Hornsea Project Two	1	Band (2012)	4	98	4	2	1	0	
Humber Gateway	1	Not available	1	99.2	5	2	2	1	
Hywind	1	Band (2012)	1	99.2	7		2	0	
Kentish Flats Extension	1	Band (2012)	1	98.9	2		1	0	
Lincs	1	Band (2000)	1	99.2	2	1	1	1	
London Array	1	Band (2000)	1	99.2	4		1	2	
Moray East	1	Band (2012)	3	98	53		2	7	Corrected to account for reduction in number of turbines
Neart na Gaoithe	1	Band (2012)	1	99.2	40		18	11	Corrected to account for reduction in number of turbines
Race Bank	1	Band (2000)	1	99.2	23	1	17	4	
Teesside	1	Band (2000)	1	99.2	59		18	2	
Thanet	1	Band (2000)	1	99.2	0		0	0	
Triton Knoll	1	Band (2000)	1	99.2	152	12	91	49	
Westermost Rough	1	Band *et al.* (2007)	1	99.2	0	0	0	0	
Tier 1 total					564	60	232	134	
Tier 2									
Dogger Bank Creyke Beck Projects A and B	2	Band (2012)	3	98	218	87	41	90	
Dogger Bank Teesside Projects A and Sofia (formerly Dogger Bank Teesside B)	2	Band (2012)	3	98	136		28	66	

Offshore wind farm	Tier	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding	Post-breeding	Pre-breeding	Notes
East Anglia Three	2	Band (2012)	3	98	88		54	25	
Inchcape	2	Band (2012)	1	99.2	219		163	45	
Kincardine	2	Band (2012)	4	98	61		25	3	
Methil	2	Band (2011/12)	1	99.2	1		0	0	
Seagreen Alpha	2	Band (2012)	3	98	172		79	52	
Seagreen Bravo	2	Band (2012)	3	98	121		50	30	
Tier 2 total					1,015	87	441	312	
Total					1,579	148	673	446	

Significance of Effect

5.13.3.162 The sensitivity of kittiwake is considered to be high and the impact magnitude is deemed to be low in all seasons. On this basis, at this stage, it is judged that the cumulative impact of Hornsea Three together with Tier 1 projects could be of minor or moderate significance, which is potentially significant in EIA terms. However, the predicted collision mortality rate is based on conservative assumptions, including:

- The use of precautionary avoidance rates;
- The use of precautionary nocturnal activity factors in CRM undertaken for projects considered cumulatively with this likely to reduce collision risk estimates by approximately 7.2-13.2%;
- Worst case assumptions about the effects on a breeding regional population that is based only on breeding adult birds (excluding immature and non-breeding adult birds) whereas predicted collision estimates are based on the observed birds at Hornsea Three which will include immature and non-breeding adults; and
- The assumption that all projects, if constructed, will be built out to the maximum design scenario assumptions made in the respective impact assessments. Analyses conducted for operational projects indicates a potential reduction of approximately 9.6% when all seasons are combined with further significant reductions likely at consented projects that are yet to be constructed (e.g. projects in the Hornsea zone, Dogger Bank zone and Scottish waters).

5.13.3.163 When these assumptions are taken into account it is considered that the impact will be of minor or moderate significance. However, based on the likely reductions associated with the assumptions listed above it is considered that the impact will be of **minor adverse** significance which is not significant in EIA terms.

<u>Tiers 1 and 2</u>

Magnitude of impact

Breeding season

5.13.3.164 When Tier 2 projects are considered alongside Tier 1 projects in the breeding season, a total of 148 collisions are estimated to occur with Hornsea Three contributing 28% of this total. The mortality of these additional birds in the breeding season represents a 1.0% increase in baseline mortality (14,892 individuals) of the regional breeding population of kittiwake (102,002 individuals).

5.13.3.165 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.166 It is considered likely that a substantial proportion of all birds recorded in the breeding season are immature individuals (see RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). In addition, a further proportion are likely to be non-breeding adult birds. Analyses undertaken in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA suggest that 12-58% of birds at Hornsea Three in the breeding season will be immature birds. However, based on the information presented in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA it is considered that the true proportion of immatures at Hornsea Three may well be higher and that a proportion of 58% immatures is considerably precautionary. Therefore if the cumulative collision risk estimate is corrected to account for immature birds, this would provide a cumulative total of 62 birds representing a 0.42% increase in the baseline mortality of the regional breeding population.

5.13.3.167 Hornsea Three is located a considerable distance (149 km) from the nearest breeding colony and therefore the proportion of immatures present at Hornsea Three may not be directly applicable to projects located closer to breeding colonies. However, immature and non-breeding birds are known to visit colonies prior to first breeding (Coulson, 2011) and the majority of collisions predicted in the breeding season occur at those projects with limited connectivity to breeding colonies (i.e. Hornsea Three, Triton Knoll and Dogger Bank Creyke Beck A&B) based on tracking data (see Figure 1.22 in RIAA annex 3: Phenology, connectivity and apportioning for features of FFC pSPA). The application of the immature proportion calculated for Hornsea Three is therefore still considered suitably precautionary.

5.13.3.168 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 and Tier 2 reduces by 1.1%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.169 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.51 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.50). When applying the 'minimum' correction factor the number of breeding season collisions for Tier 1 projects reduces by 6.1%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for kittiwake and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.50 when applying the 'total' correction factor.

5.13.3.170 The impact of collision on kittiwake during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Post-breeding season

5.13.3.171 When Tier 2 projects are considered alongside Tier 1 projects in the post-breeding season, a total of 673 collisions are estimated to occur with Hornsea Three contributing 3.9% of this total. The mortality of these additional birds in the post-breeding season represents a 0.56% increase in baseline mortality (121,171 individuals) of the post-breeding BDMPS population of kittiwake (829,937 individuals).

5.13.3.172 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the post-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.173 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 and Tier 2 reduces by 3.9%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.174 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.51 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.50). When applying the 'minimum' correction factor the number of breeding season collisions for Tier 1 projects reduces by 7.9%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for kittiwake and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.50 when applying the 'total' correction factor.

5.13.3.175 The impact of collision on kittiwake during the post-breeding season without considering the likely age structure of the population affected is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Pre-breeding season

5.13.3.176 In the pre-breeding season, an additional 312 collisions are estimated to occur at Tier 2 projects providing a total estimate of 446 collisions of which Hornsea Three contributes 3.1%. A total of 446 collisions represents a 0.49% increase in baseline mortality (91,661 individuals) of the pre-breeding BDMPS population of kittiwake (627,816 individuals).

5.13.3.177 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the pre-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.178 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 and Tier 2 reduces by 3.3%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.179 Applying the nocturnal activity correction factors presented in Table 5.43 the collision risk estimates presented in Table 5.51 have been corrected to account for the over-estimation of nocturnal flight activity (Table 5.50). When applying the 'minimum' correction factor the number of breeding season collisions for Tier 1 projects reduces by 8.1%. It should be noted that this is the minimum by which collision risk estimates would reduce as a result of a change in the nocturnal activity factor used for kittiwake and that a realistic change would be higher and potentially closer to the collision risk estimates presented in Table 5.50 when applying the 'total' correction factor.

5.13.3.180 The impact of collision on kittiwake during the pre-breeding season without considering the likely age structure of the population affected is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the pre-breeding season due to factors including the age structure of the regional population, differences between as-built, consented and assessed turbine scenarios and the use of nocturnal activity factors that over-estimate such activity. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Sensitivity of receptor

5.13.3.181 As described in paragraphs 5.13.2.75 and 5.13.2.76, kittiwake is deemed to be of high vulnerability, low recoverability and international value. The sensitivity of the receptor is therefore, considered to be high.

Significance of Effect

5.13.3.182 The sensitivity of kittiwake is considered to be high and the impact magnitude is deemed to be low in all seasons. On this basis, at this stage, it is judged that the cumulative impact of Hornsea Three together with Tier 1 and 2 projects could be of minor or moderate significance, which is potentially significant in EIA terms. However, the predicted collision mortality rate is based on conservative assumptions, including:

- The use of precautionary avoidance rates;
- The use of precautionary nocturnal activity factors in CRM undertaken for projects considered cumulatively with this likely to reduce collision risk estimates by approximately 7.6-15.1%;

- worst case assumptions about the effects on a breeding regional population that is based only on breeding adult birds (excluding immature and non-breeding adult birds) whereas predicted collision estimates are based on the observed birds at Hornsea Three which will include immature and non-breeding adults; and
- the assumption that all projects (especially those in Tier 2), if constructed, will be built out to the maximum design scenario assumptions made in the respective impact assessments. Analyses conducted for operational projects indicates a potential reduction of approximately 3.3% when all seasons are combined with further significant reductions likely at consented projects that are yet to be constructed (e.g. projects in the Hornsea zone, Dogger Bank zone and Scottish waters).

5.13.3.183 When these assumptions are taken into account it is considered that the impact will be of minor or moderate significance. However, based on the likely reductions associated with the assumptions listed above it is considered that the impact will be of **minor adverse** significance which is not significant in EIA terms

Lesser black-backed gull

5.13.3.184 Table 5.53 presents a seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for lesser black-backed gull.

Tier 1

Magnitude of impact

Breeding season

5.13.3.185 Any collision mortality impact is predicted to be of regional spatial extent, long term duration, continuous and of low reversibility. It is predicted that the impact will affect the receptor directly.

5.13.3.186 When considering all Tier 1 projects which are within foraging range, the combined breeding season mortality is estimated to be 139 lesser black-backed gulls, of which Hornsea Three contributes 7.2%. The mortality of these additional birds in the breeding season is equal to an increase in baseline mortality (523 individuals) of approximately 26.6% on the regional breeding population (4,544 individuals) using a baseline mortality rate of 0.115 (Horswill and Robinson, 2015).

5.13.3.187 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.188 It is considered likely that a substantial proportion of all birds recorded in the breeding season are immature individuals. In addition, a further proportion are likely to be non-breeding adult birds. Site-specific age class data from boat-based surveys conducted to support the applications for the Hornsea Project One and Two offshore wind farms indicates that at least 35% of birds recorded in the breeding season were immature or juvenile birds. A lower proportion of the birds aged during Hornsea Three aerial surveys undertaken during the breeding season were identified as immatures (14%) however, a total of only 57 birds were aged meaning this may not be representative of the age structure present at Hornsea Three. Therefore the impact on the regional breeding population is likely to be an overestimate. If the cumulative collision risk estimate is corrected to account for immature birds using the proportion of immatures estimated from site-specific boat-based data, this would provide a cumulative total of 90 birds representing a 17.2% increase in the baseline mortality of the regional breeding population. It is not known what proportion of the population present at Hornsea Three consists of non-breeding birds however, it is considered unlikely that breeding lesser black-backed gulls that form part of the regional breeding population will forage at Hornsea Three.

5.13.3.189 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 29.3%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

Table 5.52: Changes to collision risk estimates for lesser black-backed gull calculated when applying the corrections factors from MacArthur Green (2017)[a].

Offshore wind farm	Breeding season		Post-breeding season		Non-breeding season		Pre-breeding season	
	No correction	Corrected	No correction	Corrected	No correction	Corrected	No correction	Corrected
Dudgeon[b]	4	4	3	3	4	4	2	2
Galloper	63	27	24	10	31	13	22	9
Humber Gateway	0	0	0	0	1	0	0	0
Kentish Flats Extension	0	0	0	0	1	0	0	0
Lincs	2	2	2	2	3	3	2	2
Race Bank	11	6	13	8	27	15	2	1
Sheringham Shoal	6	6	1	1	0	0	1	1
Westermost Rough	0	0	0	0	0	0	0	0

Offshore wind	Breeding season		Post-breeding season		Non-breeding season		Pre-breeding season	
Tier 1								
Other Tier 1 projects	52		28		65		18	
Total	139	98	73	53	131	102	47	34
% change	29.3		26.7		22.2		28.1	
Tier 2								
Other Tier 1 and 2 projects	66		44		75		29	
Total	153	112	89	69	140	111	57	44
% change	26.5		21.9		20.7		23.1	

a grey boxes indicate that impacts in the relevant season from a project are not applicable to the regional population being considered

b The correction factor from MacArthur Green (2017) for Dudgeon has been applied to collision risk estimate calculated using the assessed turbine scenario and not the collision risk estimate presented in Table 5.52Table 5.51 which accounts for the reduction between the assessed and consented turbine scenario

5.13.3.190 The impact of collision on lesser black-backed gull during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.51 is likely to be a considerable over-estimate for the breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be medium.

Post-breeding season

5.13.3.191 In the post-breeding season a total of 73 collisions are estimated to occur at Tier 1 projects with Hornsea Three contributing 1.5% of this total. This level of additional mortality represents an increase of 0.3% in baseline mortality (24,036 individuals) of the post-breeding BDMPS population (209,007 individuals).

5.13.3.192 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the post-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.193 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 26.7%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.194 The impact of collision on lesser black-backed gull during the post-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.53 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Non-breeding season

5.13.3.195 There are estimated to be 131 collisions at Tier 1 projects during the pre-breeding season with Hornsea Three contributing no collisions to this total as no lesser black-backed gulls were recorded at Hornsea Three during the defined non-breeding season for the species. This level of additional mortality represents a 2.9% increase in the baseline mortality (4,521 individuals) of the non-breeding BDMPS population (39,314 individuals) of lesser black-backed gulls.

5.13.3.196 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the non-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.197 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 22.2%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.198 The impact of collision on lesser black-backed gull during the non-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.53 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Pre-breeding season

5.13.3.199 There are estimated to be 47 collisions at Tier 1 projects during the pre-breeding season with Hornsea Three contributing 1.1% of these collisions. This total represents a 0.21% increase in the baseline mortality (22,711 individuals) of the pre-breeding BDMPS population (197,483 individuals) of lesser black-backed gulls.

5.13.3.200 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the pre-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.201 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 28.1%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.202 The impact of collision on lesser black-backed gull during the pre-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.53 is likely to be a considerable over-estimate for the pre-breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Sensitivity of receptor

5.13.3.203 Lesser black-backed gull was ranked the second highest marine bird species most vulnerable to collision impacts by Wade *et al.* (2016), mainly due to the high proportion of flights at potential collision heights, and the percentage of time in flight, including at night.

5.13.3.204 In summary, lesser black-backed gull is deemed to be of very high vulnerability, medium recoverability and regional value. The sensitivity of the receptor is therefore, considered to be medium.

Significance of Effect

5.13.3.205 The sensitivity of lesser black-backed gull is considered to be medium and the impact magnitude is deemed to be medium (breeding season). On this basis, it is judged that the cumulative impact of Hornsea Three together with Tier 1 projects could be of moderate significance, which is potentially significant in EIA terms. However, the predicted collision mortality rate is based on conservative assumptions, including:

- The use of precautionary avoidance rates;
- The use of precautionary nocturnal activity factors in CRM;
- Worst case assumptions about the effects on a breeding regional population that is based only on breeding adult birds (excluding immature and non-breeding adult birds) whereas predicted collision estimates are based on the observed birds at Hornsea Three which will include immature and non-breeding adults; and
- The assumption that all projects, if constructed, will be built out to the maximum design scenario assumptions made in the respective impact assessments. Analyses conducted for operational projects indicates a potential reduction of approximately 26.4% when all seasons are combined with further significant reductions likely at consented projects that are yet to be constructed (e.g. projects in the Hornsea zone, Dogger Bank zone and Scottish waters).

5.13.3.206 It is further considered that Hornsea Three does not contribute a significant amount of the cumulative collision risk total with the collisions estimated in the breeding season for Hornsea Three likely to affect either immature or non-breeding birds and not the regional breeding population. As such, although the overall significance of the cumulative impact of Hornsea Three together with Tier 1 projects is of **moderate adverse** significance which is significant in EIA terms it is considered that Hornsea Three does not materially alter the current cumulative impact on the regional breeding population.

Tiers 1 and 2

Magnitude of impact

Breeding season

5.13.3.207 An additional 14 collisions are estimated to occur at Tier 2 projects in the breeding season with this resulting in a total collision risk of 153 collisions in the breeding season to which Hornsea Three contributes 6.5%. The mortality of these additional birds in the breeding season is equal to an increase in baseline mortality (523 individuals) of 29.3% on the regional breeding population (4,544 individuals) using a baseline mortality rate of 0.115 (Horswill and Robinson, 2015).

5.13.3.208 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.209 As explained in paragraph 5.13.3.198, it is considered likely that a substantial proportion of all birds recorded in the breeding season are immature or non-breeding individuals. Therefore the impact on the regional breeding population is likely to be an overestimate. If the cumulative collision risk estimate is corrected to account for immature birds using the proportion of immatures estimated from site-specific boat-based data, this would provide a cumulative total of 99 birds representing a 19.0% increase in the baseline mortality of the regional breeding population.

5.13.3.210 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 26.5%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.211 The impact of collision on lesser black-backed gull during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.53 is likely to be a considerable over-estimate for the breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be medium.

Post-breeding season

5.13.3.212 When Tier 2 projects are considered alongside Tier 1 projects in the post-breeding season, a total of 89 collisions are estimated to occur with Hornsea Three contributing 1.3% of this total. The mortality of these additional birds in the post-breeding season represents a 0.37% increase in baseline mortality (24,036 individuals) of the post-breeding regional population (209,007 individuals) of lesser black-backed gull.

5.13.3.213 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the post-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.214 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 21.9%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.215 The impact of collision on lesser black-backed gull during the post-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.53 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Non-breeding season

5.13.3.216 When Tier 2 projects are considered alongside Tier 1 projects in the non-breeding season, a total of 140 collisions are estimated to occur with Hornsea Three contributing no collisions to this total. The mortality of these additional birds in the post-breeding season represents a 3.1% increase in baseline mortality (4,521 individuals) of the post-breeding regional population (39,314 individuals) of lesser black-backed gull.

5.13.3.217 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the non-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.218 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 20.7%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.219 The impact of collision on lesser black-backed gull during the non-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. The impact magnitude is therefore, considered to be low.

Pre-breeding season

5.13.3.220 In the pre-breeding season, an additional ten collisions are estimated to occur at Tier 2 projects providing a total estimate of 57 collisions in the pre-breeding season of which Hornsea Three contributes 0.9%. A total of 57 collisions represents a 0.25% increase in baseline mortality (22,711 individuals) of the pre-breeding regional population (197,483 individuals) of lesser black-backed gull.

5.13.3.221 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the pre-breeding season would be of low magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.222 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 23.1%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.223 The impact of collision on lesser black-backed gull during the pre-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.53 is likely to be a considerable over-estimate for the pre-breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Sensitivity of receptor

5.13.3.224 Lesser black-backed gull was ranked the second highest marine bird species most vulnerable to collision impacts by Wade *et al.* (2016), mainly due to the high proportion of flights at potential collision heights, and the percentage of time in flight, including at night.

5.13.3.225 In summary, lesser black-backed gull is deemed to be of very high vulnerability, medium recoverability and regional value. The sensitivity of the receptor is therefore considered to be medium.

Significance of Effect

5.13.3.226 The sensitivity of lesser black-backed gull is considered to be medium and the impact magnitude is deemed to be medium (breeding season). On this basis, it is judged that the cumulative impact of Hornsea Three together with Tier 1 and 2 projects could be of moderate significance, which is potentially significant in EIA terms. However, the predicted collision mortality rate is based on conservative assumptions, including:

- The use of precautionary avoidance rates;
- The use of precautionary nocturnal activity factors in CRM;
- Worst case assumptions about the effects on a breeding regional population that is based only on breeding adult birds (excluding immature and non-breeding adult birds) whereas predicted collision estimates are based on the observed birds at Hornsea Three which will include immature and non-breeding adults; and
- The assumption that all projects, if constructed, will be built out to the maximum design scenario assumptions made in the respective impact assessments. Analyses conducted for operational projects indicates a potential reduction of approximately 23.5% when all seasons are combined with further significant reductions likely at consented projects that are yet to be constructed (e.g. projects in the Hornsea zone, Dogger Bank zone and Scottish waters).

5.13.3.227 It is further considered that Hornsea Three does not contribute a significant amount of the cumulative collision risk total with the collisions estimated in the breeding season for Hornsea Three likely to affect either immature or non-breeding birds and not the regional breeding population. As such, although the overall significance of the cumulative impact of Hornsea Three together with Tier 1 projects is of **moderate adverse** significance which is significant in EIA terms it is considered that Hornsea Three does not materially alter the current cumulative impact on the regional breeding population.

Table 5.53: Seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for lesser black-backed gull.

Offshore wind farm	Tier	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding	Post-breeding	Non-breeding	Pre-breeding	Notes
Hornsea Three	-	Band (2012)	3	98.9	12	10	1	0	1	
Tier 1										
Dudgeon	1	Band (2000)	1	99.5	12	4	3	4	2	Corrected to account for reduction in number of turbines
East Anglia ONE	1	Band (2012)	3	98.9	43	6	6	31	0	Corrected to account for reduction in number of turbines
Galloper	1	Band *et al.* (2007)	1	99.5	139	63	24	31	22	
Greater Gabbard	1	Band (2000)	1	99.5	62	12	13	23	14	
Hornsea Project One	1	Band (2012)	4	98.9	9	5	2	1	1	
Hornsea Project Two	1	Band (2012)	4	98.9	1	0	0	0	0	
Humber Gateway	1	Not available	1	98.9	2	0	0	1	0	
Kentish Flats Extension	1	Band *et al.* (2007)	1	98.9	2	0	0	1	0	
Lincs	1	Band (2000)	1	98.9	9	2	2	3	2	
Neart na Gaoithe	1	Band (2012)	1	98.9	2		0	0	0	Corrected to account for reduction in number of turbines (assessed vs consented turbine scenarios)
Race Bank	1	Band (2000)	1	98.9	54	11	13	27	2	
Sheringham Shoal	1	Band (2000)	1	98.9	8	6	1	0	1	
Thanet	1	Band (2000)	1	98.9	6	2	2	1	0	
Triton Knoll	1	Band (2000)	1	98.9	32	16	4	10	3	
Westermost Rough	1	Band *et al.* (2007)	1	98.9	0	0	0	0	0	
Tier 1 total					**390**	**139**	**73**	**131**	**47**	
Tier 2										
Dogger Bank Creyke Beck A and B	2	Band (2012)	3	98.9	19	12	1	1	4	
Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B)	2	Band (2012)	3	98.9	18		8	5	0	
East Anglia Three	2	Band (2012)	3	98.9	9	2	5	2	1	
Seagreen Alpha	2	Band (2012)	2	99.5	7		1	2	1	
Seagreen Bravo	2	Band (2012)	2	99.5	16		0	1	4	
Tier 2 total					**68**	**14**	**16**	**9**	**10**	

Offshore wind farm	Tier	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding	Post-breeding	Non-breeding	Pre-breeding	Notes
Total					458	153	89	140	57	

Great black-backed gull

5.13.3.228 Table 5.55 presents a seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for great black-backed gull.

Tier 1

Magnitude of impact

Breeding season

5.13.3.229 When considering all Tier 1 projects, the combined breeding season mortality is estimated to be 49 great black-backed gulls, of which Hornsea Three contributes approximately 25.3%. The mortality of these additional birds in the breeding season is equal to an increase in baseline mortality (2,380 individuals) of 2.1% on the national breeding population (34,000 individuals) using a baseline mortality rate of 0.07 (Horswill and Robinson, 2015).

5.13.3.230 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.231 It is considered likely that a substantial proportion of all birds recorded in the breeding season are immature individuals as the foraging range of great black-backed gull from breeding colonies does not overlap with Hornsea Three. In addition, a further proportion are likely to be non-breeding adult birds. Therefore, mortality predicted during the breeding season is considered likely to result in considerably less than 49 adult birds from the national breeding population. This is supported by the results of survey data covering Hornsea Three. Age class data from boat-based surveys conducted to support the applications for the Hornsea Project One and Two offshore wind farms indicates that across Hornsea Three approximately 80% of birds recorded in the breeding season were immature or juvenile birds. This is supported by age class data collected during aerial surveys of Hornsea Three with 91% of birds recorded in the breeding season identified as immature birds (although only 43 birds were aged during the breeding season). Further to this, Hornsea Three is not within the range of foraging great black-backed gull from any breeding colonies at which the species is present. This therefore supports the conclusion that the majority of birds at Hornsea Three in the breeding season are immature or non-breeding birds and represents a considerable reduction in the magnitude of impact predicted on the national breeding population.

5.13.3.232 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 3.8%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

Table 5.54: Changes to collision risk estimates for great black-backed gull calculated when applying the corrections factors from MacArthur Green (2017)[a].

Offshore wind farm	Breeding season		Post-breeding season	
	No correction	Corrected	No correction	Corrected
Galloper	0	0	22	9
Humber Gateway	2	1	5	2
Kentish Flats Extension	0	0	0	0
Teesside	3	2	41	28
Westermost Rough	0	0	0	0
Tier 1				
Other Tier 1 projects	45		339	
Total	49	47	407	378
% change	3.8		7.1	
Tier 2				
Other Tier 1 and 2 projects	56		537	
Total	60	59	606	577
% change	3.1		4.8	
a grey boxes indicate that impacts in the relevant season from a project are not applicable to the regional population being considered				

5.13.3.233 The impact of collision on great black-backed gull during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.55 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Non-breeding season

5.13.3.234 In the non-breeding season a total of 407 collisions are estimated to occur at Tier 1 projects with Hornsea Three contributing 9.8% of this total. This level of additional mortality represents an increase of 6.4% in baseline mortality (6,398 individuals) of the non-breeding BDMPS population (91,399 individuals).

5.13.3.235 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the non-breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.236 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 7.1%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.237 The impact of collision on great black-backed gull during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated, the cumulative collision risk estimate presented in Table 5.53 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be medium.

Sensitivity of receptor

5.13.3.238 Great black-backed gull was rated the seabird species most vulnerable to collision impacts by Wade *et al.* (2016), mainly due to the high proportion of flights at potential collision heights, and the percentage of time in flight, including at night.

5.13.3.239 In summary, great black-backed gull is deemed to be of very high vulnerability, medium recoverability and national value. The sensitivity of the receptor is therefore, considered to be high.

Significance of Effect

5.13.3.240 The sensitivity of great black-backed gull is considered to be high and the impact magnitude is deemed to be medium (non-breeding season). On this basis, it is judged that the cumulative impact of Hornsea Three together with Tier 1 projects could be of moderate significance, which is potentially significant in EIA terms. However, the predicted collision mortality rate is based on conservative assumptions, including:

- The use of precautionary avoidance rates;
- The use of precautionary nocturnal activity factors in CRM;
- Worst case assumptions about the effects on a breeding regional population that is based only on breeding adult birds (excluding immature and non-breeding adult birds) whereas predicted collision estimates are based on the observed birds at Hornsea Three which will include immature and non-breeding adults; and
- The assumption that all projects, if constructed, will be built out to the maximum design scenario assumptions made in the respective impact assessments. Analyses conducted for operational projects indicates a potential reduction of approximately 6.8% when all seasons are combined with further significant reductions likely at consented projects that are yet to be constructed (e.g. projects in the Hornsea zone, Dogger Bank zone and Scottish waters).

5.13.3.241 Despite these assumptions it is still considered that the cumulative impact of Hornsea Three together with Tier 1 projects is of **moderate adverse** significance, which is potentially significant in EIA terms.

<u>Tiers 1 and 2</u>

Magnitude of impact

Breeding season

5.13.3.242 An additional 11 collisions are estimated to occur at Tier 2 projects in the breeding season with this resulting in a total collision risk of 60 collisions in the breeding season, Hornsea Three contributing 20.7% of the total. The mortality of these additional birds in the post-breeding season represents a 2.5% increase in baseline mortality (2,380 individuals) of the national breeding population of great black-backed gull (34,000 individuals).

5.13.3.243 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.244 As explained in paragraph 5.13.3.231, it is considered likely that a substantial proportion of all birds recorded in the breeding season are immature or non-breeding birds and therefore the impact on the breeding population is likely to be an overestimate.

5.13.3.245 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 and Tier 2 reduces by 3.1%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.246 The impact of collision on great black-backed gull during the breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.55 is likely to be a considerable over-estimate for the post-breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be low.

Non-breeding season

5.13.3.247 When Tier 2 projects are considered alongside Tier 1 projects in the non-breeding season, a total of 606 collisions are estimated to occur with Hornsea Three contributing 6.6% of this total. The mortality of these additional birds in the post-breeding season represents a 9.5% increase in baseline mortality (6,398 individuals) of the non-breeding regional population of great black-backed gull (91,399 individuals).

5.13.3.248 As an impact that would affect the receptor directly, has a regional spatial extent, is long term in duration, is continuous and of low to medium reversibility it is predicted that the cumulative collision risk estimate in the non-breeding season would be of medium magnitude. However, there are a number of additional factors that suggest the magnitude of the impact would be lower.

5.13.3.249 When applying the turbine scenario correction factors calculated by MacArthur Green (2017) (Table 5.45), the total breeding season collision risk estimate for Tier 1 reduces by 4.8%. In addition, there are also likely to be reductions for those projects mentioned in paragraph 5.13.3.94 based on the information presented in Table 5.44.

5.13.3.250 The impact of collision on great black-backed gull during the non-breeding season is predicted to be of regional spatial extent, long term duration, continuous and of low to medium reversibility. It is predicted that the impact will affect the receptor directly. As has been illustrated the cumulative collision risk estimate presented in Table 5.55 is likely to be a considerable over-estimate for the non-breeding season due to factors including the age structure of the regional population and differences between as-built, consented and assessed turbine scenarios. When these factors are taken into account the impact magnitude is therefore, considered to be medium.

Sensitivity of receptor

5.13.3.251 Great black-backed gull was rated the seabird species most vulnerable to collision impacts by Wade *et al.* (2016), mainly due to the high proportion of flights at potential collision heights, and the percentage of time in flight, including at night.

5.13.3.252 In summary, great black-backed gull is deemed to be of very high vulnerability, medium recoverability and national value. The sensitivity of the receptor is therefore considered to be high.

Table 5.55: Seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for great black-backed gull.

Offshore wind farm	Tier	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding	Non-breeding	Notes
Hornsea Three	-	Band (2012)	3	98.9	52	12	40	
Tier 1								
Aberdeen Demo	1	Band (2012)	2	99.5	3	0	3	
Beatrice	1	Band (2012)	3	98.9	59	5	54	Corrected to account for reduction in number of turbines
Blyth Demo	1	Band (2007)	1	99.5	8	2	6	
East Anglia ONE	1	Band (2012)	3	98.9	47	1	46	Corrected to account for reduction in number of turbines
Galloper	1	Band (2007)	1	99.5	22	0	22	
Hornsea Project One	1	Band (2012)	4	98.9	49	5	44	
Hornsea Project Two	1	Band (2012)	4	98.9	10	1	9	
Humber Gateway	1	Not available	1	99.5	6	2	5	
Hywind	1	Band (2012)	1	99.5	5	0	5	
Kentish Flats Extension	1	Band (2007)	1	99.5	0	0	0	
Moray East	1	Band (2012)	3	98.9	24	8	15	Corrected to account for reduction in number of turbines
Neart na Gaoithe	1	Band (2012)	1	99.5	5	0	4	Corrected to account for reduction in number of turbines (assessed vs consented turbine scenarios)
Teesside	1	Band (2000)	1	99.5	44	3	41	
Thanet	1	Band (2000)	1	99.5	0	0	0	
Triton Knoll	1	Band (2000)	1	99.5	122	9	112	
Westermost Rough	1	Band (2007)	1	99.5	0	0	0	
Tier 1 total					**457**	**49**	**407**	
Tier 2								
Dogger Bank Creyke Beck A and B	2	Band (2012)	3	98.9	29	2	27	
Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B)	2	Band (2012)	3	98.9	32	3	29	
East Anglia Three	2	Band (2012)	3	98.9	45	2	43	
Inchcape	2	Band (2012)	1	99.5	37	0	37	
Seagreen Alpha	2	Band (2012)	2	99.5	37	1	36	
Seagreen Bravo	2	Band (2012)	2	99.5	30	3	27	

Offshore wind farm	Tier	Band model	Option	Avoidance rate (%)	Annual collisions	Breeding	Non-breeding	Notes
Tier 2 total					**210**	**11**	**198**	
Total					**666**	**60**	**606**	

Significance of Effect

5.13.3.253 The sensitivity of great black-backed gull is considered to be high and the impact magnitude is deemed to be medium (non-breeding season). On this basis, it is judged that the cumulative impact of Hornsea Three together with Tier 1 projects could be of moderate to major significance, which is potentially significant in EIA terms. However, the predicted collision mortality rate is based on conservative assumptions, including:

- The use of precautionary avoidance rates;
- The use of precautionary nocturnal activity factors in CRM;
- Worst case assumptions about the effects on a breeding regional population that is based only on breeding adult birds (excluding immature and non-breeding adult birds) whereas predicted collision estimates are based on the observed birds at Hornsea Three which will include immature and non-breeding adults; and
- The assumption that all projects, if constructed, will be built out to the maximum design scenario assumptions made in the respective impact assessments. Analyses conducted for operational projects indicates a potential reduction of approximately 4.5% when all seasons are combined with further significant reductions likely at consented projects that are yet to be constructed (e.g. projects in the Hornsea zone, Dogger Bank zone and Scottish waters).

5.13.3.254 Despite these assumptions it is still considered that the cumulative impact of Hornsea Three together with Tier 1 and 2 projects is of **moderate adverse** significance, which is potentially significant in EIA terms.

Migratory seabirds

5.13.3.255 In section 5.11.2 the potential impact of collision risk was assessed for Arctic skua, great skua, little gull, common tern and Arctic tern. The CRM conducted for these species for Hornsea Three has predicted less than one collision for all five species (Table 5.25).

5.13.3.256 Impacts of this magnitude are considered to represent no change in the baseline mortality of the relevant populations for these species and as such the significance of these effects is considered to be **negligible**. It is therefore considered that Hornsea Three will not contribute to any cumulative impact on these species and no further consideration of collision risk to migratory seabirds is required.

5.14 Transboundary effects

5.14.1.1 A screening of transboundary impacts has been carried out and is presented in annex 5.4: Transboundary Impacts Screening Note. This screening exercise identified that there was potential for significant transboundary effects with regard to offshore ornithology from Hornsea Three upon the interests of other EEA States.

5.14.1.2 In the IPC's (2010) Scoping Opinion for Hornsea Project One, it was noted that given the movements of birds between SPAs across the North Sea, it was considered necessary to consider the potential impact of this development on the interest features of mainland European coastal SPAs.

5.14.1.3 SPAs across continental Europe have been designated as part of the network for important bird populations found during breeding, staging/migration and/or wintering periods. For each of these periods, the potential impacts of Hornsea Three on the ornithological receptors that comprise qualification components of continental SPAs and non-designated but recognised important bird areas have been assessed here.

Dogger Bank

5.14.1.4 The UK/German/Dutch Dogger Bank SAC was also considered as it has ornithological receptors listed in its citation (http://eunis.eea.europa.eu/sites/DE1003301). The citation was created by the German office responsible for overseeing European designated sites (Bundesamt für Naturschutz), and lists fulmar, gannet, kittiwake and guillemot as either resident or present during staging.

5.14.1.5 Hotspots of seabird concentrations within the extent of British Fishery Limits at Dogger Bank were identified by JNCC in order to identify potential marine SPAs, based on the top 1% qualifying numbers and regularity of occurrence (Kober *et al.,* 2010). A number of 'near-qualifying' areas (top 5% numbers and regularity) were identified, including Dogger Bank, which is important for guillemot in winter (as reported by Skov *et al*., 1995). Kober *et al*. (2010) reported an estimated 35,869 individuals within the area. Variability in numbers, however, meant that the area would not qualify in most years, and so currently fails to meet SPA qualification criteria.

Brown Ridge

5.14.1.6 The Brown Ridge has been identified as an area of sensitivity, and recent information suggests the area qualifies as SPA for wintering guillemot and razorbill, which have migrated from Scotland with their young. The sand bank lies almost entirely on the Dutch part of the North Sea and is located roughly halfway between the Dutch and English coast, some 20 nautical miles northeast of the East Anglia One project.

5.14.2 Species considered for assessment

5.14.2.1 The impact assessment in section 5.11 concluded that the effects of Hornsea Three on the VORs will be no greater than minor adverse significance. For migratory seabird species (little gull, Arctic skua, great skua, common tern and Arctic tern), collision risk and barrier effects were demonstrated to be very low magnitude, and not significant at a population level. It is therefore concluded that no non-UK SPA population of these species would be significantly affected by impacts associated with Hornsea Three, and these species require no further consideration.

5.14.2.2 This is also considered to be the case for non-seabird species such as waders and wildfowl, which may cross the North Sea in large numbers from continental SPAs such as the Waddenzee in the Netherlands. Migration CRM did, however, demonstrate that the magnitude of mortality to selected representative species is likely to be very low, and not significant compared to any SPA population. Non-seabird species are therefore also discounted from any significant transboundary effects.

5.14.2.3 Adverse effects equivalent to Minor significance were, however, recognised in certain circumstances for other seabird receptors, and these are considered below in paragraphs 5.14.3.1 to 5.14.4.32 within the context of non-UK SPA and international populations. The SPAs scoped into this assessment are based on information taken from the European designated sites website (http://www.eea.europa.eu/data-and-maps/data/natura-4).

5.14.3 Breeding season

5.14.3.1 During the breeding season, seabirds are likely to have a recognised foraging range to be able to return regularly to tend the nest. Hornsea Three is located relatively centrally within the North Sea, close to the boundary between UK and Dutch waters.

5.14.3.2 The results from a desk-based search utilising GIS data from the European designated sites website indicated that no SPAs are located within mean maximum foraging range of Hornsea Three for any of the VORs (Thaxter *et al.,* 2012), with the possible exception of the wide-ranging fulmar and gannet which have large maximum distances.

5.14.3.3 Only one continental European SPA is designated for breeding gannets - the Côte de Granit Rose-Sept Iles SPA, which is on the French Breton Peninsula, and not within mean maximum foraging range of Hornsea Three. A small number of French SPAs hold small breeding colonies of fulmar, but again these sites are outside mean maximum foraging range and it is, therefore, very unlikely that Hornsea Three will play an important role for these birds during the breeding season (see for example Wakefield *et al.* 2013 for core foraging ranges of gannets from individual SPAs).

5.14.3.4 For most of the seabird species considered here, habitat is generally unsuitable along much of the north-western European coastline, lacking the high cliffs or isolated island habitat preferred by species such as auks, gannet and kittiwake. As such, it can be concluded that during the breeding season, any connectivity between individuals from any continental SPA and Hornsea Three would be infrequent at best, and of a non-significant scale. No significant transboundary effects are therefore predicted during this period, and no more than a minor adverse effect is predicted, which is not significant in EIA terms.

5.14.4 Staging and wintering

5.14.4.1 As shown in Wright *et al.* (2012), all of the VORs considered for Hornsea Three have broad migration zones within the North Sea, and species such as auks disperse widely rather than having any set migration. Non-trivial connectivity between Hornsea Three and any particular continental population is therefore difficult to determine with any confidence.

5.14.4.2 The SPAs and important bird areas considered here have a mixture of usages, but often the site is designated during both staging and wintering periods for the species. Birds are wider ranging during the non-breeding season, and so there is greater opportunity for connectivity between the SPAs and Hornsea Three, although greater numbers of birds are likely to be present at this time, often coming from across Western Europe. The impacts on each receptor are evaluated below.

Fulmar

5.14.4.3 Fulmar is a qualifying species of a number of continental European SPAs, during breeding, winter and staging periods. The European population has been estimated at 2.8 to 4.4 million pairs (Wright *et al.*, 2012) with 11 to 18% in the UK.

5.14.4.4 Although numbers of fulmar within in the southern and central North Sea are unknown, the total flyway population is large (10,000,000 individuals, Stienen *et al.*, 2007). Birds are likely to forage widely across the North Sea, and it is therefore unlikely that individuals from any non-UK population will selectively forage within Hornsea Three. As a widely-ranging species not rated as being susceptible to wind farm impacts, it can be reasonably concluded that no non-UK populations will be significantly affected by Hornsea Three.

5.14.4.5 A significance of no more than minor adverse is therefore predicted for any effect relating to the construction, operation or decommissioning of Hornsea Three. This is not significant in EIA terms.

5.14.4.6 The potential for impacts on fulmars from non-UK SPAs are considered in the HRA Screening Report for Hornsea Three (DONG Energy, 2016b).

Gannet

5.14.4.7 Gannet is a qualifying species within some German SPAs, where a small number (<500) are present at each site during winter and staging periods. The European gannet population is estimated by Wright *et al.* (2012) to be 300,000 to 310,000 pairs, with the UK holding around 70% of the population.

5.14.4.8 Gannets migrate southwards towards Iberia and North Africa after breeding, and so continental SPA birds are mainly likely to be part of the UK breeding population either en route there, or overwintering slightly further north. Birds from Iceland and Ireland conversely are likely to head southwards via the west coast of Britain. Any connectivity of gannets from non-UK SPAs with Hornsea Three will be minimal and likely restricted to migratory flights to or from breeding colonies. It was established in the impact assessment that due to the favourable conservation status of the species in Britain and the rest of Europe, no significant effects on any population would be likely. This is also upheld for transboundary effects. A minor adverse effect is therefore predicted, which is not significant in EIA terms.

5.14.4.9 The potential for impacts on gannets from non-UK SPAs are considered in the HRA Screening Report for Hornsea Three (DONG Energy, 2016b).

Great black-backed gull

5.14.4.10 Great black-backed gull is a qualifying species of a sizeable number of SPAs in Belgium, Germany and France, during breeding, winter and staging. With the exception of northeast Scotland and Norway, the species is largely absent as a breeder along North Sea coasts, except in small numbers.

5.14.4.11 Great black-backed gulls are evidently partial migrants, due to the appearance of birds in winter along many eastern coasts where no breeding has taken place (Wernham *et al.*, 2002). Unlike most British breeders, Fennoscandian breeding populations undertake definite migration, with many ringed birds recovered in Britain coming from Norway and Murmansk. As Norway holds the majority of breeding birds, those present in continental SPAs during the non-breeding season are likely to comprise mainly migratory non-SPA birds from Norway, or those from continental SPAs that are largely sedentary. As such, Hornsea Three is unlikely to be important to any particular population, and so no significant transboundary effects are predicted.

5.14.4.12 A significance of no more than minor adverse is therefore predicted for any effect relating to the construction, operation or decommissioning of Hornsea Three. This is not significant in EIA terms.

5.14.4.13 The potential for impacts on great black-backed gulls from non-UK SPAs are considered in HRA Screening Report for Hornsea Three (DONG Energy, 2016b).

Kittiwake

5.14.4.14 Kittiwakes are northerly breeders, with those in Britain being nearer the southern part of the breeding range, although there are some colonies in Denmark, France and Spain (Wernham *et al.*, 2002). The East Atlantic biogeographic breeding population was given as 6.6 million pairs by Wright *et al.* (2012). Outside the breeding season, the species is the most pelagic of gulls and is distributed across the North Atlantic Ocean, with continental SPAs in Belgium, Germany and France mainly holding the species in winter. During this time, kittiwakes from many breeding areas mix in the North Sea, and birds make extensive movements to avoid atmospheric depressions and being forced onto continental coasts by strong winds.

5.14.4.15 Their distribution outside the breeding season is probably partly dependent on weather conditions and food supplies, and there can be large movements especially along North Sea coasts in response to weather conditions (Wright *et al.,* 2012).

5.14.4.16 The species ranges widely in winter and it is very unlikely that any particular population will be connected with birds found within Hornsea Three as birds from different colonies are likely to be widely spread throughout the North Sea. No significant transboundary effects are therefore predicted.

5.14.4.17 A significance of no more than minor adverse is therefore predicted for any effect relating to the construction, operation or decommissioning of Hornsea Three. This is not significant in EIA terms.

5.14.4.18 The potential for impacts on kittiwakes from non-UK SPAs are considered in the HRA Screening Report for Hornsea Three (DONG Energy, 2016b).

Puffin

5.14.4.19 A small number of SPAs in France have puffin as a qualifying species, with some during the breeding season and others during winter. The European population is an estimated 5,700,000 to 7,300,000 pairs, with the UK hosting up to 10% (Wright *et al.,* 2012). The majority of birds come from Iceland (3 million pairs) and Norway (1.5 million pairs) and hence there are few non-UK SPAs for breeding birds.

5.14.4.20 It is thought that puffins may be dispersive rather than following particular migratory routes, with the birds breeding at sites around Britain and Ireland dispersing very widely to sites as far afield as Norway, Newfoundland and the Canary Islands during the non-breeding season (Wernham *et al*., 2002).

5.14.4.21 Many of the birds present within Hornsea Three may therefore be part of the large Icelandic or Norwegian populations during winter months, and are unlikely to be coming from nearer continental populations. No significant transboundary effects are therefore predicted.

5.14.4.22 A significance of no more than minor adverse is therefore predicted for any effect relating to the construction, operation or decommissioning of Hornsea Three. This is not significant in EIA terms.

5.14.4.23 The potential for impacts on puffins from non-UK SPAs are considered in the HRA Screening Report for Hornsea Three (DONG Energy, 2016b).

Razorbill

5.14.4.24 There are a suite of SPAs for razorbill in France, Germany and Denmark, with most holding birds during winter months. The European razorbill population is estimated to be 430,000 to 770,000 breeding pairs (Wright *et al.*, 2012), with 12 to 22% coming from the UK.

5.14.4.25 After the breeding season and post-breeding moult, there is a gradual movement of razorbills southwards from their colonies. No defined migratory routes exist, but concentrations may exist in the Dover strait (Wernham *et al.*, 2002). In winter the species is found in relatively shallow waters close to the shore. British razorbills have been recorded throughout the species' range in the eastern Atlantic and western Mediterranean. Birds in northwest Britain have a strong tendency to move eastwards and winter off Norway and Denmark, with relatively few moving through the English Channel to France and Iberia.

5.14.4.26 It is not considered likely that continental birds from any particular colony are regular visitors to Hornsea Three in winter because although birds may disperse to and from northerly breeding colonies, connectivity is likely to be infrequent, compared to more preferred regions such as Dogger Bank or Brown Ridge. It is acknowledged that some birds may be displaced from Hornsea Three towards these preferred sites, which may increase the pressure on feeding individuals. However, much movement in winter is likely to be in response to locations of food sources, and so any effect will be fleeting. No significant transboundary effects are therefore predicted.

5.14.4.27 A significance of no more than minor adverse is therefore predicted for any effect relating to the construction, operation or decommissioning of Hornsea Three. This is not significant in EIA terms.

5.14.4.28 The impacts on razorbills from non-UK SPAs are considered in the HRA Screening Report for Hornsea Three (DONG Energy, 2016b).

Guillemot

5.14.4.29 There are a number of SPAs in Belgium, Denmark, Germany, and France in particular, where guillemot is a qualifying species in winter. The European guillemot population is around 2.0 to 2.7 million breeding pairs (Wright *et al.*, 2012), with around 30% from the UK. Birds may therefore come from a wide variety of breeding sites to winter in particular SPAs. Guillemot is a dispersive rather than migratory species, breeding from Svalbard south to Portugal (Wernham *et al.,* 2002). Birds move further away from breeding colonies until December, when birds increasingly are found in the southern North Sea, eventually peaking in February. There has been evidence that those breeding in the north (Iceland, UK) have furthest movements, whereas those further south travel a shorter distance, heading towards the Bay of Biscay. There is much mixing of populations in the North Sea and English Channel.

5.14.4.30 Like razorbill, any impacts on Hornsea Three will likely be diluted between a large number of breeding populations in Scotland and continental Europe largely on dispersal, and so there will be no significant connectivity with any non-UK population, including those at Dogger Bank or Brown Ridge, which are preferred by the species. No significant transboundary effects are therefore predicted.

5.14.4.31 A significance of no more than minor adverse is therefore predicted for any effect relating to the construction, operation or decommissioning of Hornsea Three. This is not significant in EIA terms.

5.14.4.32 The potential for impacts on guillemots from non-UK SPAs are considered in the HRA Screening Report for Hornsea Three (DONG Energy, 2016b).

5.15 Inter-related effects

5.15.1.1 Inter-relationships are considered to be the impacts and associated effects of different aspects of the proposal on the same receptor. These are considered to be:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, operation and maintenance, and decommissioning), to interact to potentially create a more significant effect on a receptor than if just assessed in isolation in these three key project stages (e.g. subsea noise effects from piling, operational turbines, vessels and decommissioning).
- Receptor led effects: Assessment of the scope for all effects to interact, spatially and temporally, to create inter-related effects on a receptor. As an example, all effects on offshore ornithology, such as disturbance, displacement, etc. may interact to produce a different, or greater effect on this receptor than when the effects are considered in isolation. Receptor-led effects might be short term, temporary or transient effects, or incorporate longer term effects.

5.15.1.2 A description of the likely inter-related effects arising from Hornsea Three on offshore ornithology is provided in volume 2, chapter 12: Inter-Related Effects (Offshore). The likely impacts are as follows:

- Disturbance and displacement due to construction activity;
- Indirect effects , such as changes in habitat of abundance and distribution of prey species;
- Displacement due to presence of turbines and other ancillary structures;
- Mortality from collision with rotating turbine blades;
- Barrier effects may prevent clear transit of birds between foraging and breeding sites, or on migration;
- Attraction to lit structures by migrating birds may cause disorientation, reduction in fitness and possible mortality; and
- Accidental pollution leading to effects on ornithological receptors.

5.16 Conclusion and summary

5.16.1.1 This chapter presents the results of the EIA for the potential impacts of Hornsea Project Three on offshore ornithology, covering all impacts from Hornsea Three seaward of MHWS during its construction, operation and maintenance, and decommissioning phases. Detailed technical information underpinning the impact assessments presented within this chapter is contained within volume 5, annex 5.1: Baseline Characterisation Report, annex 5.2: Analysis of displacement impacts on seabirds, annex 5.3: Collision Risk Modelling and annex 5.4: Data Hierarchy Report.

5.16.1.2 Characterisation of the baseline environment through twenty months of aerial survey data and desktop literature review found the species assemblage at Hornsea Three ornithological study area to be typical for the southern North Sea. A total of twenty-one species were recorded during aerial surveys with guillemot, kittiwake and razorbill the three most frequently encountered species. Other abundant species included fulmar and gannet. The presence of these species is to be expected with Hornsea Three within the foraging range of some of these species from breeding colonies (e.g. FFC pSPA).

5.16.1.3 The potential impacts on offshore ornithology, associated with the construction, operation and maintenance, and decommissioning of Hornsea Three, have been identified and are summarised in Table 5.56. The identified impacts for Hornsea Three alone will have no more than a minor adverse effect on all receptors at a regional or national level. On this basis, there is no indication, that Hornsea Three alone will have a significant impact on any VOR.

5.16.1.4 When considering the cumulative effects of Hornsea Three together with other projects and activities, several impacts of minor to moderate or moderate adverse significance are predicted. These include cumulative displacement impacts on guillemot and cumulative collision risk impacts on gannet and great black-backed gull. It is however considered that these predictions involve considerable precaution including:

- The methods used to predict mortality rates are based on conservative assumptions, including the use of precautionary parameters in relevant risk assessments (e.g. displacement and mortality rates in displacement analysis and avoidance rates and nocturnal activity factors in CRM).
- The predicted mortality rates in the breeding season are based on the number of birds of each species observed at the wind farm and it is known that these will include a proportion of immature and non-breeding adult birds. The reference populations against which the magnitude of impacts are gauged are, however, typically expressed only in terms of breeding adults.
- It is considered highly unlikely that all projects included in the cumulative assessment will be brought forward or, if constructed, they are unlikely to be built out to the maximum design scenario assumptions made in the respective impact assessments.

5.16.1.5 The screening of transboundary impacts identified that there was potential for significant transboundary effects for offshore ornithological receptors from Hornsea Three upon the interests of other European Economic Area (EEA) States. Following consideration of the relevant impact assessments, these impacts were not predicted to have significant effects on seabird populations of other EEA States.

Table 5.56: Summary of potential environment effects, mitigation and monitoring.

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
Construction Phase											
Disturbance/displacement due to construction activity	N/A	Common scoter	No change				High	Negligible (not significant in EIA terms)	None	N/A	The proposed approach to monitoring for offshore ornithology is discussed in the In Principle Monitoring Plan.
		Red-throated diver	Negligible				High	Minor adverse (not significant in EIA terms)			
		Gannet:	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Puffin	Low				Medium to high	Minor adverse (not significant in EIA terms)			
		Razorbill	Low				Low to medium	Negligible or minor adverse (not significant in EIA terms)			
		Guillemot	Low				Medium	Minor adverse (not significant in EIA terms)			
		Sandwich tern	Negligible				Medium	Negligible or minor adverse (not significant in EIA terms)			
Indirect effects, such as changes in habitat or abundance and distribution of prey.	N/A	Common scoter	No change				High	Negligible (not significant in EIA terms)	None	N/A	The proposed approach to monitoring for offshore ornithology is discussed in the In Principle Monitoring Plan.
		Red-throated diver	Negligible				High	Minor adverse (not significant in EIA terms)			
		Fulmar	Negligible				Medium	Negligible or minor adverse (not significant in EIA terms)			
		Gannet:	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Kittiwake	Negligible				Low to medium	Negligible or minor adverse (not significant in EIA terms)			
		Puffin	Negligible				Medium to high	Negligible (not significant in EIA terms)			
		Razorbill	Negligible				Low to medium	Negligible or minor adverse (not significant in EIA terms)			

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
		Guillemot	Negligible				Low to medium	Negligible or minor adverse (not significant in EIA terms)			
		Sandwich tern	Medium				Negligible	Negligible or minor adverse (not significant in EIA terms)			
		Lesser black-backed gull	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Great black-backed gull	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
Impact of pollution including accidental spills and contaminant releases which may affect species' survival rates or foraging activity	Development of, and adherence to, a CoCP.	Common scoter	No change				Medium to high	Negligible (not significant in EIA terms)	None	N/A	None
		Red-throated diver	No change				Medium to high	Negligible (not significant in EIA terms)			
		Fulmar	No change				Low	Negligible (not significant in EIA terms)			
		Gannet	No change				Medium to high	Negligible (not significant in EIA terms)			
		Puffin	No change				Medium to high	Negligible (not significant in EIA terms)			
		Razorbill	No change				Medium to high	Negligible (not significant in EIA terms)			
		Guillemot	No change				Medium to high	Negligible (not significant in EIA terms)			
		Sandwich tern	Medium				No change	Negligible (not significant in EIA terms)			
		Kittiwake	No change				Low to medium	Negligible (not significant in EIA terms)			
		Lesser black-backed gull	No change				Low	Negligible (not significant in EIA terms)			
		Great black-backed gull	No change				Low	Negligible (not significant in EIA terms)			

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
Operation and maintenance phase											
Impact of physical displacement from an area around turbines (300) and other ancillary structures (up to twelve offshore transformer substations, three offshore accommodation platforms and four offshore HVAC booster substations booster stations) during the operation and maintenance phase of the development may result in effective habitat loss and reduction in survival or fitness rates.	N/A	Fulmar	Low	Negligible	Negligible	Negligible	Medium	Negligible - minor adverse (not significant in EIA terms)	None	N/A	The proposed approach to monitoring for offshore ornithology is discussed in the In Principle Monitoring Plan.
		Gannet	Negligible	Negligible		Negligible	Medium	Negligible - minor adverse (not significant in EIA terms)			
		Puffin	Low		Negligible		Medium to high	Minor adverse (not significant in EIA terms)			
		Razorbill	Low	Negligible	Negligible	Negligible	Low to medium	Negligible - minor adverse (not significant in EIA terms)			
		Guillemot	Low		Low		Low to medium	Minor adverse (not significant in EIA terms)			
The impact of indirect effects, such as changes in habitat or abundance and distribution of prey.	N/A	Common scoter	No change				High	Negligible (not significant in EIA terms)	None	N/A	The proposed approach to monitoring for offshore ornithology is discussed in the In Principle Monitoring Plan.
		Red-throated diver	Negligible				High	Minor adverse (not significant in EIA terms)			
		Fulmar	Negligible				Medium	Negligible or minor adverse (not significant in EIA terms)			
		Gannet	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Puffin	Negligible				Medium to high	Minor adverse (not significant in EIA terms)			
		Razorbill	Negligible				Low to medium	Negligible or minor adverse (not significant in EIA terms)			
		Guillemot	Negligible				Low to medium	Negligible or minor adverse (not significant in EIA terms)			

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
		Sandwich tern	Medium				Negligible	Negligible or minor adverse (not significant in EIA terms)			
		Kittiwake	Negligible				Low to medium	Negligible or minor adverse (not significant in EIA terms)			
		Lesser black-backed gull	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Great black-backed gull	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
Mortality from collision with rotating turbine blades	N/A	Gannet	Negligible	Negligible		Negligible	Medium	Negligible or minor adverse (not significant in EIA terms)	None	N/A	The proposed approach to monitoring for offshore ornithology is discussed in the In Principle Monitoring Plan.
		Arctic skua	No change (Annual)				High	Negligible (not significant in EIA terms)			
		Great skua	No change (Annual)				High	Negligible (not significant in EIA terms)			
		Common tern		No change		No change	Medium	Negligible (not significant in EIA terms)			
		Arctic tern	No change (Annual)				Medium	Negligible (not significant in EIA terms)			
		Kittiwake	Low	Low		Negligible	High	Minor adverse (not significant in EIA terms)			
		Little gull	No change (Annual)				Medium	Negligible (not significant in EIA terms)			
		Lesser black-backed gull	Low	No change	No change	Negligible	Medium	Minor adverse (not significant in EIA terms)			
		Great black-backed gull	Low		Low		Medium	Minor adverse (not significant in EIA terms)			
		Other migratory species	No change (Annual)				High	Negligible (not significant in EIA terms)			

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
Impact of barrier effects caused by the physical presence of turbines and ancillary structures may prevent clear transit of birds between foraging and breeding sites, or on migration.	N/A	Fulmar	Low				Low	Negligible or minor adverse (not significant in EIA terms)	None	N/A	The proposed approach to monitoring for offshore ornithology is discussed in the In Principle Monitoring Plan.
		Gannet	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Arctic skua	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Great skua	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Puffin	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Razorbill	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Guillemot	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Common tern	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Arctic tern	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Kittiwake	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Little gull	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Lesser black-backed gull	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Great black-backed gull	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
Impact of attraction to lit structures by migrating birds in particular may cause disorientation, reduction in fitness and possible	N/A	All receptors	Low				Low	Negligible or minor adverse (not significant in EIA terms)	None	N/A	None
		Fulmar	Low				Low	Negligible or minor adverse (not significant in EIA terms)			

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
mortality		Gannet	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Arctic skua	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Great skua	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Puffin	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Razorbill	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Guillemot	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Common tern	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Arctic tern	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Kittiwake	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Little gull	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Lesser black-backed gull	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Great black-backed gull	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
Impact of disturbance as a result of activities associated with maintenance of operation and maintenance turbines, cables and other infrastructure may result in disturbance or displacement	N/A	Common scoter	Negligible				Medium to high	Minor adverse (not significant in EIA terms)	None	N/A	The proposed approach to monitoring for offshore ornithology is discussed in the In Principle Monitoring Plan.
		Red-throated diver	Negligible				Medium to high	Minor adverse (not significant in EIA terms)			
		Fulmar	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
of bird species		Gannet	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Puffin	Negligible				Medium	Minor adverse (not significant in EIA terms)			
		Razorbill	Negligible				Low to medium	Negligible or minor adverse (not significant in EIA terms)			
		Guillemot	Negligible				Medium	Minor adverse (not significant in EIA terms)			
		Sandwich tern	Medium				Negligible	Negligible or minor adverse (not significant in EIA terms)			
The impact of pollution including accidental spills and contaminant releases associated with maintenance or supply/service vessels which may affect species' survival rates or foraging activity.	Implementation of an appropriate PEMMP	Common Scoter	No change				Medium to high	Negligible (not significant in EIA terms)	None	N/A	N/A
		Red-throated diver	No change				Medium to high	Negligible (not significant in EIA terms)			
		Fulmar	No change				Low	Negligible (not significant in EIA terms)			
		Gannet	No change				Medium to high	Negligible (not significant in EIA terms)			
		Puffin	No change				Medium to high	Negligible (not significant in EIA terms)			
		Razorbill	No change				Medium to high	Negligible (not significant in EIA terms)			
		Guillemot	No change				Medium to high	Negligible (not significant in EIA terms)			
		Sandwich tern	Medium				Negligible	Negligible (not significant in EIA terms)			
		Kittiwake	No change				Low to medium	Negligible (not significant in EIA terms)			
		Lesser black-backed gull	No change				Low	Negligible (not significant in EIA terms)			

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
		Great black-backed gull	No change				Low	Negligible (not significant in EIA terms)			
Decommissioning Phase											
The impact of decommissioning activities such as increased vessel activity and underwater noise may result in direct disturbance or displacement from important foraging and habitat areas of birds.	N/A	Common scoter	No change				High	Negligible (not significant in EIA terms)	None	N/A	None
		Red-throated diver	Negligible				High	Minor adverse (not significant in EIA terms)			
		Gannet	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Puffin	Low				Medium to high	Minor adverse (not significant in EIA terms)			
		Razorbill	Low				Low to medium	Negligible or minor adverse (not significant in EIA terms)			
		Guillemot	Low				Medium	Minor adverse (not significant in EIA terms)			
		Sandwich tern	Medium				Negligible	Negligible or minor adverse (not significant in EIA terms)			
The impact of indirect effects, such as changes in habitat or abundance and distribution of prey	N/A	Common scoter	Negligible				High	Minor adverse (not significant in EIA terms)	None	N/A	None
		Red-throated diver	Negligible				High	Minor adverse (not significant in EIA terms)			
		Fulmar	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
		Gannet	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Puffin	Low				Medium to high	Minor adverse (not significant in EIA terms)			
		Razorbill	Low				Low to medium	Negligible or minor adverse (not significant in EIA terms)			

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
		Guillemot	Low				Medium	Minor adverse (not significant in EIA terms)			
		Sandwich tern	Medium				Negligible	Negligible or minor adverse (not significant in EIA terms)			
		Kittiwake	Low				Low	Negligible or minor adverse (not significant in EIA terms)			
		Lesser black-backed gull	Negligible				Low to medium	Negligible or minor adverse (not significant in EIA terms)			
		Great black-backed gull	Negligible				Low	Negligible or minor adverse (not significant in EIA terms)			
The impact of pollution including accidental spills and contaminant releases associated with removal of infrastructure and supply/service vessels may lead to direct mortality of birds or a reduction in foraging capacity.	Development of a Decommissioning Programme	Common scoter	No change				Medium to high	Negligible (not significant in EIA terms)	None	N/A	None
		Red-throated diver	No change				Medium to high	Negligible (not significant in EIA terms)			
		Fulmar	No change				Low	Negligible (not significant in EIA terms)			
		Gannet	No change				Medium to high	Negligible (not significant in EIA terms)			
		Puffin	No change				Medium to high	Negligible (not significant in EIA terms)			
		Razorbill	No change				Medium to high	Negligible (not significant in EIA terms)			
		Guillemot	No change				Medium to high	Negligible (not significant in EIA terms)			
		Sandwich tern	Medium				No change	Negligible (not significant in EIA terms)			
		Kittiwake	No change				Low to medium	Negligible (not significant in EIA terms)			
		Lesser black-backed gull	No change				Low	Negligible (not significant in EIA terms)			

Description of impact	Measures adopted as part of the project	Receptor	Magnitude of impact				Sensitivity of receptor	Significance of effect	Additional measures	Residual effect	Proposed monitoring
			Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season					
		Great black-backed gull	No change				Low	Negligible (not significant in EIA terms)			

References

Balmer, D. E., Gillings, S., Caffrey, B. J., Swann, R. L., Downie, I. S., & Fuller, R. J. (2013). Bird Atlas 2007–11: the breeding and wintering birds of Britain and Ireland. Thetford, British Trust for Ornithology.

Band, B. (2011). Using a collision risk model to assess bird collision risks for offshore wind farms. The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-02. Norfolk, British Trust for Ornithology.

Band, B. (2012). Using a collision risk model to assess bird collision risks for offshore wind farms. The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-02. Norfolk, British Trust for Ornithology.

Band, W. (2000). Wind farms and Birds: calculating a theoretical collision risk assuming no avoiding action. Scottish Natural Heritage Guidance Note.

Band, W., Madders, M., and Whitfield, D.P. (2007). Developing field and analytical methods to assess avian collision risk at wind farms. In: de Lucas, M., Janss, G.F.E. and Ferrer, M. (eds.) Birds and Wind Farms: Risk Assessment and Mitigation. Madrid, Quercus. p. 259-275.

Barrow Offshore Wind Ltd. (2009). Post Construction Monitoring Report for Barrow Offshore Wind Farm. Barrow Offshore Wind Ltd., Copenhagen.

Barton C., Pollock C. and Harding N. (2009). Arklow Bank seabird and marine mammal monitoring programme. Year 8. A report to Airtricity.

BERR (2007). Aerial surveys of waterbirds in Strategic Wind Farm Areas: 2005/2006 Final Report. Department of Business, Environment and Regulatory Reform, London.

Birdlife International (2017). *Calonectris borealis. (amended version published in 2016) The IUCN Red List of Threatened Species 2017*. [Online]. Available at: http://www.iucnredlist.org/details/22732244/0 (Accessed September 2017).

Bradbury, G., Trinder, M., Furness, B., Banks, A.N., Caldow, R.W.G. and Hume, D. (2014). Mapping Seabird Sensitivity to Offshore Wind Farms. PLOS ONE, 12 (1), pp. 1-17.

Brown, A. and Grice, P. (2005). Birds in England. London, Poyser.

Burton, N.H.K., Banks, A.N., Calladine, J.R. and Austin, G.E. (2013). The importance of the United Kingdom for wintering gulls: population estimates and conservation requirements. Bird Study, 60 (1), 87-101.

Camphuysen, C.J. (2005) (ed.). Understanding marine foodweb processes: an ecosystem approach to sustainable sandeel fisheries in the North Sea. IMPRESS final report. Royal Netherlands Institute for Sea Research, Texel.

Camphuysen, C.J., Fox, T., Leopold, M.F. and Petersen, I.K. (2004). Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the UK. A report for COWRIE.

Christensen, T.K., Hounisen, J.P., Clausager, I. and Petersen, I.K. (2004). Visual and Radar Observations of Birds in Relation to Collision Risk at the Horns Rev. Offshore Wind Farm. Annual status report 2003. Report commissioned by Elsam Engineering A/S 2003. NERI Report. Rønde, Denmark: National Environmental. Research Institute.

CIEEM (2010). Guidelines for Ecological Impact Assessment in Britain and Ireland: Marine and Coastal. Winchester, Institute of Ecology and Environmental Management.

Cook, A.S.C.P., Humphreys, E.M., Masden, E.A. and Burton, N.H.K. (2014). The avoidance rates of collision between birds and offshore turbines. Thetford, British Trust for Ornithology.

Cramp, S. and Perrins, C.M. (1977 - 1994). Handbook of the birds of Europe, the Middle East and Africa. The birds of the western Palearctic. Oxford, Oxford University Press.

DECC (2009). Aerial Surveys of Waterbirds in the UK: 2007/08, Final Report. Department of Energy and Climate Change, London.

DECC (2011a). Department of Energy and Climate Change - Overarching National Policy Statement for Energy (EN-1). London, Stationery Office.

DECC (2011b). Department of Energy and Climate Change - National Policy Statement for Renewable Energy Infrastructure (EN-3). London, Stationery Office.

DECC (2011c). Department of Energy and Climate Change - Offshore Energy Strategic Environmental Assessment: OESEA2 Environmental Report - Future Leasing/Licensing for Offshore Renewable Energy, Offshore Oil and Gas, Hydrocarbon Gas and Carbon Dioxide Storage and Associated Infrastructure. Department for Energy and Climate Change, February 2011. URN 10D/1024.

del Hoyo, J.; Elliott, A. and Sargatal, J. (1996). Handbook of the Birds of the World, vol. 3: Hoatzin to Auks. Barcelona, Lynx Edicions.

Desholm, M. (2005). TADS investigations of avian collision risk at Nysted Offshore Wind Farm. Denmark, National Environmental Research Institute.

Dierschke, V. and Garthe, S. (2006). Literature review of offshore wind farms with regards to seabirds. In: Zucco, C., Wende, W., Merck, T., Köchling, I. and Köppel, J. (eds.): Ecological research on offshore wind farms: international exchange of experiences. Part B: literature review of ecological impacts. BfN-Skripten 186: 131–198.

Dierschke, V., Garthe, S. and Mendel, B. (2006). Possible conflicts between offshore wind farms and seabirds in the German sectors of North Sea and Baltic Sea. In: Köller, J., Köppel, H. and Peters, W. (Eds.): Offshore wind energy. Research on environ mental impacts. Berlin, Springer. p 121-143.

DONG Energy (2016a). Hornsea Project Three Offshore Wind Farm Environmental Impact Assessment: Scoping Report.

DONG Energy (2016b). Hornsea Project Three Offshore Wind Farm. Habitat Regulations Assessment: Screening Report.

Drewitt, A.L. and Langston, R.H.W. (2006). Assessing the impacts of wind farms on birds. Ibis, 148. 29-42.

DTI (2006). Aerial Surveys of Waterbirds in Strategic Windfarm Areas: 2004/05, Final Report. Department of Trade and Industry, London.

Eaton, M.A., Aebischer, N.J., Brown, A.F., Hearn, R., Lock, L., Musgrove, A.J., Noble, D., Stroud, D. and Gregory, R.D. (2015). Birds of Conservation Concern 4: the population status of birds in the United Kingdom, Channel Islands and the Isle of Man. *British Birds* 108, 708-746.

ECON (2012). Boat-based ornithological monitoring at the Lynn and Inner Dowsing Wind Farms: Year 3 (2011) post-construction report. Report for Centrica Renewable Energy Limited.

Everaert, J. (2006). Wind turbines and birds in Flanders: preliminary study results and recommendations. Natuur. Oriolus, 69(4), 145-155.

Everaert, J. (2008). Effecten van windturbines op de fauna in Vlaanderen : onderzoeksresultaten, discussie en aanbevelingen. Effects of wind turbines on fauna in Flanders - Study results, discussions and recommendations. Rapporten van het Instituut voor Natuur- en Bosonderzoek, 2008(44). Instituut voor Natuur- en Bosonderzoek: Brussel : Belgium.

Everaert, J., Devos, K. and Kuijken, E. (2002). Windturbines en vogels in Vlaanderen. Voorlopige onderzoeksresultaten en buitenlandse bevindingen. Report 2002.3, Instituut voor Natuurbehoud,Brussels. Available at http://publicaties.vlaanderen.be/docfolder/12563/Effecten_windturbines_op_de_fauna_Vlaanderen_2008.pdf.

Everaert, J. and Kuijken, E. (2007). Wind turbines and birds in Flanders (Belgium): Preliminary summary of the mortality research results. Belgian Research Institute for Nature and Forest.

Exo, K-M., Hüppop, O. and Garthe, S. (2003). Offshore-Windenergieanlagen und Vogelschutz. Seevögel 23, 83-95.

Forrester, R.W., Andrews, I.J., McInerny, C.J., Murray, R.D., McGowan, R.Y., Zonfrillo, B., Betts, M.W., Jardine, D.C. and Grundy, D.S. (eds) (2007). The Birds of Scotland. Aberlady, The Scottish Ornithologists' Club.

Frederiksen, M. *et al.* (2012). Multicolony tracking reveals the winter distribution of a pelagic seabird on an ocean basin scale. Diversity Distrib. 18, 530–542.

Frost, T.M., Austin, G.E., Calbrade, N.A., Holt, C.A., Mellan, H.J., Hearn, R.D., Stroud, D.A., Wotton, S.R. and Balmer, D.E. (2017). Waterbirds in the UK 2015/16: The Wetland Bird Survey. Thetford, British Trust for Ornithology.

Furness, R.W. (2015). Non-breeding season populations of seabirds in UK waters. Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Report NECR164.

Furness, R.W. and Todd, C.M. (1984). Diets and feeding of Fulmars Fulmarus glacialis during the breeding season:a comparison between St Kilda and Shetland colonies. *Ibis,* 126 (3), pp. 379-387.

Furness, R.W., Wade, H.M. and Masden, E.A. (2013). Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management, 119, 56-66.

Garthe, S, and Hüppop, O. (1996). Nocturnal scavenging by gulls in the southern North Sea. Colonial Waterbirds 19, 232-241.

Garthe, S. and Hüppop, O. (2004). Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology, 41, 724- 734.

Garthe, S., Grémillet, D. and Furness, R.W. (1999). At-sea activity and foraging efficiency in chick-rearing northern gannets (*Sula bassana*): a case study in Shetland. *Marine Ecology Progress Series*, 185, 93-99.

Garthe, S., Ludynia, K., Hüppop, O., Kubetzki, U., Meraz, J.F. and Furness, R.W. (2012). Energy budgets reveal equal benefits of varied migration strategies in northern gannets. *Marine Biology*, 159, 1907-1915.

Goodale W. and T. Divoll. (2009). Birds, Bats and Coastal Wind Farm Development in Maine: A Literature Review. Report BRI 2009-18. Gorham, Maine, BioDiversity Research Institute.

Guse, N., Garthe, S. & Schirmeister, B. (2009). Diet of red-throated divers *Gavia stellata* reflects the seasonal availability of Atlantic herring Clupea harengus in the southwestern Baltic sea. Journal of Sea Research, 62: 268-275.

GWFL (2011). Galloper Wind Farm Project Environmental Statement - Chapter 11: Offshore Ornithology.

Hamer, K.C., Humphreys, E.M., Garthe, S., Hennicke, J., Peters, G., Grémillet, D., Phillips, R.A., Harris, M.P. and Wanless, S. (2007). Annual variation in diets, feeding locations and foraging behaviour of gannets in the North Sea: flexibility, consistency and constraint. Marine Ecology Progress Series, 338, 295-305.

Hamer, K.C., Monaghan, P., Uttley, J.D., Walton, P. and Burns, M.D. (1993). The influence of food supply on the breeding ecology of kittiwakes *Rissa tridactyla* in Shetland. *Ibis*, 135, 255-263.

Hamer, K.C., Phillips, R.A., Wanless, S., Harris, M.P. and Wood, A.G. (2000). Foraging ranges, diets and feeding locations of gannets in the North Sea: evidence from satellite telemetry. *Marine Ecology Progress Series*, 200, 257-264.

Harris, M.P. and Wanless, S. (2011). The Puffin. Poyser.

Holt, C., Austin, G., Calbrade, N., Mellan, H., Hearn, R., Stroud, D., Wotton, S. and Musgrove, A. (2012). *Waterbirds in the UK 2010/11.* [Online]. Available at: https://www.bto.org/volunteer-surveys/webs/publications/webs-annual-report/waterbirds-in-the-uk/wituk-201011 (Accessed January 2018).

Horswill, C. & Robinson R. A. (2015). Review of seabird demographic rates and density dependence. *JNCC Report No. 552.* Joint Nature Conservation Committee, Peterborough

Hüppop, O., Dierschke, J., Exo, K-M., Fredrich, E. and Hill, R. (2006). Bird migration studies and potential collision risk with offshore wind turbines. Ibis, 148, 90-109.

ICES (2011). Effects of offshore wind farms on seabirds. p.12-17. In: Report of the Working Group on Seabird Ecology (WGSE) 1-4 November 2011. Madeira, Portugal. p. 73. CM2011/SSGEF:07. ICES, Copenhagen.

IPC (2010). Advice Note six: Preparation and submission of application documents. Bristol, IPC.

JNCC (2017). Seabird Monitoring Programme database. [Online]. Available at: http://jncc.defra.gov.uk/smp/ (Accessed January 2018).

JNCC (2016). Online species accounts for SPA species. [Online]. Available at http://www.jncc.gov.uk/page-1419 (Accessed January 2018).

JNCC (2014). Joint Response from the Statutory Nature Conservation Bodies to the Marine Scotland Science Avoidance Rate Review. Joint Nature Conservation Committee (JNCC), Natural England (NE), Natural Resource Wales (NRW), Northern Ireland Environment Agency (NIEA), Scottish Natural Heritage (SNH).

JNCC (2013). Seabird Population Trends and Causes of Change: 1986-2015 Report. [Online]. Available at: http://jncc.defra.gov.uk/page-3201 (Accessed March 2018).

JNCC (2004). *Developing Regional Seas for UK Waters using Biogeographic Principles.* [Online]. Available at: http://jncc.defra.gov.uk/page-1612 (Accessed March 2018).

JNCC, Natural Resources Wales, Department of Agriculture, Environment and Rural Affairs/Northern Ireland Environment Agency, Natural England and Scottish Natural Heritage, (2017). Joint SNCB Interim Displacement Advice Note. [Online]. Available at: http://jncc.defra.gov.uk/pdf/Joint_SNCB_Interim_Displacement_AdviceNote_2017.pdf (Accessed May 2017).

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. and Burton, N.H.K. (2014). Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology, 51, 31-41.

Kaiser, M. Elliot, A,. Galanidi, M., Rees, E.I.S., Caldow, R., Stillman, R., Sutherland, W. & Showler, D. (2002). Predicting the displacement of Common Scoter Melanitta nigra from benthic feeding areas due to offshore windfarms. Report Cowrie-BEN-03-2002. University of Wales, Bangor.

Kerlinger, P. and Curry, R. (2002). Desktop Avian Risk Assessment for the Long Island Power Authority Offshore Wind Energy Project. Prepared for AWS Scientific Inc. and Long Island Power Authority.

King, S., Maclean, I.M.D., Norman, T., and Prior, A. (2009). Developing Guidance on Ornithological Cumulative Impact Assessment for Offshore Wind Farm Developers. COWRIE.

Kober. K., Webb. A., Win. I., Lewis. M., O'Brien. S., Wilson. L.J., Reid. J.B. (2010). An analysis of the numbers and distribution of seabirds within the British Fishery Limit aimed at identifying areas that qualify as possible marine SPAs. JNCC Report, No. 431.

Kotzerka. J., Garthe. S. and Hatch. S.A. (2010). GPS tracking devices reveal foraging strategies of Black-legged Kittiwakes. *Journal of Ornithology*. 151. 459-467.

Krijgsveld, K.L., Fijn, R.C., Heunks, C.P., van Horssen, W., de Fouw, J., Collier, M.P., Poot, M.J.M., Beuker, D. and Dirksen, S. (2010). Effect Studies Offshore Wind Farm Egmond aan Zee. Progress report on fluxes and behaviour of flying birds covering 2007 and 2008. Bureau Waardenburg report 09-023. Bureau Waardenburg, Culemborg.

Krijgsveld, K.L., Fijn, R.C., Japink, M., van Horssen, P.W., Heunks, C., Collier, M.P., Poot, M.J.M., Beuker, D. and Dirksen, S. (2011). Effect studies Offshore Wind Farm Egmond aan Zee: Final report on fluxes, flight altitudes and behaviour of flying birds. NoordzeeWind report nr OWEZ_R_231_T1_20111114_fluxandflight, Bureau Waardenburg report nr 10-219.

Langston, R.H.W. (2010). Offshore wind farms and birds: Round 3 zones, extensions to Round 1 and 2 sites and Scottish Territorial Waters. RSPB Research Report No. 39.

Langston, R.H.W., Teuten, E. and Butler, A. (2013). Foraging ranges of northern gannets Morus bassanus in relation to proposed offshore wind farms in the North Sea: 2010-2012. Sandy: Royal Society for the Protection of Birds

Lawrence, E.S., Painter, S. and Little, B. (2007). Responses of birds to the wind farm at Blyth Harbour, Northumberland, UK, in: de Lucas, M. *et al.* (ed.) (2007). Birds and wind farms: risk assessment and mitigation. p. 47-69.

Lawson, J., Kober, K., Win, I., Allcock, Z., Black, J., Reid, J.B., Way, L. and O'Brien, S.H. (2015). An assessment of the numbers and distributions of wintering red-throated diver, little gull and common scoter in the Greater Wash. JNCC Report 574. Peterborough, JNCC.

Leopold, M.F., Dijkman, E.M., Teal, L. and the OWEZ-team (2010). Local birds in and around the Offshore Wind Farm Egmond aan Zee (OWEZ). NoordzeeWind rapport OWEZ_R_221_T1_20100731_local_birds. Imares / NoordzeeWind, Wageningen / IJmuiden.

Leopold, M.F., Dukman, E.M., and Teal, L. (2011). Local Birds in and around the Offshore Wind Farm Egmond aan Zee (OWEZ) (T-0 and T-1, 2002-2010). Texel, The Netherlands, Wageningen IMARES.

Longcore, T. and Rich, C. (2004). Ecological light pollution. Frontiers in Ecology and the Environment/Ecological Society of America, 2 (4), 191-198.

Lowther, S. (2000). The European Perspective: Some Lessons from Case Studies, In: Proc Nat Avian – Wind Power Plan Meet III, San Diego, Kalifornija 1998, Environmental Research Associates, Ontario, Kanada, http://ww.nationalwind.org/pubs/avian98 (13.5.2006).

MacArthur Green (2017). *Estimates of Ornithological Headroom in Offshore Wind Farm Collision Mortality.* The Crown Estate.

Maclean, I.M.D., Wright, L.J., Showler, D.A., and Rehfisch, M.M. (2009). A review of assessment methodologies for offshore wind farms. British Trust for Ornithology Report, commissioned by COWRIE Ltd.

Madsen, P.T., Wahlberg, M., Tougaard, J. and Tyack, P. (2006). Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology Progress Series,* 309, 279-295.

Masden, E.A. (2015). Developing an avian collision risk model to incorporate variability and uncertainty. Environmental Research Institute North Highland College – UHI University of the Highlands and Islands.

Mendel, B., Kotzerka, J., Commerfield, J., Schwemmer, H., Sonntag, N. and Garthe, S. (2014). *Effects of the* alpha ventus *offshore test site on distribution patterns, behaviour and flight heights of seabirds*. Federal Maritime and Hydrographic Agency

Mitchell, P.I., Newton, S.F., Ratcliffe, N. and Dunn, T.E. (2004). Seabird populations of Britain and Ireland. Poyser, London.

MMO (2014). *East Inshore and East Offshore Marine Plans.* [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/312496/east-plan.pdf (Accessed March 2018).

MMO (2015). *Vessel Density Grid 2015.* [Online]. Available at: https://data.gov.uk/dataset/b7ae1346-7885-4e2d-aedf-c08a37d829ee/vessel-density-grid-2015 (Accesed March 2018).

Musgrove, A.J., Aebicher, N.J., Eaton, M.A., Hearn, R.D., Newson, S.E., Noble, D.G., Parsons, M., Risely, K. and Stroud, D.A. (2013). Population estimates of birds in Great Britain and the United Kingdom. British Birds, 106, 64-100.

Natural England (2013). Walney Extension Offshore Wind Farm Application. Written Representations of Natural England. Planning Inspectorate Reference: EN010027.

Natural England (2014). Hornsea Offshore Wind Farm – Project One Application: Written Representations of Natural England.

Natural England (2015a). Hornsea offshore wind farm - project two application. Written submission for deadline 3: Appendix 4. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed January 2018).

Natural England (2015b). Hornsea offshore wind farm - project two application. Written submission for deadline 3: Appendix 5. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed January 2018).

Natural England (2015c). Hornsea offshore wind farm - project two application. Written submission for deadline 3: Appendix 6. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed January 2018).

Natural England (2015d). Hornsea offshore wind farm - project two application. Written submission for deadline 6. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs (Accessed January 2018).

Natural England (2016). East Anglia Three. Written Representations of Natural England. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-001109-no17.Natural%20England (Accessed January 2017).

Natural England and JNCC (2012). Joint Natural England and JNCC Interim Advice Note – Presenting information to inform assessment of the potential magnitude and consequences of displacement of seabirds in relation of Offshore Wind farm Developments.

Natural England and JNCC (2010). Outer Thames Estuary SPA Departmental Brief.

Nelson, E., Vallejo, G., Canning, S., Kerr, D., Caryl, F., McGregor, R., Rutherford, V. and Lancaster, J. (2015). Analysis of Marine Ecology Monitoring Plan Data – Robin Rigg Offshore Wind Farm. [Online]. Available at: http://www.gov.scot/Topics/marine/Licensing/marine/scoping/Robin-Rigg (Accessed March 2018).

nPower Renewables (2008). North Hoyle Offshore Wind Farm FEPA Monitoring Final Report.

O'Brien, S.H., Wilkson, L.J., Webb, A. and Cranswick, P.A. (2008). Revised estimate of numbers of wintering Red-throated Divers *Gavia stellata* in Great Britain. Bird Study 55, 152–160.

Ørsted (2018). Hornsea Three Offshore Wind Farm. Habitats Regulations Assessment. Report to Inform Appropriate Assessment. London: Ørsted.

Percival, S.M. (2009). Kentish Flats Offshore Wind Farm: Review of Monitoring of Red Throated Divers 2008-2009. Ecology Consulting report to Vattenfall.

Percival, S.M. (2010). Kentish Flats Offshore Wind farm: Diver surveys 2009-2010. On behalf of Vattenfall Wind Power.

Perrow, M.R., Gilroy, J.J., Skeate, E.R. and Mackenzie, A. (2010). *Quantifying the relative use of coastal waters by breeding terns: towards effective tools for planning & assessing the ornithological impact of offshore wind farms.* [Online]. Available at: https://www.thecrownestate.co.uk/media/450936/ei-km-ex-pc-birds-062010-planning-and-assessing-the-ornithological-impact-of-offshore-wind-farms-breeding-terns.pdf (Accessed January 2018).

Petersen, I.K. (2005). Bird numbers and distributions in the Horns Rev offshore wind farm area. Annual status report 2004. - NERI Report, Commissioned by Elsam Engineering A/. 34 pp.

Petersen, I.K. and Fox, A.D. (2007). Changes in bird habitat utilization around the Horns Rev 1 offshore wind farm, with particular emphasis on Common Scoter. National Environmental Research Institute, p. 36.

Petersen, I.K., Christensen, T.K., Kahlert, J., Desholm, M. and Fox, A.D. (2006). Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark. NERI Report Commissioned by Ørsted and Vattenfall A/S 2006. National Environmental Research Institute Ministry of the Environment-Denmark, Denemarken.

Petersen, I.K., Clausager, I. and Christensen, T.J. (2004). Bird Numbers and Distribution on the Horns Rev. Offshore Wind Farm Area. Annual Status Report 2003. Report commissioned by Elsam Engineering A/S 2003. Rønde, Denmark: National Environmental. Research Institute.

Planning Inspectorate (PINS) (2016). *Scoping Opinion. Proposed Hornsea Three Offshore Wind Farm*. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/eastern/hornsea-project-three-offshore-wind-farm/?ipcsection=docs (Accessed March 2018).

Planning Inspectorate (PINS) (2015). Advice Note Seventeen: Cumulative Effects Assessment Relevant to Nationally Significant Infrastructure Projects, [Online], Available at: https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/12/Advice-note-17V4.pdf (Accessed January 2018).

Ratcliffe, N., Phillips, R.A., and Gubbay, S. (2000). Foraging ranges of UK seabirds from their breeding colonies and its implication for creating marine extensions to colony SPAs. Unpublished Report to BirdLife International.

Robinson, R.A. (2017). BirdFacts: profiles of birds occurring in Britain and Ireland. [Online]. Available at: http://www.bto.org/birdfacts (Accessed May 2017)

RPS (2009). Assessing the relative use of the Westermost Rough Offshore Wind Farm by little gull, Hydrocoloeus minutus with reference to the interaction with Hornsea Mere, SPA, East Yorkshire. Commissioned by Ørsted.

RPS (2012). Lincs / LID6 Offshore Wind Farm – Boat-based Ornithological Monitoring: Construction Phase. Report for CREL.

Ruddock, M. and Whitfield, D.P., (2007). A Review of Disturbance Distances in Selected Bird Species. [Online]. Available at: http://www.snh.org.uk/pdfs/strategy/renewables/birdsd.pdf (Accessed March 2013).

Schwemmer, P., Mendel, B., Sonntag, N., Dierschke, V. and Garthe, S. (2011). Effects of ship traffic on seabirds in offshore waters: implications for marine conservation and spatial planning. Ecological Applications 21: 1851-1860.

Scottish Government (2017). *Scoping opinion for the proposed section 36 consent and associated marine licence application for the revised inch cape offshore windfarm and revised inch cape offshore transmission works – ornithology aspects only*. [Online]. Available at: http://www.gov.scot/Topics/marine/Licensing/marine/scoping/ICOLRevised-2017 (Accessed March 2018).

Seys, J., Offringa, H., van Waeyenberge, J., Meire, P., Vincx, M. & Kuijken, E. (2001). Distribution patterns of seabirds in Belgian marine waters. In: Seys J. (ed.) Sea- and coastal bird data as tools in the policy and management of Belgian marine waters, pp. 22-39. PhD Thesis, University of Gent, Gent, Belgium.

Skov, H., Durinck, J., Leopold, M.F. and Tasker, M.L. (1995). Important bird areas for seabirds in the North Sea. Birdlife International, Cambridge.

SMart Wind (2013). Hornsea Offshore Wind Farm Project One. Environmental Statement Volume 5 – Offshore Annexes Chapter 5.5.1 Ornithology Technical Report. [Online]. Available at: https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-one/?ipcsection=docs (Accessed March 2018).

SMart Wind (2015a). Hornsea Offshore Wind Farm Project Two Environmental Statement Volume 5 – Offshore Annexes; Annex 5.5.1 Ornithology Technical Report. PINS Document Reference 7.5.5.1.. Smart Wind Limited.

SMart Wind (2015b). Hornsea Project Two Environmental Statement

SNH (2010). Survey Methods for Use in Assessing the Impacts of Onshore Wind Farms on Bird Communities. Scottish Natural Heritage. Revised December 2010. [Online]. Available at http://www.snh.org.uk/pdfs/strategy/renewable/bird_survey.pdf (Accessed January 2018).

SNH (2013). *Avoidance rates for wintering species of geese in Scotland at onshore wind farms.* Scottish Natural Heritage.

Speakman, J., Gray, H. and Furness, L. (2009). University of Aberdeen report on effects of offshore wind farms on the energy demands on seabirds (October 2009). Institute of Biological and Environmental Sciences, University of Aberdeen. Report for DECC.

Stienen, E.W.M., van Waeyenberge, J., Kuijken, E. and Seys, J. (2007). Trapped within the corridor of the Southern North Sea: the potential impact of offshore wind farms on seabirds. In: Birds and Wind Farms - Risk assessment and Mitigation (eds. de Lucas M., Janss G.F.E. and Ferrer M.), p. 71-80. Quercus, Madrid, Spain.

Stone, C.J., Webb, A., Barton, C., Ratcliffe, N., Redd, T.C., Tasker, M.L., Camphuysen, C.J. and Pienkowski, M.W. (1995). An atlas of seabird distribution in north-west European waters. Joint Nature Conservation Committee and Nederlands Institute voor Onderzoek der Zee, Peterborough.

Thaxter, C.B., Lascelles, B., Sugar, K., Cook, A.S.C.P., Roos, S., Bolton, M., Langton, R.H.W. and Burton, N.H.K. (2012). Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas.

The U.S. Department of the Interior (2004). Geological and Geophysical Exploration for Mineral Resources in the Gulf of Mexico Outer Continental Shelf: Final Programmatic Environmental Assessment. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. New Orleans, United States of America.

Thomas, C. (2011). Yorkshire Bird Report 2009. Yorkshire Naturalists Union.

Trapp, J. L. (1998). Bird kills at towers and other man–made structures: an annotated partial bibliography (1960–1998). U S Fish and Wildlife Service, Office of Migratory Bird Management,Arlington, Virginia.

Tulp, I., Schekkerman H., Larsen J.K., van der Winden J., van de Haterd R.J.W., van Horssen P., Dirksen S., and Spaans A.L. (1999). Nocturnal flight activity of sea ducks near the wind farm Tuno Knob in the Kattegat. IBN-DLO Report No. 99.30.

Vanerman, N., Courtens, W., Van de walle, M., Verstraete, H. and Stienen, E.W.M. (2016). *Seabird monitoring at offshore wind farms in the Belgian part of the North Sea Updated results for the Bligh Bank & first results for the Thorntonbank*. Brussels: Instituut voor Natuur- en Bosonderzoek.

Vanerman, N., Courtens, W., Van de walle, M., Verstraete, H. and Stienen, E.W.M. (2017). *Seabird monitoring at the Thorntonbank offshore wind farm. Updated seabird displacement results & an explorative assessment of large gull behavior inside the wind farm area.* Brussels: Instituut voor Natuur- en Bosonderzoek.

Vanermen N., Stienen E.W.M., Courtens W., Onkelinx T., Van de walle M. and Verstraete H. (2013). Bird monitoring at offshore wind farms in the Belgian part of the North Sea - Assessing seabird displacement effects. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2013 (INBO.R.2013.755887). Instituut voor Natuur- en Bosonderzoek, Brussel.

Votier, S.C., Bicknell, A., Cox, S.L., Scales, K.L., Patrick, S.C. (2013). A Bird's Eye View of Discard Reforms: Bird-Borne Cameras Reveal Seabird/Fishery Interactions. PLoS ONE 8(3): e57376. doi:10.1371/journal.pone.0057376

Votier, S.C., Birkhead, T.R., Oro, D., Trinder, M., Grantham, M.J., Clark, J.A., McCleery, R.H., and Hatchwell, B.J. (2008). Recruitment and survival of immature seabirds in relation to oil spills and climate variability. Journal of Animal Ecology, 77, 974-983.

Wade H.M., Masden. E.A., Jackson, A.C. and Furness, R.W. (2016). Incorporating data uncertainty when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments. Marine Policy, 70, 108–113.

Wakefield, E.D., Bodey, T.W., Bearhop, S., Blackburn, J., Colhoun, K., Davies, R., Dwyer, R.G., Green, J.A., Grémillet, D., Jackson, A.L., Jessopp, M.J., Kane, A., Langston, R.H.W., Lescroël, A., Murray, S., Le Nuz, M., Patrick, S.C., Péron, C., Soanes, L.M., Wanless, S., Votier, S.C. and Hamer, K.C. (2013). Space Partitioning Without Territoriality in Gannets. Science, 341 (6141), 68-70.

Walls, R. Canning, S., Lye, G., Givens, L., Garrett, C. and Lancaster, J. (2013). Analysis of Marine Environmental Monitoring Plan Data from the Robin Rigg Offshore Wind Farm, Scotland (Operational Year 1). Natural Power report for E.ON Climate and Renewables.

Wanless, S., Murray, S. and Harris, M.P. (2005). The status of Northern Gannet in Britain & Ireland in 2003/04. British Birds, 98, 280-294.

Webb, A., Tasker, M.L. and Greenstreet, S.P.R. (1985). The distribution of Guillemots Uria aalge, Razorbills Alca torda and Puffins Fratercula arctica at sea around Flamborough Head, June 1984. Peterborough: NCC.

Welcker, M., Liesenjohann, M., Blew, J., Nehls, G. & Grunkorn, T. (2017). Nocturnal migrants do not incur higher collision risk at wind turbines than diurnally active species. Ibis, 159, 366–373.

Wernham, C.V., Toms, M.P., Marchant, J.H., Clark, J.A., Sirwardena, G.M. and Baillie, S.R. (Eds). (2002). The Migration Atlas: movement of the birds of Britain and Ireland. Poyser.

Wetlands International (2006). Waterbird population estimates – fourth edition. Wetlands International, Wageningen, The Netherlands.

Wetlands International (2017). "Waterbird Population Estimates". Retrieved from wpe.wetlands.org on Friday 12 May 2017

Williams, J.M., Tasker, M.L., Carter, I.C. and Webb, A. (1995). A method of assessing seabird vulnerability to surface pollutants. Ibis, 1137, S147-S152.

Wilson, L.J., Black, J., Brewer, M.J., Potts, J.M., Kuepfer, A., Win, I., Kober, K., Bingham, C., Mavor, R. and Webb, A. (2014). Quantifying usage of the marine environment by terns Sterna sp. around their breeding colony SPAs. JNCC Report 500. Peterborough: JNCC.

Wright, L.J., Ross-Smith, V.H., Massimino, D., Dadam, D., Cook, A.S.C.P. and Burton, N.J.K. (2012). Assessing the risk of offshore wind farm development to migratory birds designated as features of UK Special Protection Areas (and other Annex 1 species). The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-05. BTO and The Crown Estate. SOSS Website.

WWT Consulting and MacArthur Green (2014). Seabird sensitivity mapping in English territorial waters. Natural England.

WWT Consulting, RPS and MacArthur Green (2012). *Gannet Population Viability Analysis*. SOSS Report 04.