Hornsea Four Preliminary Environmental Information Report (PEIR)

Volume 2,
Chapter 5 : Offshore & Intertidal Ornithology

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Glossary

Term	Definition
Agreement for Lease (AfL)	For Hornsea Four, the AfL area was originally described and presented as the array area in the Scoping Report, which represents the original lease area from The Crown Estate (TCE)
Collision Risk Model (CRM)	General term to describe the method of estimating the collision risk of seabirds (estimated mortality) to operational turbines, which could be either deterministic or stochastic.
Commitment	A term used interchangeably with mitigation. Commitments are embedded mitigation measures. Commitments are either primary (design) or tertiary (inherent) and embedded within the assessment at the relevant point in the Environmental Impact Assessment (EIA) (e.g. at Scoping or Preliminary Environmental Information Report (PEIR)). The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms.
Cumulative effects	The combined effect of Hornsea Four in combination with the effects from a number of different projects, on the same single receptor/resource. Cumulative impacts are those that result from changes caused by other past, present or reasonably foreseeable actions together with Hornsea Project Four.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIP).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity, of the receptor or resource in accordance with defined significance criteria.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Impact Assessment (EIA) Report.
EIA Directive	European Union Directive 85/337/EEC, as amended by Directives 97/11/EC, 2003/35/EC and 2009/31/EC and then codified by Directive 2011/92/EU of 13 December 2011 (as amended in 2014 by Directive 2014/52/EU).
EIA Regulations	The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the 'EIA Regulations').
Export cable corridor (ECC)	The specific corridor of seabed (seaward of Mean High Water Springs (MHWS)) and land (landward of MHWS) from the Hornsea Four array area to the Creyke Beck National Grid substation, within which the export cables will be located.
Habitats Regulations Assessment (HRA)	A process which helps determine likely significant effects and (where appropriate) assesses adverse impacts on the integrity of European conservation sites and Ramsar sites. The process consists of up to four stages of assessment: screening, appropriate assessment, assessment of alternative solutions and assessment of imperative reasons of over-riding public interest (IROPI).
Highest Astronomical Tide (HAT)	The highest level which can be predicted to occur under average meteorological conditions and any combination of astronomical conditions.
Hornsea Four	The proposed Hornsea Project Four offshore wind farm; the term covers all elements within the DCO (i.e. both the offshore and onshore components).

Term	Definition
Hornsea Zone	The former 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 Three and Hornsea Four. The Hornsea Zone has therefore been dissolved and is referred to throughout the PEIR as the former Hornsea Zone.
Impact	Change that is caused by an action; for example, land clearing (action) during construction which results in habitat loss (impact).
Maximum Design Scenario (MDS)	The maximum design parameters of each Hornsea Four asset (both on and offshore) considered to be a worst case for any given assessment.
Mean High Water Spring (MHWS)	The height of mean high water during spring tides in a year.
Mean Low Water Spring (MLWS)	The height of mean low water during spring tides in a year.
Mitigation	A term used interchangeably with Commitment(s) by Hornsea Four. Mitigation measures (Commitments) are embedded within the assessment at the relevant point in the EIA (e.g. at Scoping or PEIR).
Nationally Significant Infrastructure Project (NSIP)	Large scale development including power generating stations which requires development consent under the Planning Act 2008. An offshore wind farm project with a capacity of more than 100 MW constitutes an NSIP.
Planning Inspectorate (PINS)	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
SeaMaST	Seabird densities from the predicted density maps and the underlying dataset of the SeaMaST project (Seabird Mapping and Sensitivity Tool) described in Bradbury *et al.* (2014) was identified by Natural England, through the Evidence Plan Process, as the most appropriate data set for the purpose of estimating the density and abundances of red-throated divers within the ECC. The SeaMaST data were compiled from offshore boat and aerial observer surveys spanning the period 1979–2012.
Stochastic Collision Risk Model (sCRM)	A program used to assess the collision risk (estimated mortality) of seabirds to operational turbines of offshore wind farms. A stochastic CRM is used to account for uncertainty around input variables.
Hornsea Four array area	The proposed area for Hornsea Four within which the Wind Turbine Generators (WTGs) would be installed

Acronyms

Acronym	Definition
AfL	Agreement for Lease
BDMPS	Biologically Defined Minimum Population Scale
BoCC	Birds of Conservation Concern
BTO	British Trust for Ornithology
CEA	Cumulative Effects Assessment
CMS	Construction Method Statement
CRM	Collision Risk Model
CTVs	Crew Transport Vessels
DAA	Developable Area Approach
DCO	Development Consent Order
dMLs	Deemed Marine Licences
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
EIA Report	Environmental Impact Assessment Report (note that the new EIA Directive refers to an EIA Report and not an Environmental Statement)
EP	Evidence Plan
ES	Environmental Statement
FCC	Flamborough and Filey Coast
GSD	Ground Sample Distance
HAT	Highest Astronomical Tide
HDD	Horizontal Directional Drilling
HGV	Heavy Goods Vehicle
HRA	Habitats Regulations Assessment
HVAC	High Voltage Alternating Current
ICES	International Council for the Exploration of the Sea.
IEEM	Institute of Ecology and Environmental Management
JNCC	Joint Nature Conservation Committee
LGV	Large Goods Vehicle
MAT	Migration Assessment Tool
MDS	Maximum Design Scenario
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MSL	Mean Sea Level
MSS	Marine Scotland Science
NE	Natural England
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OWEZ	Offshore Wind Farm Egmond aan Zee
OWF	Offshore Wind Farm
PBR	Potential Biological Removal
PCH	Proportion of Birds at Potential Collision Risk Height
PEIR	Preliminary Environmental Information Report

Acronym	Definition
PINS	Planning Inspectorate
pSPA	Potential Special Protection Area
RIAA	Report to inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
RWS	Rijkswaterstaat
SAC	Special Area of Conservation
sCRM	Stochastic Collision Risk Modelling
SeaMaST	Seabird Mapping and Sensitivity Tool
SNCB	Statutory Nature Conservation Body
SOSS	Strategic Ornithological Support Services
SOVs	Service Operation Vessels
SPA	Special Protection Area
SSSIs	Sites of Special Scientific Interest
TADS	Thermal Animal Detection System
UK	United Kingdom
WeBS	Wetland Bird Survey
WTG	Wind Turbine Generator
WWT	Wildfowl & Wetlands Trust
YNU	The Yorkshire Naturalist Union

Units

Unit	Definition
cm	Centimetre (distance)
km	Kilometre (distance)
km^2	Kilometre squared (area)
dB	Decibel (intensity of sound)
m	Metre (distance)
°	Degrees (angle)
%	Percentage (proportion)

5.1 Introduction

5.1.1.1 This chapter of the Preliminary Environmental Information Report (PEIR) presents an assessment of the potential impacts of the Hornsea Project Four offshore wind farm (hereafter Hornsea Four) on offshore and intertidal ornithology. Specifically, this chapter considers the potential impact of Hornsea Four on birds within the array area (and a 4 km buffer), the Export Cable Corridor (ECC) and the intertidal zone seaward of Mean High Water Springs (MHWS) and landward of Mean Low Water Springs (MLWS) during its construction, operation and maintenance, and decommissioning phases. Birds that reside landward of MHWS are considered within Volume 3, Chapter 3: Ecology and Nature Conservation.

5.1.1.2 Orsted Hornsea Project Four Limited (the Applicant) is proposing to develop Hornsea Four. Hornsea Four will be located approximately 65 km from the East Riding of Yorkshire in the Southern North Sea, with an array area of approximately 600 km^2 and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume 1, Chapter 1: Introduction** for further details on the Hornsea Zone).

5.1.1.3 The PEIR boundary for Hornsea Four includes the Hornsea Four array area and a corridor for the offshore ECC from the array to the landfall area. The landfall will be at a yet to be determined location on the coast roughly to the east Fraisthorpe and to the north Barmston, as detailed in **Volume 4, Annex 4.3.1: Grid Connection and Refinement of the Cable Landfall**. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network (please see **Volume 1, Chapter 4: Project Description** for full details on the Project Design).

5.1.1.4 This chapter summarises information contained within technical reports, which are included at **Volume 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**, **Volume 5, Annex 5.2: Offshore Ornithology Displacement Analysis** and **Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.

5.1.1.5 It also summarises the consultation (see **Table 5.3**, in **Section 5.4**) that has been held with stakeholders and the scope and methodology of the assessment. The predicted magnitude of impacts and significance of effect arising due to construction (see **Section 5.11.1**), operation and maintenance (see **Section 5.11.2**), and decommissioning (see **Section 5.11.3**) of the wind farm on offshore and intertidal ornithological receptors are assessed on the basis of the maximum design scenario. Measures to prevent or reduce the significance of the possible effects are discussed where appropriate (see Commitments in **Table 5.2**). Cumulative impacts arising from the proposed development and other offshore plans, projects and activities are assessed as appropriate (see **Section 5.12**).

5.2 Purpose

5.2.1.1 The primary purpose of the Environmental Statement (ES) is to support the Development Consent Order (DCO) application for Hornsea Four under the Planning Act 2008 (the 2008 Act). This PEIR constitutes the Preliminary Environmental Information for Hornsea

Four and sets out the findings of the EIA to date to support pre-application consultation activities required under the 2008 Act. The EIA will be finalised following completion of pre-application consultation and the Final ES will accompany the application to the Planning Inspectorate (PINS) for Development Consent.

5.2.1.2 This PEIR chapter:

- Presents the existing environmental baseline established from desk studies, site-specific survey data and consultation;
- Presents the potential environmental effects on offshore and intertidal ornithology arising from Hornsea Four, based on the information gathered and the analysis and assessments undertaken to date;
- Identify any assumptions and limitations encountered in compiling the environmental information; and
- Highlight any necessary monitoring and/or mitigation measures which could prevent, minimise, reduce or offset the possible environmental effects identified in the EIA process.

5.3 Planning, Policy and Legislative Context

5.3.1.1 Central government planning policy and guidance on offshore renewable energy Nationally Significant Infrastructure Projects (NSIPs), specifically in relation to offshore and intertidal ornithology, 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).

5.3.1.2 NPS EN-1 and NPS EN-3 both include guidance on what matters are to be considered in the assessment (i.e. *scope provisions*). These are summarised in **Table 5.1** below.

Table 5.1: Summary of NPS EN-1 and EN-3 scope provisions relevant to Offshore and Intertidal Ornithology.

Summary of NPS EN-1 and EN-3 scope provisions with respect to Offshore and Intertidal Ornithology	How and where considered in the PEIR
EN-1 Paragraph 5.3.4 – requires the applicant to *"show how the project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests."*	Hornsea Four has taken advantage of opportunities to conserve and enhance bird biodiversity interests as detailed in **Volume 2, Chapter 5: Offshore and Intertidal Ornithology**.
EN-1 Paragraph 5.3.6 – states that the IPC *"should take account of the context of the challenge of climate change: failure to address this challenge will result in significant adverse impacts to biodiversity."* It also notes that *"the benefits of nationally significant low carbon energy infrastructure development may include benefits for biodiversity and geological conservation interests and these benefits may outweigh harm to these interests. The IPC may take account of any such net benefit in cases where it can be demonstrated."*	Hornsea Four delivers benefits as a nationally significant low carbon energy infrastructure development and does include benefits for bird biodiversity interests. These benefits do outweigh minor harm to these interests, as detailed in **Volume 2, Chapter 5: Offshore and Intertidal Ornithology**.

Summary of NPS EN-1 and EN-3 scope provisions with respect to Offshore and Intertidal Ornithology	How and where considered in the PEIR
EN-1 Paragraph 5.3.7 - moots that *"development should aim to avoid significant harm to biodiversity and geological conservation interests, including through mitigation and consideration of reasonable alternatives… where significant harm cannot be avoided, then appropriate compensation measures should be sought."*	Hornsea Four has been designed to avoid significant harm to bird biodiversity interests, including through mitigation and consideration of reasonable alternatives where significant harm cannot be avoided, then appropriate compensation measures have been sought, as detailed in **Volume 2, Chapter 5 Offshore and Intertidal Ornithology.**
EN-1 Paragraph 5.3.8 – intimates that *"the IPC should ensure that appropriate weight is attached to designated sites of international, national and local importance; protected species; habitats and other species of principal importance for the conservation of biodiversity; and to biodiversity and geological interests within the wider environment."*	Protected sites are presented in **Section 5.7.3.** Assessment of the potential effects of Hornsea Four on the features of these protected sites is provided in **Section 5.10**.
EN-1 Paragraph 5.3.9 – states that *"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."*	Protected sites are presented in **Section 5.7.3.** Assessment of the potential effects of Hornsea Four on the features of these protected sites is provided in **Section 5.10**.
EN-1 Paragraph 5.3.15 – *"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."*	The Applicant has explored, developed and created suitable opportunities for building-in beneficial biodiversity and geological features as part of good design for Hornsea Four, as detailed in **Volume 2, Chapter 5: Offshore and Intertidal Ornithology.**
EN-1 Paragraph 5.3.16 – reminds that *"many individual wildlife species receive statutory protection under a range of legislative provisions."*	The Applicant has taken into account the statutory protection afforded to bird species under a range of legislative provisions, as detailed in **Volume 2, Chapter 5: Offshore and Intertidal Ornithology.**
EN-1 Paragraph 5.3.17 - explains that *"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. The IPC should refuse consent where harm to the habitats or species and their habitats would result, unless the benefits (including need) of the development outweigh that harm. In this context the IPC should give substantial weight to any such harm*	The Applicant has taken into account other bird species and habitats that have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The Applicant has ensured that these species and habitats are protected from the potentially adverse effects of Hornsea Four by accepting the need for requirements or planning obligations as part of the consenting process.

Summary of NPS EN-1 and EN-3 scope provisions with respect to Offshore and Intertidal Ornithology	How and where considered in the PEIR
to the detriment of biodiversity features of national or regional importance which it considers may result from a proposed development."	
EN-1 Paragraph 5.3.19 – reiterates that, *"where the applicant cannot demonstrate that appropriate mitigation measures will be put in place, the IPC should consider what appropriate requirements should be attached to any consent and/or planning obligations entered into."*	The Applicant can demonstrate that appropriate bird mitigation measures will be put in place, via Co86, Co87, Co88 and Co138, as detailed in **Section 5.8.2** and **Table 5.16**.
EN-1 Paragraph 5.3.3 - states that *"the applicant should ensure that the ES clearly sets out any effects on internationally, nationally and locally designated sites of ecological importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity."*	Protected sites are presented in **Section 5.7.3.** Assessment of the potential effects of Hornsea Four on the features of these protected sites is provided in **Section 5.10**. Further consideration and assessment for designated sites with potential connectivity to the wind farm will be provided in Report to Inform Appropriate Assessment (RIAA).
EN-3 Paragraph 2.6.104 – states that EIAs should include all project stages, consultation over surveys and Collision Risk Model (CRM)	Potential effects at all stages of the development are accounted for in **Section 5.10**, including displacement and CRM, which were agreed as defining this PEIR through the consultation process detailed in **Section 5.4**. The survey methods were discussed and agreed with Natural England through the Evidence Plan Process (see **Section 5.4**)
EN-1 Paragraph 5.3.18 – states that EIAs should include effects on and opportunities to enhance and mitigation for biodiversity	Potential effects, opportunities and mitigation on birds considered through the assessment are incorporated into the assessment process where applicable (**Section 5.10**). Mitigation measures are implemented through Co86, Co87, Co88 and Co138 (see **Section 5.8.2**) and the Developable Area Approach (see **Section 5.5.1**).
EN-3 Paragraph 2.6.64 - states that the *"assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed offshore wind farm"*	The potentially significant aspects of offshore ecology and biodiversity have been described and considered within the EIA and DCO application documentation for all stages of the lifespan of Hornsea Four. Potential impacts assessed include all stages of the lifespan of the proposed offshore wind farm; during construction (**Section 5.11.1**), operation and maintenance (**Section 5.11.2**) and decommissioning (**Section 5.11.3**).
EN-3 Paragraph 2.6.101 – explains that *"offshore wind farms have the potential to impact on birds through:* • *collisions with rotating blades;* • *direct habitat loss;*	These impacts are assessed in **Section 5.10**.

Summary of NPS EN-1 and EN-3 scope provisions with respect to Offshore and Intertidal Ornithology	How and where considered in the PEIR
• *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."*	
EN-3 Paragraph 2.6.102 - states that *"the scope, effort and methods required for ornithological surveys should have been discussed with the relevant statutory advisor."*	The survey methods were discussed and agreed with Natural England and RSPB through the Evidence Plan Process (see **Section 5.4**)
EN-3 Paragraph 2.6.103 – states that *"relevant data from operational offshore wind farms should be referred to in the applicant's assessment."*	Relevant data from operational offshore wind farms has been referred to in the Hornsea Four EIA and HRA. The use of relevant data presented within published literature is considered throughout **Section 5.11.2** to inform the impact assessment process.
EN-3 Paragraph 2.6.104 - states that *"it may be appropriate for the assessment to include collision risk modelling for certain bird species."*	Potential impacts from collision risk are presented and assessed in **Section 5.11.2**

5.3.1.3 NPS EN-1 and NPS EN-3 also highlight several factors relating to the *determination* of an application and in relation to *mitigation*. These are summarised in **Table 5.2** below.

Table 5.2: Summary of EN-3 policy on decision making relevant to Offshore and Intertidal Ornithology.

Summary of EN-3 decision making relevant provisions with regards to Offshore and Intertidal Ornithology	How and where considered in the PEIR
NPS EN-3 Paragraph 2.6.68 – states that *"the IPC should consider the effects of a proposal on marine ecology and biodiversity taking into account all relevant information made available to it."*	The offshore and intertidal ornithology aspects of marine ecology and biodiversity have been described and considered within this PEIR chapter for Hornsea Four.
NPS EN-3 Paragraph 2.6.69 – explains that *"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."*	Hornsea Four has been designed carefully to avoid and /or and mitigate significant effects on Natura 2000 sites.
NPS EN-3 Paragraph 2.6.70 – *"mitigation may be possible in the form of careful design of the development itself and the construction techniques employed."*	Hornsea Four has been designed carefully (including with regard to the construction techniques employed) to avoid and /or and mitigate significant effects on Natura 2000 sites.
NPS EN-3 Paragraph 2.6.71 –advises that *"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*	Future monitoring has been considered within the Hornsea Four assessment.

Summary of EN-3 decision making relevant provisions with regards to Offshore and Intertidal Ornithology	How and where considered in the PEIR
then be mitigated and to enable further useful information to be published relevant to future projects."	
NPS EN-3 Paragraph 2.6.107 – requires that *"aviation and navigation lighting be minimised to avoid attracting birds, taking into account impacts on safety."*	Hornsea Four has been designed with consideration of, (where possible) and within the limits of, lighting requirements for aviation and shipping purposes, to minimise aviation and navigation lighting in order to avoid attracting birds, taking into account impacts on safety.
NPS EN-3 Paragraph 2.6.108 – notes that, *"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."*	The developable area for the Hornsea Four array area has been considered carefully so that the wind turbines are within an area that minimises collision risk. The process of assessing the developable area and the changes accommodated between Scoping and the PEIR are described in **Section 5.5.1** .
NPS EN-3 Paragraph 2.6.109 – requires that *"construction vessels associated with offshore wind farms should, where practicable and compatible with operational requirements and navigational safety, avoid rafting seabirds during sensitive periods."*	Construction vessels associated with Hornsea Four will, where practicable and compatible with operational requirements and navigational safety, avoid rafting seabirds during sensitive periods.
NPS EN-3 Paragraph 2.6.110 – explains that *"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."*	Mitigation measures for offshore ornithological interests have been considered within the Hornsea Four assessment process (**Section 5.8.2**).

5.3.1.4 In addition to Central government planning policy and guidance, a range of international conventions and European and domestic (i.e. UK) legislation relates specifically to Offshore & Intertidal Ornithology.

5.3.1.5 The key international conventions promoting the conservation of birds are as follows:

- the Convention on Wetlands of International Importance especially as Waterfowl Habitat (the 'Ramsar Convention'). 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.*" ;
- the Convention on the Conservation of Migratory Species of Wild Animals (the 'Bonn Convention'). 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; and

- the Convention on the Conservation of European Wildlife and Natural Habitats (the 'Bern Convention'). 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.

5.3.1.6 Statutory protection for wild birds and the habitats that support them is provided by a combination of European and National legislation. 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').

5.3.1.7 The Birds Directive (Council Directive 2009/147/EC on the Conservation of Wild Birds [this being the revised Directive accounting for EU enlargement since the original Directive of 1979]) provides a framework for the conservation and management of wild birds in EU member states. The most relevant provisions of the Directive are the identification and classification of Special Protection Areas (SPAs) for rare or vulnerable species listed in Annex I of the Directive and for all regularly occurring migratory species (required by Article 4). The Directive requires national Governments to establish SPAs and to have in place mechanisms to protect and manage them. The SPA protection procedures originally set out in Article 4 of the Birds Directive have been replaced by the Article 6 provisions of the Habitats Directive. The Birds Directive also establishes a general scheme of protection for all wild birds (required by Article 5). Both the EU Birds Directive and the Wildlife and Countryside Act 1981 (as amended) provide protection against killing of birds (with a few exceptions) and provide protection for sites that support either specific bird species or concentrations of birds.

5.3.1.8 The Habitats Directive (Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora) provides a framework for the conservation and management of natural habitats, wild fauna (except birds) and flora in EU member states. The provisions of the Directive relevant to offshore ornithology are the procedures for the protection of Special Areas of Conservation (SACs) and SPAs (Article 6). The procedures require an appropriate assessment of any plan or project likely to affect a SAC or SPA and not to approve any plan or project that would have an adverse effect on a SAC or SPA except under very tightly constrained conditions. The procedures for the protection of SACs and SPAs are implemented in the United Kingdom (UK) through the Conservation of Habitats and Species Regulations 2010 and the Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 for waters beyond 12 nm.

5.3.1.9 The Conservation of Habitats and Species Regulations 2010 (hereafter called the 'Habitats Regulations') transposes the Birds Directive and the Habitats Directive into national law in the terrestrial, coastal and inshore (out to 12 nm) environment, operating in conjunction with the Wildlife and Countryside Act 1981. The Habitats Regulations

place an obligation on 'competent authorities' to carry out an appropriate assessment of any proposal likely to affect a SAC or SPA, to seek advice from Natural England (NE) and/ or Joint Nature Conservation Committee (JNCC), and not to approve an application that would have an adverse effect on a SAC or SPA (except under very tightly constrained conditions that involve decisions by the Secretary of State).

5.3.1.10 The Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007 transpose the Birds Directive and the Habitats Directive into national law in the offshore (beyond 12 nm) environment. The Offshore Regulations place an obligation on 'competent authorities' to carry out an appropriate assessment of any proposal likely to affect a SAC or SPA, to seek advice from Natural England and/ or JNCC, and not to approve an application that would have an adverse effect on a SAC or SPA (except under very tightly constrained conditions that involve decisions by the Secretary of State).

5.3.1.11 The Wildlife and Countryside Act 1981 (as amended) is the principal mechanism for the legislative protection of wildlife in Great Britain. It provides protection for all wild birds with the few exceptions being provided by a licensing system. The act establishes the system of site protection for species and habitats through the notification of a suite of Sites of Special Scientific Interest (SSSI). The SSSI designation underpins the protection provided for SPAs and SACs on land and down to MLWS.

5.3.1.12 The Natural Environment and Rural Communities Act 2006 imposes a duty on public bodies to conserve biodiversity, including a requirement to compile a list of habitats and species of principal importance for the purpose of conserving biodiversity.

5.4 Consultation

5.4.1.1 Consultation is a key part of the DCO application process. Consultation regarding Offshore and Intertidal Ornithology has been conducted through Evidence Plan (EP) Technical Panel meetings and the EIA Scoping Report (Ørsted, 2018a). An overview of the project consultation process is presented within **Volume 1, Chapter 6: Consultation**.

5.4.1.2 A summary of the key issues raised during consultation specific to Offshore and Intertidal Ornithology is outlined in **Table 5.3** below together with how these issues have been considered in the production of this PEIR.

Table 5.3: Consultation Responses.

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
Natural England and RSPB	12 September 2018 Evidence Plan Meeting 1 Offshore & Intertidal	Request that the latest tracking studies and data be used in order to provide for the most robust assessment of connectivity of seabirds from colonies to the Array Area during the breeding season.	This is addressed throughout the PEIR including in **Section 5.7** (Baseline Environment) and **Section 5.10** (Impact Assessment).

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
	Ornithology Technical Panel		
Natural England and RSPB	12 September 2018 Evidence Plan Meeting 1 Offshore & Intertidal Ornithology Technical Panel	Agreed that non-breeding species and seasons (for seabirds and non-seabirds) should be considered following similar standard methods for species recorded outside of the breeding season. Natural England agreed that the methods used in recent projects, including Hornsea Project Three and Norfolk Vanguard would be sufficient.	This is addressed throughout the PEIR as requested, including Section 5.6.1 (Biological seasons, populations and demographics for offshore ornithology receptors) and Section 5.10 (Impact Assessment).
Natural England and RSPB	12 September 2018 Evidence Plan Meeting 1 Offshore & Intertidal Ornithology Technical Panel	Requested that further data be provided on migrant non-seabird assessments before agreement could be reached on scoping out of future assessment.	This is addressed throughout the PEIR as requested, including Section 5.7 (Baseline Environment) and Section 5.10 (Impact Assessment).
Natural England and RSPB	12 September 2018 Evidence Plan Meeting 1 Offshore & Intertidal Ornithology Technical Panel	Agreed that a 24-month survey period and coverage (10% coverage of the array area and a 4 km buffer) was standard and was pleased that the project had this ahead of Scoping.	The rationale for 24 months of data being collected and agreed as fit for the purpose of baseline characterisation for impacts assessments is agreed as standard and described in Section 5.5.2 (Site-Specific Surveys).
Natural England and RSPB	12 September 2018 Evidence Plan Meeting 1 Offshore & Intertidal Ornithology Technical Panel	Request that all population estimates are provided with information on precision to allow Natural England and the Royal Society for the Protection of Birds (RSPB) to judge what reliance can be placed on the population estimate.	These details are presented for all species recorded in the 24-month survey programme in the Baseline Technical Report (Volume 2, Chapter 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report).
Natural England and RSPB	12 September 2018 Evidence Plan Meeting 1 Offshore & Intertidal	Requested and agreed that at PEIR stage the use of Furness (2015) should be used as the base for compiling different biological seasons for all seabirds. On completion of the analysis of the 24 months of site-specific data it is possible that activities for specific species may dictate that amendments be required in order to provide a more evidence led	This is addressed throughout the PEIR as requested, including Section 5.6.1 (Biological seasons, populations and demographics for offshore ornithology

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
	Ornithology Technical Panel	approach to individual species-specific bio-seasons in the draft Report to Inform Appropriate Assessment (RIAA) and final EIA Report. Both Natural England and the RSPB agreed in principle to this approach.	receptors) and **Section 5.10** (Impact Assessment)
RSPB	17 September 2018 Evidence Plan Meeting 2 Offshore & Intertidal Ornithology Technical Panel	Summarised the key ornithological points detailed within the Hornsea Four Scoping Report; discussed Natural England's response to the Scoping Report. RSPB agreed for the intertidal section to consider sanderling alone. Discussed the Digital Aerial Survey conducted by Hornsea Four. RSPB noted that additional data from further two cameras would be beneficial and supported the undertaking of precision analysis (MRSea density modelling) to investigate precision and aid the Developable Area Approach (DAA) process.	The impacts on Sanderling are considered in **Sections 5.11.1.42 - 5.11.1.55.** The DAA process is discussed in **Section 5.5.1**.
Natural England	13 November 2018 Scoping Opinion	As well as the 24 months data collected, we advise that the developer use data collected from tracking studies from Bempton Cliffs and other colonies, for example Langston et al. (2013) and Wakefield et al. (2017), as well as sensitivity analyses such as SeaMAST, to fully characterise the importance of the Hornsea Project Four site for SPA species.	These data and literature were considered within the Baseline Technical Report (**Volume 2, Chapter 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**) and also within **Section 5.10** (Impact Assessment).
Natural England	13 November 2018 Scoping Opinion	Requested further consideration provided on both migrating seabirds and non-seabirds, particularly those connected with designated sites in England.	In response to Natural England's request a review of potential impacts on migrating seabirds and non-seabirds was completed for this PEIR and is presented within **Section 5.10** (Impact Assessment).
Natural England	13 November 2018 Scoping Opinion	We note the intention to scope out intertidal ornithology from the ES. Whilst some surveys indicate that the cable landfall area may be of relatively low value, Yorkshire Naturalist Unit records suggest that nationally-important numbers of sanderling can be present. We also note that the NEWS data seems to show a gap which overlaps the corridor to the south. We question whether it is appropriate to scope out	In response to Natural England's request additional consideration was provided for sanderling and an impact assessment was completed for this PEIR and is presented within

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
		intertidal ornithology without further data being made available.	Section 5.10 (Impact Assessment).
Natural England	13 November 2018 Scoping Opinion	It will be necessary to see the precision of population estimates before being able to conclude that the stated minimum 10% DAS coverage is sufficient. We may request additional data (e.g. from any additional cameras on the DAS planes) are analysed where the precision around estimates is poor.	These data and literature were considered within the Baseline Technical Report (Volume 2, Chapter 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report).
Natural England	13 November 2018 Scoping Opinion	We reiterate the need for clear evidence trail to scope out indirect impacts to birds. Where decisions to scope out indirect impacts on seabirds are made on the basis of assessments which have not yet been carried out or consulted upon (e.g. fisheries), our view is that it would be more appropriate to scope such impacts in.	In response to Natural England's request additional consideration was provided for potential indirect impacts within this PEIR and are presented within Section 5.10 (Impact Assessment).
Natural England	13 November 2018 Scoping Opinion	The potential impacts of construction and operational phase lighting from turbines and associated structures on offshore ornithology receptors (including migratory passerines) are not identified in the scoping report. We recommend that this issue is scoped into the EIA.	In response to Natural England's request additional consideration was provided for potential impacts from lit structures on birds within this PEIR and is presented within Section 5.10 (Impact Assessment).
Natural England	13 November 2018 Scoping Opinion	Given the proximity of Hornsea Project Four to the Flamborough & Filey Coast SPA, and the potential for in-combination effects with other Hornsea OWF projects, we are pleased to see that barrier effects have been scoped into the EIA.	Potential impacts from barrier effect on birds within this PEIR and is presented within Section 5.10 (Impact Assessment).
Natural England	13 November 2018 Scoping Opinion	A buffer zone around the export cable corridor to assess red-throated diver disturbance will need to be used, as disturbance reactions to boats can occur at ~2 km. All available data sources should be used to characterise the use of inshore waters by red-throated diver and inform the likely impact to the Greater Wash SPA, for example the JNCC report informing SPA classification (Lawson *et al.* 2015), SeaMaST, and Marine Ecosystems Research Programme density maps.	In response to Natural England's advice potential impacts on red-throated diver out to a 2 km buffer surrounding cable laying activities within the ECC (making use of SeaMast data) were considered within this PEIR and is presented within Section 5.10 (Impact Assessment).

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
RSPB (Natural England Absent)	17 December 2018 Evidence Plan Meeting 4 Offshore & Intertidal Ornithology Technical Panel	A review of the Scoping Opinion was conducted by the project team, with the aim to allow for dialogue between all parties. This was not possible due to Natural England not attending in person or via the conference line available. This meeting was used to discuss the Scoping Opinion received from Natural England also the HRA Screening response from the RSPB.	Not applicable.
Natural England and RSPB	10 April 2019 Evidence Plan Meeting 3 Offshore & Intertidal Ornithology Technical Panel	Confirmed that their advice is to run the CRM through the Marine Scotland Science (MSS) 'ShinyApp' feature on the online platform. Natural England confirmed that they have not shifted from the use of the avoidance rates set out in the SNCB guidance for gannet, kittiwake and large gulls based on the JNCC *et al.*, (2014) paper in response to Cook *et al.*, (2014). Natural England suggested that more than one nocturnal activity factor should be used, using a range drawn from Garthe and Hüppop (2004) or King *et al.*, (2009). The RSPB requested that the dates and timings of surveys would be presented in the baseline technical report in order to feed into the process of considering nocturnal activity rates. Natural England requested that CRM be presented for five species considered to be key on a cumulative basis in the North Sea: kittiwake, gannet, herring gull, lesser black-backed gull and great black-backed gull, even if not recorded in the Hornsea Four array area in significant densities. Discussed the Digital Aerial Survey methodology note which had been issued to consultees prior to the meeting; RSPB would like to see methodology demonstrated in PEIR, including methods for apportioning.	The background to justification for the assessment of collision risk are detailed in the CRM Technical Report (**Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**). Digital aerial survey methodology is clearly detailed in the Baseline Technical Report (**Volume 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Technical Report**).
Natural England and RSPB	11 June 2019 Evidence Plan Meeting 4 Offshore & Intertidal Ornithology Technical Panel	Natural England stated that 24 months of survey data is the minimum, there is no problem with resolution of imagery and the frequency of surveying is adequate. They did highlight that the only query is about the amount of data that is being used (10% and not the 20% collected). A precision note was provided to consultees on 30/05/19 in order to address this topic, in addition to carrying out MRSea density modelling as part of the DAA process. However, Natural England and RSPB maintained their	The survey methods and rationale for 24 months of data being collected follow the same premise as other offshore wind farms where they were agreed as standard and defined as fit for the purpose of baseline characterisation for

Consultee	Date, Document, Forum	Comment	Where addressed in the PEIR
		position that they need to have the greatest confidence in the data used so anything that can be done to improve that confidence has to be seen as a good thing – the more data analysed, the better the estimates are likely to be. This was in response to being made aware of the developable area reducing from Scoping to PEIR. Both consultees welcomed the reduced array area.	impact assessments. This is described in **Section 5.6.2** (Site-Specific Surveys)
Natural England	11 June 2019 Evidence Plan Meeting 4 Offshore & Intertidal Ornithology Technical Panel	Natural England were in agreement that the 'SeaMast' data is fit for the purpose of defining the baseline for red-throated divers within the Hornsea Four ECC and agree that the maximum displacement surrounding a cable laying vessel for use in the assessment of displacement should be out to 2 km surrounding the vessel. However, they noted that the 'SeaMast' mapping and sensitivity tool was never devised to provide absolute densities and that a range of densities would be best to consider from wider area.	This is addressed in the assessments on construction displacement in **Section 5.10**.
Natural England and RSPB	11 June 2019 Evidence Plan Meeting 4 Offshore & Intertidal Ornithology Technical Panel	Natural England and RSPB reiterated that they have not shifted their position from the use of the avoidance rates set out in the Statutory Nature Conservation Body (SNCB) guidance for gannet, kittiwake and large gulls based on the JNCC *et al.*, (2014) paper in response to Cook *et al.*, (2014). Both Natural England and the RSPB again suggested that more than one nocturnal activity factor should be used, using a range drawn from Garthe and Hüppop (2004) or King *et al.*, (2009). Natural England requested that CRM be presented for five species considered to be key on a cumulative basis in the North Sea, kittiwake, gannet, herring gull, lesser black-backed gull and great black-backed gull, even if not recorded in the Hornsea Four array area in significant densities. They requested use of stochastic and deterministic CRM through the MSS 'ShinyApp' feature on the online platform. However, it was not confirmed how to use the MSS 'ShinyApp' for deterministic CRM outputs and so it was agreed that following the PEIR it would be tested as an alternative in order to provide a comparison ahead of the final EIA Report submission.	The background to justification for the assessment of collision risk are detailed in the CRM Technical Report (**Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**).

5.5 Study area

5.5.1 Changes to the 'Developable Area' between Scoping and PEIR

5.5.1.1 The Hornsea Four Developable Area Approach (DAA) is set out in **Volume 1, Chapter 6: Consultation**. In keeping with the Hornsea Four approach to Proportionate EIA, due consideration was given to the size and location (within the exiting offshore Agreement for Lease (AfL) area) of the Project taken forward at PEIR. Hornsea Four have adopted a major site reduction from the AfL presented at Scoping (868km^2) to the PEIR boundary (600km^2) presented in **Figure 5.1**, the narrative of which is captured in **Volume 1, Chapter 3: Site Selection and Consideration of Alternatives**.

5.5.1.2 The area for which WTGs are proposed to be developed for Hornsea Four (the developable area) has been modified between the Scoping and PEIR. The modification, presented in **Figure 5.1**, is based on qualitative examination of 24 months of site-specific data to understand the spatial distribution of known key seabird species (kittiwakes, gannets, and guillemots) within the Agreement for Lease (AfL) area (array area presented at Scoping). Through this process Hornsea Four has sought to minimise potential impacts, from the outset, on offshore ornithological receptors in particular (as well as other human, biological and environmental receptors). This was undertaken in recognition of the potential interaction of Hornsea Four with offshore ornithological receptors and accounting for this being a key issue for previous Hornsea projects. These data were analysed to identify where each species and all species combined may occur within the AfL area.

5.5.1.3 The three species identified for analysis in this process (kittiwakes, gannets, and guillemots) were selected as they are the most abundant within the AfL area and a 4 km buffer throughout 24 months of survey data and potentially most sensitive to impacts associated with the construction and operation of Hornsea Four. They are also broadly considered to be the most at risk from either colliding with WTGs or being displaced from the array area. The purpose of this process was to identify any areas within the AfL area that may be considered higher risk to the three species and by way of reducing the developable area to mitigate any potential adverse impacts from Hornsea Four.

5.5.1.4 Species-specific temporal patterns in usage of the AfL area were investigated by creating seasonal (breeding and the non-breeding bio-seasons) cumulative density distribution maps using the 24 months of site-specific data. Qualitative examination was used to determine whether patterns were recorded for these three species during the breeding season and the non-breeding period.

5.5.1.5 The cumulative density of all three species during the breeding bio-season appeared to be highest in the southern part of the AfL area, with relatively lower densities recorded in the northern part. Similarly, during the non-breeding bio-season, the cumulative density of all three species was relatively high in the southern part of the AfL area. Areas of relatively high concentrations also existed in the north-west and south-west corners of the northern part of the AfL area but occurred in relatively lower densities than what was recorded in the southern part.

5.5.1.6 Overall, the highest relative density for all three species combined occurred in the southern part (54% of all observations over the 24 month survey period for the three key species). It was subsequently decided that the southern part of the AfL area represented the highest risk for the proposed development in terms of potential impacts on the on the kittiwake, gannet, and guillemot populations, such as the breeding colonies closest to Hornsea Four at the Flamborough and Filey Coast (FFC) SPA.

5.5.1.7 The revised developable area selected for the PEIR (**Figure 5.1**) was completed through the abstinence of utilisation of the southern part of the AfL area. The decision reduced the developable area in the southern part of the AfL area was made despite that region having the best overall relative development value, when not taking into consideration any potential ornithological impacts. Further detail on the developable area reduction in presented within **Volume 1, Chapter 3: Site Selection and Consideration of Alternatives**.

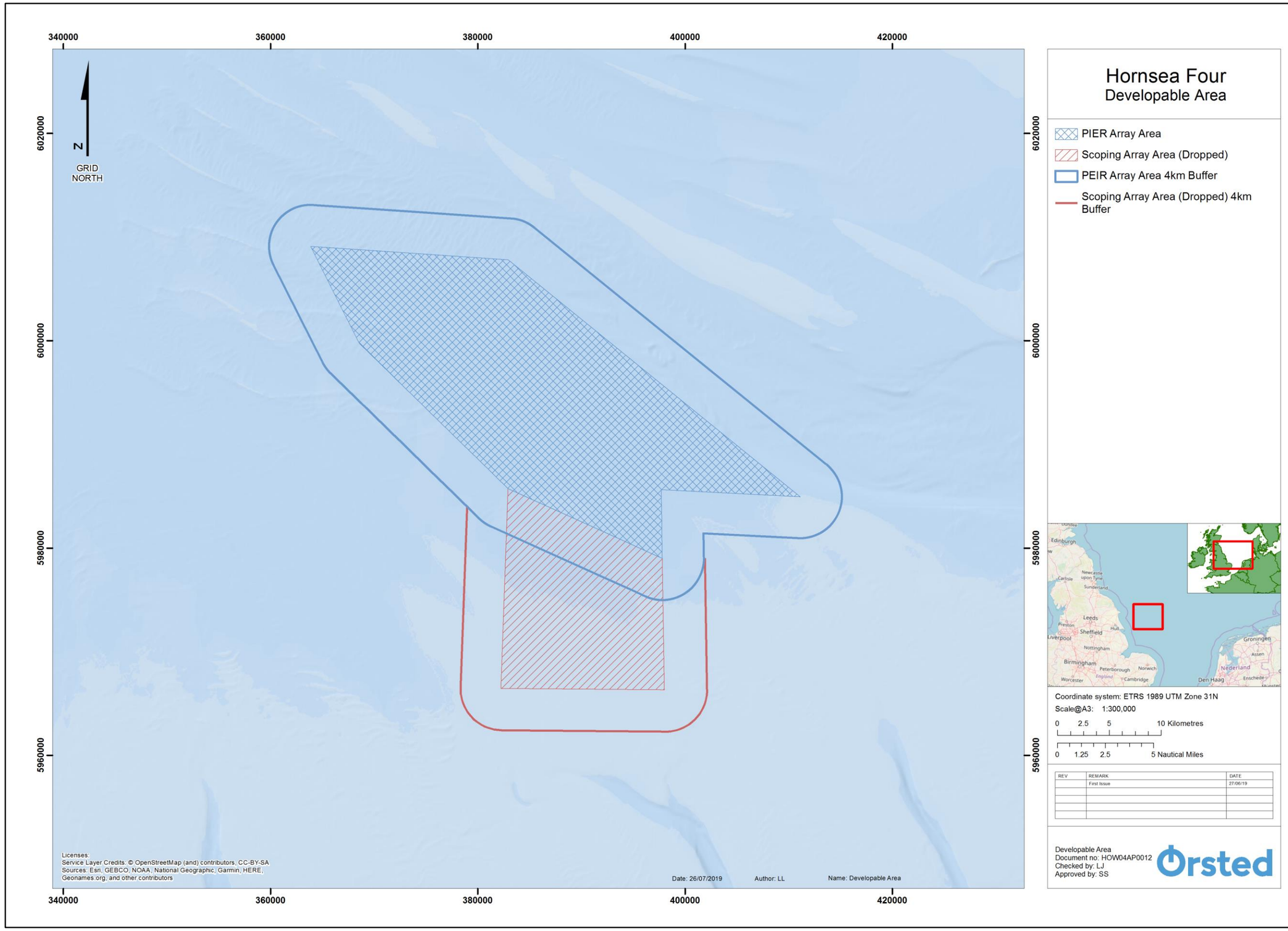

Figure 5.1: The Scoping Area reduction of Hornsea Four and the proposed PEIR Array Area (not to scale).

5.5.2 Study area for Hornsea Four PEIR

5.5.2.1 This section defines the study area for this chapter ("the Hornsea Four Offshore and Intertidal Ornithology Study Area") and includes an explanation as to how and why the study area has been defined. The study areas for both the project alone assessment and cumulative effects assessment (CEA) are defined.

5.5.2.2 The offshore and intertidal boundary of Hornsea Four is delineated on **Figure 5.2** overleaf and specifically consists of the:

- Hornsea Four array area: This is where the offshore wind farm will be located, which will include the WTGs, array cables, offshore accommodation platforms and a range of offshore substations as well as offshore interconnector cables and export cables;
- Hornsea Four offshore ECC: This is where the permanent export cable(s), as well as the offshore High Voltage Alternating Current (HVAC) booster station(s) (if required), will be located; and
- Hornsea Four cable landfall area: The cable landfall area is the intertidal zone seaward of Mean High Water Spring (MHWS) and landward of Mean Low Water Spring (MLWS) where works, vehicles and plant machinery will be located for connecting the offshore ECC to the onshore ECC.

5.5.2.3 The study area for the offshore and intertidal ornithology receptors includes all of the sea and coasts within these the Hornsea Four array area (at PEIR), a 4 km buffer surrounding the array area, the offshore export cable corridor (ECC) and the cable landfall areas, with a particular focus on the sea within a 4 km buffer surrounding the Hornsea Four array area, the latter of which follows Natural England recommendations and agreed as appropriate through the evidence plan process (at Technical Panel Meeting 1 on 12.09.18). Account also has to be taken of the mobility of birds, noting that for instance, birds that breed outside the study area might fly in to or across the study area to feed during the breeding season, might fly into the study area outside of the breeding season to spend the winter or might fly across the study area on migration.

5.5.2.4 For the purposes of this section a split between offshore and intertidal is required in order to refine the focus of the ornithological assessments. The intertidal area and related assessments consider birds using the habitat mostly between MHWS and MLWS, recognising that some of these birds might nest or roost on the shore landward of MHWS. The offshore area and related assessments consider birds using the habitat seaward of MLWS within the offshore ECC out to the Hornsea Four array area and a 4 km buffer surrounding it.

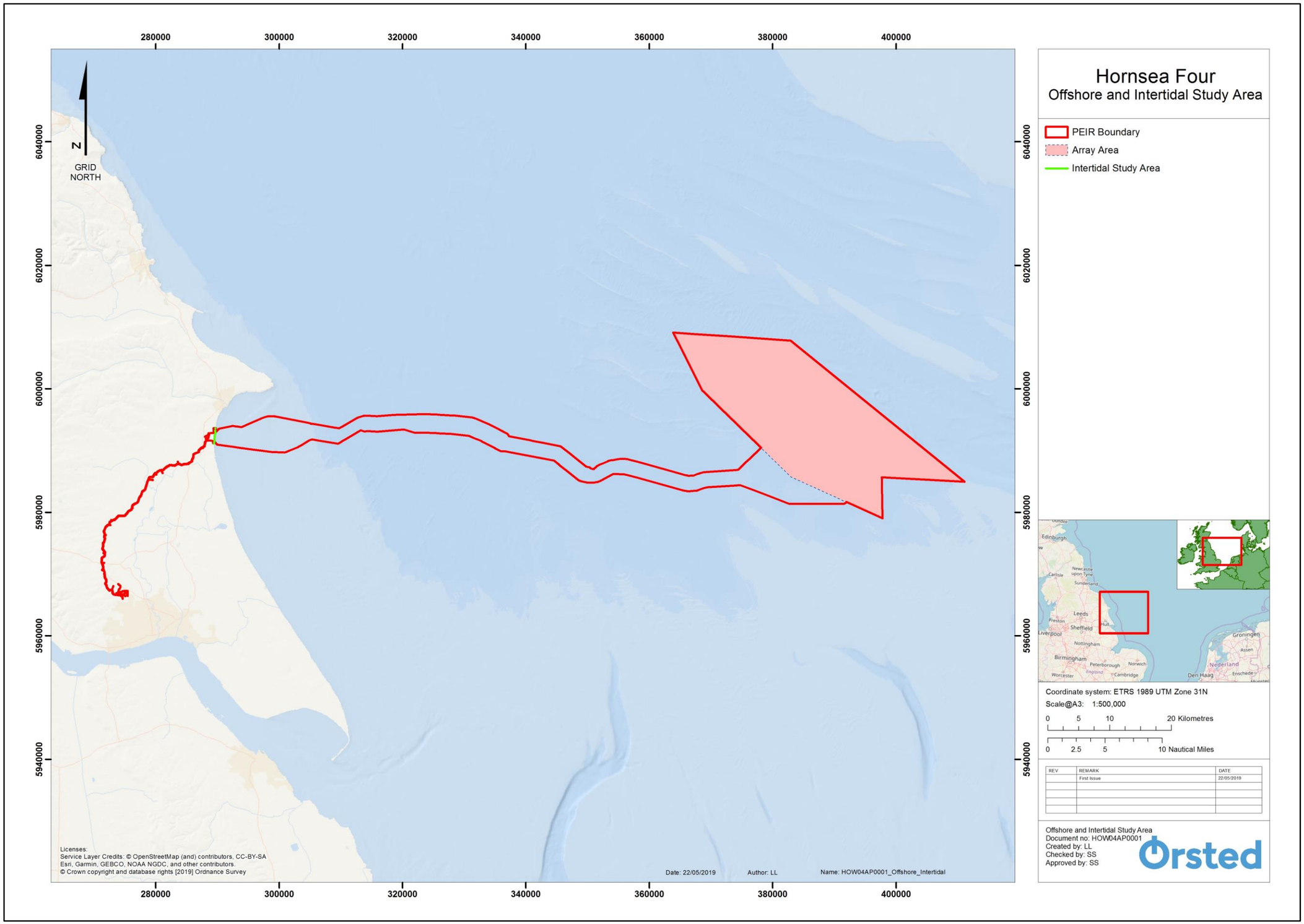

Figure 5.2: The Hornsea Four offshore and intertidal ornithology study area (not to scale).

5.6 Methodology to inform baseline

5.6.1 Desktop Study

5.6.1.1 A detailed desktop review of existing studies and datasets was undertaken to obtain information on intertidal and offshore avifauna within the defined Hornsea Four study area as shown in Figure 5.3.

5.6.1.2 The sources of information given in Table 5.4 below were consulted to obtain information on intertidal avifauna. Following confirmation through Scoping Opinions (PINS, 2018), these sources provide the most appropriate species-specific information on the distribution and abundance of birds to characterise the intertidal and nearshore environment within the Hornsea Four landfall area MHWS and MLWS.

Table 5.4: Key sources of information on intertidal avifauna used for Hornsea Four.

Source	Summary	Coverage of Hornsea Four array and ECC
British Trust for Ornithology (http://www.bto.org/volunteer-surveys/webs)	Co-ordinated counts of the non-estuarine shoreline (covering supratidal, intertidal and ~1 km in to coastal waters) in the winters of 1984/85, 1997/98, 2006/07 and 2015/16 originally under the title of the 'Winter Shorebird Count' and for the most recent three times under the title of 'Non-Estuarine Waterbird Survey'	Each of the four winter surveys had consistent coverage of the stretch of coast from Hilderthorpe to Skipsea that coincides with the scoping boundary of the ECC.
National Bird Atlas 2007-11 (Balmer *et al.*, 2013)	Results of five years of breeding season and winter surveys across the UK showing at a 10 km square scale the distribution, relative density and change over recent years for all frequently occurring bird species.	The scoping boundary of the ECC overlaps primarily with 10 km squares TA15 & TA16.
Yorkshire Bird Reports	An annual publication summarising bird sightings and survey results for Yorkshire.	Counts of birds that were considered to be notable by the report editors are listed for the Holderness coast and specific location along it, including those within the scoping boundary of the ECC.
Dogger Bank Creyke Beck (A&B) Offshore Wind Farm (OWF) surveys (Forewind, 2013)	Bird surveys were carried out at, and within a buffer around, the cable landfall on the Holderness coast.	The Dogger Bank Creyke Beck (A&B) survey area overlaps with the scoping boundary of the ECC.

5.6.1.3 The sources of information on offshore avifauna given in Table 5.5 below were consulted to characterise the wider region for the purpose of impact assessment and were identified in agreement with Natural England and the RSPB.

Table 5.5: Key sources of information on offshore avifauna used for Hornsea Four.

Title, year and reference	Summary	Relevance to Hornsea Four offshore ornithology receptors
Peer reviewed literature	Published, peer reviewed scientific papers on seabird behaviour and characteristics e.g. Robinson, 2018; Thaxter *et al.*, 2012; Furness *et al.*, 2018.	These covered an area of marine waters that was specific to the study. Those studies conducted on a North Sea or UK waters basis are generally relevant to the Hornsea Four array area and ECC.
OWF grey literature	Post-consent monitoring reports on seabirds and offshore wind farms e.g. Royal Haskoning, 2013.	These covered the array area and a buffer of other particular OWFs
OWF assessment methodologies	Publications on assessment methodologies for seabirds and OWFs e.g. Maclean *et al*, 2009; Wright *et al.*, 2012; SNCBs, 2017; Band 2012; Bowgen & Cook, 2018.	These contain generic methods that have to be applied in the site-specific circumstances of Hornsea Four.
Seabird Atlases	Publications on seabird distribution and movements within UK waters and further afield e.g. Stone *et al.*, 1995; Stienen *et al.*, 2007; Wernham *et al.*, 2002.	These contain information that is relevant to Hornsea Four, coastal waters off north east England or as wide as the North Sea.
Seabird population estimates	Publications on seabird, waterbird and other bird species population estimates for the UK and wider regions e.g. BTO WeBS online, 2019; Furness, 2015; Musgrove *et al.*, 2013; Mitchell *et al.*, 2004.	These contain information that is relevant to Hornsea Four, coastal waters off north east England or as wide as the North Sea.

5.6.2 Site-Specific Surveys

5.6.2.1 Species accounts presented on offshore avifauna consist of the data collected during 24 site-specific digital aerial surveys of the AfL area presented at Scoping for the Hornsea Four array area plus 4 km buffer carried out between 2016 and 2018, from which the data relevant to this PEIR assessment on the revised array area has been extracted (see Figure 5.3, and Table 5.6).

5.6.2.2 Supplementary data from digital aerial surveys and boat-based surveys for adjacent, partly overlapping wind farm areas were used to inform the EIA. A summary of these sources is given in Table 5.6.

5.6.2.3 Survey methodology and sources of information for the purpose of impact assessment were identified in consultation with Natural England and the RSPB (Table 5.3). The technical and methodological detail is provided in the baseline technical report (Volume 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report).

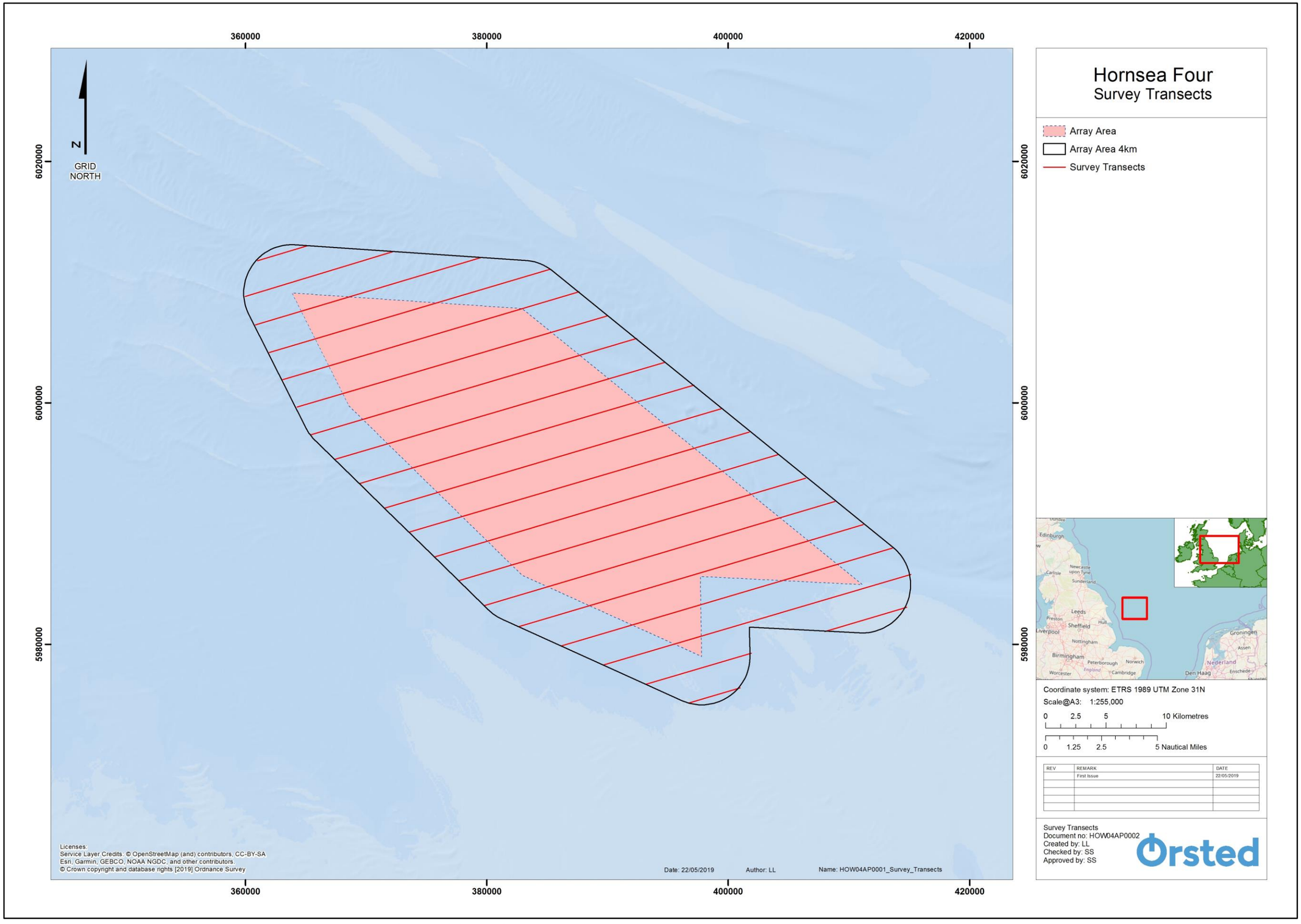

Figure 5.3: Transect lines of digital aerial surveys (2016-2018) across Hornsea Four (with 4 km buffer) of relevance to this PEIR (not to scale).

Table 5.6: Summary of survey data (2010-2018) of relevance to Hornsea Four.

Title, year and reference	Summary	Relevance to Hornsea Four
Hornsea Four - digital aerial surveys	2018: 3 Monthly digital aerial surveys (video) carried at 2 cm GSD out in January, February, March 2017: 12 monthly digital aerial surveys (video) carried out at 2 cm GSD January through December 2016: 9 digital aerial surveys (video) carried out at 2 cm GSD in April, June (2 surveys), July, August, September, October (incomplete), November, December	Transects separated by 2.5 km covering Hornsea Four array area and a 4 km buffer, providing 10% spatial coverage.
Hornsea Project Three Offshore Wind Farm (hereafter Hornsea Three) – digital aerial surveys	Digital aerial surveys (video) conducted monthly between April 2016 and November 2017, sampling 10% of the area and considering all recorded bird species	No overlap with Hornsea Four array area or 4 km buffer; data to provide context for Hornsea Four.
Hornsea Project Two Offshore Wind Farm (hereafter Hornsea project Two) – digital aerial surveys	12 Digital aerial surveys (stills) between June 2012 and February 2013, sampling 10% of the Project Two array area and a 4 km buffer and considering all recorded bird species	Overlap with south eastern part of Hornsea Four array area and its 4 km buffer.
Former Hornsea Zone – digital aerial surveys	12 Digital aerial surveys (stills) between June 2012 and February 2013, sampling 4% of the former zone and considering all recorded bird species	Hornsea Four array area and 4 km buffer included within surveys of former zone.
Hornsea Three - boat-based surveys	No project specific boat-based surveys of the array area or buffer but included with a low coverage through the former Hornsea zone surveys	Hornsea Four array area and 4 km buffer included within surveys of former zone.
Hornsea Two - boat-based surveys	Boat-based transect surveys conducted monthly between March 2010 and February 2013 of the array area and a 4 km buffer	Overlap with south eastern part of Hornsea Four array area and its 4 km buffer.
Hornsea Project One Offshore Wind Farm (hereafter Hornsea Project One) - boat-based surveys	Boat-based transect surveys conducted monthly between March 2010 and February 2013 of the array area and a 4 km buffer.	No overlap with Hornsea Four array area or its 4 km buffer; survey results provide context for Hornsea Four.
Former Hornsea Zone – boat-based surveys	Boat-based transect surveys of the former Hornsea Zone plus a 10 km buffer between March 2010 and February 2013.	Hornsea Four array area and 4 km buffer included within the surveys of the former zone.

5.7 Baseline environment

5.7.1 Existing baseline - intertidal

5.7.1.1 The existing baseline of intertidal avifauna of the Hornsea Four array and ECC derived from the desktop study is provided in detail within **Volume 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report** and summarised in **Table 5.7** below.

Table 5.7: Summary of existing baseline of intertidal avifauna for the Hornsea Four array and ECC derived from the desktop study.

Source	Summary
British Trust for Ornithology (http://www.bto.org/volunteer-surveys/webs)	The peak winter count of non-estuarine waterbird birds (expressed as within a range of values) are as given in **Table 5.8**, including the thresholds for identifying a site of national importance for each species and the population estimate for the East Yorkshire coast (winter 2015/16) for species that are habitat specialists of sandy coasts.
National Bird Atlas 2007-11 (Balmer *et al*, 2013)	The national atlas identifies the following species that breed along the open coast and that can be associated with feeding in the intertidal environment from Hilderthorpe to Skipsea during the breeding season: Shelduck, oystercatcher and herring gull.
Yorkshire Bird Reports	Notable records of birds recording on migration or during the non-breeding (wintering period) are referred. Of those species recorded in peak numbers within the Yorkshire Bird Report 2012 and 2013 (YNU, 2015 & YNU, 2018) only sanderling lies above the 1% of the national populations for the given season the threshold for consideration within impact assessments, with 200 and 295 recorded at Barmston on December 29th 2012 and January 7th 2013, respectively. No species of duck, wader, gull or tern breeding within or near the intertidal zone along the coast between Hilderthorpe and Skipsea are mentioned.
Dogger Bank Creyke Beck (A&B) OWF surveys (Forewind, 2013)	The peak counts of 10 wintering waterbird species recorded in 2011/2012 are as follows: Oystercatcher 2, Ringed Plover 2, Turnstone 2, Knot 1 Sanderling 8, Bar-tailed Godwit 1, Redshank 11, Black-headed Gull 15, Common Gull 593, Great Black-backed Gull 17.

Table 5.8: Summary of Non-estuarine waterbird peak winter counts for the coast from Hilderthorpe to Skipsea (Source: BTO).

Survey Species	1985	1997/98	2006/07	2015/16	East Yorkshire coastal population	Great Britain 1% threshold
Shelduck	0	0	0	0	3	3,000
Wigeon	0	0	0	0	39	4,400
Mallard	0	0	1-20	11-20	11	6,800
Common Scoter	0	1-50	0	0	5	1,000
Goldeneye	0	0	0	0	3	200
Goosander	0	0	0	0	3	120
Red-throated Diver	0	0	0	0	42	170
Great Northern Diver	0	0	0	0	1	25
Cormorant	0	0	0	3-30	81	350
Shag	0	0	0	0	6	1,100
Grey Heron	0	0	0	0	1	610
Little Grebe	0	0	0	0	8	160
Great Crested Grebe	0	1-20	0	4-6	5	190
Slavonian Grebe	0	0	0	0	3	11
Oystercatcher	1-10	21-40	3-30	3-30	148	3,200
Golden Plover	0	0	0	9-12	10	4,000
Lapwing	0	0	0	0	6	6,200
Ringed Plover	0	61-90	1-3	61-90	112	340
Curlew	0	0	1-10	0	10	1,400
Turnstone	0	31-60	0	1-40	221	480
Sanderling	1-40	61-90	1-20	41-60	77	160
Dunlin	1-20	41-80	1-3	11-20	31	3,500
Purple Sandpiper	0	1-20	0	0	2	130
Redshank	1-30	1-50	1-20	1-10	75	1,200
Snipe	0	0	0	0	1	10,000
Black-headed Gull	nc	nc	nc	1-60	493	22,000
Mediterranean Gull	nc	nc	nc	0	1	18
Common Gull	nc	nc	nc	1-200	1,590	7,000
Lesser Black-bd Gull	nc	nc	nc	11-20	30	1,200
Herring Gull	nc	nc	nc	201-400	1,527	1,300
Great Black-bd Gull	nc	nc	nc	3-30	147	760

Table note: nc = no count recorded

5.7.1.1 These data provide evidence that waterbird occurrence is considered insignificant within the intertidal environment at the proposed landfall area with only one species (sanderling present during the winter) potentially occurring above 1% of the national population (wintering), i.e. the threshold for consideration within impact assessments.

5.7.2 Existing baseline - offshore

5.7.2.1 The existing baseline of offshore avifauna of the Hornsea Four array area is based on the most recent site-specific surveys (24 aerial digital surveys between April 2016 and March 2018). The detail on all species recorded within the array area and a 4 km buffer is provided in detail within **Volume 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report** and summarised below.

5.7.2.2 A total of 22 bird species were recorded during the 24-month survey programme (**Table 5.9**). The findings of the 24-month survey programme identified the key following species (those recorded in the greatest abundance / density within the Hornsea Four array area and 4 km buffer); fulmar, gannet, kittiwake, great black-backed gull, guillemot, razorbill and puffin.

5.7.2.3 Fulmars were recorded in all 24 digital aerial surveys within the Hornsea Four array area. Peak abundance occurred during the migration-free breeding bio-season (April to August) with an estimated mean peak abundance of 288 birds and a mean peak density of 0.480 birds/km². Fulmar were loosely distributed throughout the Hornsea Four array area within three of the four bio-seasons. Densities increased in the non-migratory breeding bio-season with the highest densities in the northwest of the Hornsea Four array area and north of the 4 km buffer area, the latter being a hotspot in the return migration bio-season.

5.7.2.4 Gannets were recorded in 22 of the 24 digital aerial surveys and were loosely distributed throughout the Hornsea Four array area and 4 km buffer. Gannet peak abundance in the Hornsea Four array area occurs during the non-migratory breeding bio-season (April to August) with estimated mean peak abundance of 1,048 birds and mean peak density of 1.745 birds/km². In the 4 km buffer area gannet peak abundance occurs during the post-breeding bio-season (September to November) with an estimated mean peak abundance of 812 birds and mean peak density of 1.515 birds/km². Densities increased in the non-migratory breeding bio-season with the highest densities in the southeast of the Hornsea Four array area, bordering the 4 km buffer. In the post-breeding bio-season, densities were generally reduced with the highest densities remaining in the southeast of the Hornsea Four array area.

5.7.2.5 The most abundant small gull species was kittiwake, which was recorded in each of the surveys within the 24-month programme. Numbers of kittiwake peaked in the Hornsea Four array area during the post-breeding migration bio-season (August – December) with an estimated mean peak of 5,829 birds and mean peak density of 9.709 birds/km². Kittiwakes were loosely distributed throughout the Hornsea Four array area and 4 km buffer. Densities increased in the non-migratory breeding bio-season with the highest densities in the south of the Hornsea Four array area and 4 km buffer. The highest densities occurred in the post-breeding bio-season, mostly in the 4 km buffer to the northwest and south, with a further high-density area in the east of the Hornsea Four array area and 4 km buffer.

5.7.2.6 The great black-backed gull was the most abundant large gull species recorded in 19 of the 24 digital aerial surveys, loosely distributed in low densities throughout the Hornsea Four array area and 4 km buffer. Abundance in the Hornsea Four array area peaked during the migration-free winter bio-season (December), with an estimated mean peak abundance of 222 birds and a mean peak density of 0.370 birds/km².

5.7.2.7 The most abundant species recorded in each of the 24 months of aerial digital surveys was guillemot. Abundance was highest during the post-breeding migration bio-season (July – October) with an estimated mean peak abundance of 36,523 birds and density of 60.836 birds/km². In the 4 km buffer guillemot abundance was also highest during the post-breeding migration bio-season with an estimated mean peak of 35,086 birds and density of 65.515 birds/km². Guillemots were distributed throughout the Hornsea Four array area and 4 km buffer. Densities increased in the return-migration and post-breeding bio-seasons with the highest densities in the northwest and southeast of the Hornsea Four array area and 4 km buffer.

5.7.2.8 Razorbills were recorded in all 24 digital aerial surveys within the Hornsea Four array area and peaked during the post-breeding migration bio-season (August – October) with an estimated mean peak abundance of 4,502 birds and a mean peak density of 7.500 birds/km². In the 4 km buffer razorbill abundance also occurred at its highest during the post-breeding migration bio-season with an estimated peak abundance of 2,651 birds and a mean peak density of 4.950 birds/km². Razorbills were loosely distributed throughout the Hornsea Four array area and 4 km buffer.

5.7.2.9 Puffins were recorded in 14 of the 24 monthly digital aerial surveys within the Hornsea Four array area, which were loosely distributed in low densities. Abundance was highest in the Hornsea Four array area during the post-breeding migration bio-season (July – August) with an estimated mean peak abundance of 313 birds and a mean peak density of 0.522 birds/km². In the 4 km buffer puffin abundance was also highest during the post-breeding migration bio-season with an estimated mean peak abundance of 211 birds and a mean peak density of 0.315 birds/km².

5.7.2.10 In addition, 'commic' terns (unidentified common terns or Arctic terns) were recorded in five of the 24 digital aerial surveys within the Hornsea Four array area, which were sparsely distributed. The peak season for 'commic' tern abundance in the Hornsea Four array area was during post-breeding migration (July – September) bio-season with an estimated mean peak of 1,136 individuals and a mean peak density of 1.892 birds/km².

5.7.2.11 Further species recorded in either very low abundance / densities and / or on only a very small number of occasions included; red-throated diver, Manx shearwater, lapwing, curlew, Arctic skua, great skua, little gull, black-headed gull, common gull, lesser black-backed gull, herring gull, Sandwich tern, little auk, feral pigeon and starling (see **Table 5.9** below).

5.7.2.12 The desktop review of published sources of information on offshore avifauna (see Table 5.9 below) confirms that the Hornsea Four array area and 4 km buffer as well as the ECC lie within an important area for seabirds, including;

- Migrant birds and birds from local populations overwintering in the area;
- Breeding birds foraging from nearby coastal colonies; and
- Vagrants or seasonal migrant birds (cf. Stienen et al. 2007).

5.7.2.13 Besides pelagic seabirds (e.g. gannet, fulmars and auks), other species that spend part of their annual life cycle at sea (e.g. divers, gulls, seaducks) may also be present in particular months, with numbers of non-seabird migrants also present during relevant migratory periods (e.g. wildfowl, waders and passerines).

Table 5.9: Bird species recorded in site-specific digital aerial video surveys of the Hornsea Four study area (2016-2918); key-species in bold.

Divers and pelagic species	Gulls	Skuas & terns	Auks	Other
Red-throated diver	**Kittiwake**	Great skua	**Guillemot**	Lapwing
Gannet	Black-headed gull	Arctic skua	**Razorbill**	Curlew
Fulmar	Little gull	Sandwich tern	**Puffin**	Feral pigeon
Manx shearwater	Common gull	Common/Arctic tern	Little auk	Starling
	Herring gull			
	Great black-backed gull			
	Lesser black-backed gull			

5.7.2.14 Details on the aerial digital video survey methodology and how the information collected during the 24-month survey programme was used to estimate design-based species-specific abundances for birds have been provided in **Volume 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**, including the process of unidentified species apportionment and the application of availability bias correction factors. Other information collected during the surveys such as species spatial distribution, flight height, flight direction and age classification are also contained within the **Volume 5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**.

5.7.2.15 The species recorded during the aerial digital video surveys are those that have been assessed to consider the risk to the populations due to potential impacts from Hornsea Four. The assessment of potential risk includes consideration of the species abundance in comparison to regional, national, and international populations, sensitivity to wind farm impacts, or biological characteristics that make them susceptible to impacts such as species with flight distributions that have a high proportion within the rotor swept zone.

5.7.3 Conservation status of offshore ornithology receptors

5.7.3.1 The conservation status of the species recorded during the survey programme is provided in Table 5.10 below.

Table 5.10: Summary of nature conservation value of species considered at risk of impacts.

Species	Conservation Status
Red-throated diver	BoCC Green listed, Birds Directive Migratory Species, Birds Directive Annex 1
Fulmar	BoCC Amber listed, Birds Directive Migratory Species
Gannet	BoCC Amber listed, Birds Directive Migratory Species
Arctic skua	BoCC Red listed, Birds Directive Migratory Species
Great skua	BoCC Amber listed, Birds Directive Migratory Species
Kittiwake	BoCC Red listed, Birds Directive Migratory Species
Little gull	BoCC Green listed, Birds Directive Migratory Species
Lesser black-backed gull	BoCC Amber listed, Birds Directive Migratory Species
Herring gull	BoCC Red listed, Birds Directive Migratory Species
Great black-backed gull	BoCC Amber listed, Birds Directive Migratory Species
Common tern	BoCC Amber listed, Birds Directive Migratory Species, Birds Directive Annex 1
Arctic tern	BoCC Amber listed, Birds Directive Migratory Species, Birds Directive Annex 1
Guillemot	BoCC Amber listed, Birds Directive Migratory Species
Razorbill	BoCC Amber listed, Birds Directive Migratory Species
Puffin	BoCC Red listed, Birds Directive Migratory Species

5.7.3.2 There are a number of SPAs that the birds in Table 5.10 may be associated with and that this is detailed within the RIAA. Those sites identified for potential connectivity will form the basis of RIAA. However, for the purpose of this PEIR for offshore and intertidal ornithology, the same list of sites were used to establish those seabird colonies and seabirds from these sites that may be considered to be connected to Hornsea Four during the construction, operation or decommissioning phases of the development.

5.7.4 Biological seasons, populations and demographics for offshore ornithology receptors

5.7.4.1 Bird behaviour and abundance is recognised to differ across a calendar year dependent upon the biological (bio-seasons) seasons that may be applicable to different seabird species. Separate bio-seasons are recognised in this PEIR in order to establish the level of importance any seabird species has within the offshore ornithology study area during any particular period of time. The biologically defined minimum population scales (BDMPS) bio-seasons are based on those in Furness (2015), hereafter referred to as BDMPS bio-seasons or bio-seasons (Table 5.11). The bio-seasons are defined within this PEIR as: return migration, migration-free breeding, post-breeding migration / dispersion and migration-free winter. These four bio-seasons can be applied to different periods within the annual cycle for most seabird species, though not all four are applicable for all seabird species, with different combinations used depending on the biology and the life history of a species:

- Return migration: when birds are migrating to breeding grounds;
- Migration-free breeding: when birds are attending colonies, nesting and provisioning young;
- Post-breeding migration / dispersion: when birds are either migrating to wintering areas or dispersing from colonies; and
- Migration-free winter: when non-breeding birds are over-wintering in an area.

5.7.4.2 Following guidance from Natural England's Scoping response the non-breeding season reference populations were taken from Furness (2015), which are provided in Table 5.11 below, where applicable.

Table 5.11: BDMPS bio-seasons (Furness 2015).

Species	Return Migration	Migration-free Breeding	Post-breeding Migration	Migration-free Winter	Non-breeding
Red-throated diver	February to April (13,277)	May to August	September to November (13,277)	December to January (10,177)	
Fulmar	December to March (957,502)	April to August	September to October (957,502)	November (568,736)	-
Gannet	December to March (248,385)	April to August	September to November (456,298)		-
Arctic skua	April to May (1,227)	June to July	August to October (6,427)	-	-
Great skua	March to April (8,485)	May to July	August to October (19,556)	November to February (143)	-
Kittiwake	January to April (627,816)	May to July	August to December (829,937)		-
Little gull (not in Furness, 2015)	-	May to July	-	-	August to April
Lesser black-backed gull	March to April (197,483)	May to July	August to October (209,007)	November to February (39,314)	-
Herring gull	January to April	May to July	August to November	December	September to February (466,511)
Great black-backed gull	January to April	May to July	August to November	December	September to March (91,399)
'Commic' tern	April to May (308,841)	June	July to September (308,841)		-
Guillemot	December to February	March to June	July to October	November	August to February (1,617,306)

Razorbill	January to March (591,874)	April to July	August to October (591,874)	November to December (218,622)	-
Puffin	March to April	May to June	July to August	September to February	Mid-August to March (231,957)

Table Note: 'Commic' tern includes both common terns and Arctic terns because the species are difficult to distinguish.

5.7.4.3 The method to assess the potential impact from additional mortality to the population due to Hornsea Four is assessed in terms of any change in relation to the baseline mortality rate for any given species within each of the recognised bio-seasons. The average mortality across all age classes for each species are presented in Table 5.16 below. The method presented assumes all age classes are at risk to the possible impacts of the proposed development equally and as such the baseline mortality rate is a weighted average based on all age classes (Royal HaskoningDHV, 2018). Demographic rates were those provided in Horswill and Robinson (2015).

Table 5.12: Average mortality across all age classes. Average mortality calculated using age specific demographic rates and age class proportions.

Species	Parameter	Survival (age class)						Productivity	Average mortality
		0-1	1-2	2-3	3-4	5-6	Adult		
Red-throated diver	Demographic rate	0.6	0.62	-	-	-	0.84	0.571	0.228
	Population age ratio	0.179	0.145	-	-	-	0.676	-	
Gannet	Demographic rate	0.424	0.829	0.891	0.895	-	0.912	0.7	0.191
	Population age ratio	0.191	0.081	0.067	0.06	-	0.6	-	
Kittiwake	Demographic rate	0.79	0.854	0.854	0.854		0.912	0.7	0.191
	Population age ratio	0.155	0.123	0.105	0.089		0.6	-	
Great black-backed gull	Demographic rate	0.815	0.815	0.815	0.815		0.885	0.53	0.126
	Population age ratio	0.194	0.156	0.126	0.102		0.577	-	
Common tern	Demographic rate	0.441	0.441	0.85	-	-	0.883	0.764	0.263
	Population age ratio	0.223	0.103	0.048	-	-	0.626	-	
Guillemot	Demographic rate	0.56	0.792	0.917	0.939	0.939	0.939	0.672	0.14
	Population age ratio	0.168	0.091	0.069	0.062	0.056	0.552	-	
Razorbill	Demographic rate	0.63	0.63	0.895	0.895	-	0.895	0.57	0.174
	Population age ratio	0.159	0.102	0.065	0.059	-	0.613	-	
Puffin	Demographic rate	0.709	0.709	0.76	0.805	-	0.906	0.617	0.167
	Population age ratio	0.261	0.115	0.082	0.063	-	0.577	-	

5.7.4.4 The regional breeding population of each species was based on the number of birds recorded at the closest breeding colony at the Flamborough and Filey Coast (FFC) SPA, which are provided in **Table 5.14** (JNCC, 2019; Aitken, *et al.*, 2017).

5.7.4.5 The array area is within the maximum foraging range for breeding fulmars, gannets, kittiwakes, herring gulls, lesser black-backed gulls, great black-backed gulls, guillemots, razorbills, and puffins coming from the FFC SPA according to the values in Thaxter *et al.* (2012). However, the BDMPS populations for fulmar are excluded from **Table 5.14** as this species is deemed to be at very low risk from Hornsea and as such was not screened in for any potential impacts for this PEIR (**Section 5.11.2**). Two species (herring gull and lesser black-backed gull) were also only recorded in very low abundances and densities within the array area and 4 km buffer in all bio-seasons and do not form part of the detailed impact assessments in **Section 5.11.2**, so data with respect to their BDMPS populations are not included in **Table 5.14**.

5.7.4.6 Great black-backed gulls were recorded regularly within the array area throughout the site-specific surveys of Hornsea Four (see **Volume 5, Annex 5.2 Offshore Ornithology Displacement Analysis**). However, as the array area is not within foraging range of these species from any SPAs or other known colonies for this species on the east coast of England it is likely that those individuals present during the breeding bio-season may be non-breeding adults and immature birds. Therefore, as any potential impacts would be more likely to occur on the wider population only the non-breeding BDMPS populations are included in **Table 5.14**.

5.7.4.7 Evidence from tagging studies suggests that foraging areas of gannets are colony specific (Wakefield *et al.*, 2017), reducing or even eliminating the potential connectivity from birds from more northern colonies regularly foraging during the breeding season within the Hornsea Four array area.

5.7.4.8 In addition to the breeding birds from the FFC SPA, it is estimated that additional juvenile, immature and non-breeding birds may be present within the region during the non-migratory breeding season. As a proportion of juvenile, immature and non-breeding birds are considered to remain within their wintering areas, the number of individuals present regionally may be considered to be the proportion of these birds within the relevant bio-season preceding the breeding bio-season. The relevant proportion of juvenile, immature and non-breeding birds can be estimated from the population age ratio data in **Table 5.13**. This estimated proportion can then be applied to the relevant BDMPS population for each species to estimate the total regional population of juvenile, immature and non-breeding birds within the non-migratory breeding bio-season. The final step of the process is to add the known number of breeding individuals to the estimated number of juveniles, immature and non-breeding birds to provide an estimate of the total regional population of each species within their breeding bio-season, as presented in **Table 5.13** below.

Table 5.13: North Sea and English Channel BDMPS population sizes for seabirds (Calculated from the number of individuals at the FFC SPA and the wider juveniles, immatures and non-breeding birds).

Species	Return migration BDMPS for the UK North Sea and Channel	Proportion of juvenile, immature and non-breeding individuals (%)	Juvenile, immature and non-breeding individuals	Regional breeding population (at FFC SPA)	Total regional baseline population during non-migratory breeding bio-season
Gannet	248,385	39.9	99,106	13,392 AOSs (26,784 breeding adults)	125,890
Kittiwake	627,816	47.3	296,957	51,535 AONs (103,070 breeding adults)	400,027
Great black-backed gull	91,399	57.8	52,829	Not applicable	52,829
Guillemot	1,617,306	44.6	721,318	84,647 Pairs (121,754 breeding adults)	843,072
Razorbill	591,874	38.5	227,872	27,967 Pairs (40,506 breeding adults)	268,377
Puffin	231,957	44.2	102,525	2,879 breeding individuals	105,404

Table Note: AON = Apparently Occupied Nests; AOS = Apparently Occupied Sites

5.7.4.9 In addition to the regional UK North Sea and English Channel BDMPS populations, the wider bio-geographic populations for each species of interest with connectivity to UK waters (adults and immatures) have also been used in the assessment and are provided in Table 5.14 below.

Table 5.14: Biogeographic Population Sizes (Source: Furness, 2015).

Species	Biogeographic population with connectivity to UK waters (adults and immatures)
Red-throated diver	27,000
Fulmar	8,055,000
Gannet	1,180,000
Arctic skua	229,000
Great skua	73,000
Kittiwake	5,100,000
Little gull (not in Furness, 2015)*	75,000
Lesser black-backed gull	864,000

Species	Biogeographic population with connectivity to UK waters (adults and immatures)
Herring gull	1,098,000
Great black-backed gull	235,000
'Commic' tern	1,108,000 (Arctic tern: 628,000; Common tern: 480,000)
Guillemot	4,125,000
Razorbill	1,707,000
Puffin	11,840,000

Table Note: Little gull has an estimated passage population based on Steinen *et al.* (2007).

5.7.5 Predicted future baseline

5.7.5.1 The current baseline is assumed to remain unchanged within the range of natural fluctuations.

5.7.6 Data Limitations

5.7.6.1 The marine environment can be highly variable, both spatially and temporally, meaning that seabird numbers may fluctuate greatly between months, bio-seasons and between different years at any given location, lowering the probability of being able to detect consistent patterns, directional changes or to generate reliable population estimates. The data collected for the purpose of baseline characterisation of Hornsea Four was collected over a 24-month period and the method used to collect these data (aerial digital video) may be considered to represent a snapshot of each month.

5.7.6.2 However, the most recent survey data used for describing the existing baseline are consistent with data obtained from surveys conducted for other wind farm applications in UK waters and are in general agreement with information from the literature and previous surveys conducted within the former Hornsea Zone, Hornsea Project One, Hornsea Project Two and Hornsea Three. Thus, these data are considered to be representative of the site for the purpose of baseline characterisation and impact assessment of Hornsea Four, as agreed with Natural England and RSPB via the EP process (Table 5.3).

5.8 Project basis for assessment

5.8.1 Impact register and impacts "scoped out"

5.8.1.1 Based on the baseline environment, the project description outlined in Volume 1, Chapter 4: Project Description and the Commitments in Volume 4, Annex 5.2: Commitments Register, a number of impacts are proposed to be *'scoped out'* of the PEIR assessment for Offshore and Intertidal Ornithology. These impacts are outlined, together with a justification for scoping them out, in a Table 5.15 below. Further detail is provided in Volume 4, Annex 5.1: Impacts Register.

5.8.1.2 Please note that the term "scoped out" relates to the Likely Significant Effect (LSE) in EIA terms and not "scoped out" of the EIA process *per se*. All impacts "scoped out" of LSE are assessed for magnitude, sensitivity of the receiving receptor and conclude an EIA significance in the Impacts Register (see **Volume 4, Annex 5.1: Impacts Register**). This approach is aligned with the Hornsea Four Proportionate approach to EIA (see **Volume 1, Chapter 5: EIA Methodology**).

Table 5.15: Impacts Scoped Out of Assessment and Justification.

Project activity and impact	Likely significance of effect	Approach to assessment	Justification
Potential for ad-hoc maintenance of export cable through the operational phase may lead to disturbance and displacement of species within the ECC and differing degrees of buffers surrounding it (ORN-O-10).	No likely significant effect	Scoped Out	As no significant adverse impacts or effects are predicted to occur on bird species in the construction phase, then no significant adverse impacts or effects would occur through this very limited and unlikely occurrence.
Potential for ad-hoc maintenance of export cable through the intertidal zone during the operational phase may lead to disturbance and displacement of waterbird species in close proximity to the works (ORN-O-11).	No likely significant effect	Scoped Out	As no significant adverse impacts or effects are predicted to occur on intertidal bird species in the construction phase, then no significant adverse impacts or effects would occur through this very limited and unlikely occurrence.

Notes:
Grey - Potential impact is scoped out and both PINS and Hornsea Four agree.

5.8.2 Commitments

5.8.2.1 The largest commitment that Hornsea Four has made was through the major site reduction offered through the Developable Area Approach, as described in **Section 5.10.1.1**. By way of examining site-specific data from the array area and 4 km buffer presented at Scoping, it was subsequently decided that the southern part of the AfL area represented the highest risk for the proposed development in terms of potential impacts on the on the kittiwake, gannet, and guillemot populations, such as the breeding colonies closest to Hornsea Four at the Flamborough and Filey Coast (FFC) SPA.

5.8.2.2 Through this process, Hornsea Four has committed to minimising potential impacts, from the outset, on offshore ornithological receptors in particular (as well as other human, biological and environmental receptors).

5.8.2.3 Hornsea Four has committed to several Commitments (i.e. primary design principles inherent as part of the project, installation techniques and engineering designs/modifications as part of their pre-application phase), to avoid a number of

impacts or reduce impacts as far as possible. Further Commitments (adoption of best practice guidance) are embedded as an inherent aspect of the EIA process. Full details of commitments are included within the **Volume 4, Annex 5.2: Commitments Register**.

5.8.2.4 The commitments adopted by Hornsea Four in relation to Offshore and Intertidal Ornithology, are presented in **Table 5.16** below.

Table 5.16: Relevant Offshore and Intertidal Ornithology Commitments

Commitment ID	Measure Proposed	How the Measure Will Be Secured
Co86	Primary: The offshore export cable corridor and cable landfall (below MHWS) will not cross the Greater Wash SPA, Flamborough & Filey Coast SPA and the Flamborough Head SAC.	DCO Schedule 1, Part 1 Authorised Development
Co87	Primary: Proposed developable area has been selected from the larger Hornsea Four Agreement for Lease (AfL) area to avoid areas with the highest concentrations of birds (kittiwake, gannet and guillemot) that are more likely to be displaced by the construction activities, and birds that are more likely to fly at heights that brings them within the rotor swept zone and hence at risk of collision.	DCO Schedule 1, Part 1 Authorised Development
Co88	Tertiary: Construction and operational maintenance vessels (e.g. CTVs) will avoid high concentrations of rafting red-throated diver.	DCO Schedule 11, Part 2 - Condition (12)(d)(v) and; DCO Schedule 12, Part 2 - Condition (12)(d)(v) *(Vessel Management Plan)*
Co138	Primary: Lower air draught of wind turbines will be a minimum of 35 m above Mean Sea Level (MSL)	DCO Requirement 2(2)(c) *(Detailed offshore design parameters)* DCO Schedule 11, Part 2 - Condition 1(2)(c) *(Design parameters)*

5.9 Maximum Design Scenario

5.9.1.1 The Maximum Design Scenario (MDS) sets out a series of design options for Hornsea Four that represent the design scenario that would result in the maximum magnitude of effect on offshore and intertidal ornithology and therefore offer the most precautionary assessment of potential impacts and effects. The Hornsea Four MDS is used to establish the extent to which the project would impact on the environment, which is defined as the maximum adverse scenario or worst-case (Table 5.17 overleaf). However, the final design is likely to be less than the maximum extent of the consent sought as the final design would lie between these extents for all aspects of Hornsea Four, including spatial, temporal and installation methodologies.

Table 5.17: Maximum Design Scenario for Impacts on Offshore and Intertidal Ornithology

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
Construction			
Construction activities within the array area associated with foundations and WTGs may lead to disturbance and displacement of species within the array and different degrees of buffers surrounding it (ORN-C-1).	Primary Co86 Co87 Tertiary Co88	<u>Construction vessels / helicopters within Array Area:</u> - 8 construction vessels within 3 to 4 blocks of 5km^2 at one time. <u>WTG Installation:</u> - 2 installation vessels (JUV) (90 return trips) - 12 support vessels (270 return trips) - 24 transport vessels (540 return trips) - 135 helicopter return trips <u>WTG Foundation Installation:</u> - 4 installation vessels (2 JUV and 2 anchored) (90 return trips); - 16 support vessels (360 return trips) - 40 transport/feeder vessels (including tugs) (360 return trips) - 180 helicopter return trips <u>Offshore Substation Installation (including substations and accommodation platform):</u> - 2 installation vessels (36 return trips); - 12 support vessels (162 return trips) - 4 transport/feeder vessels (72 return trips) - 63 helicopter return trips <u>Offshore Substation Foundation Installation (including substations and accommodation platform):</u> - 2 installation vessels (24 return trips); - 12 support vessels (108 return trips) - 4 transport/feeder vessels (48 return trips) - 42 helicopter return trips	The maximum estimated number of blocks with vessels operating concurrently would cause the greatest disturbance to birds on site.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
		Inter-array and Interconnector cable installation: - 3 main cable laying vessels (204 return trips) - 3 main cable burial vessels (204 return trips) - 12 support vessels (1,080 return trips) - 396 helicopter return trips	
Indirect impacts during the construction phase within the array area through effects on habitats and prey species (ORN-C-2).	N/A	See MDS for Fish and Shellfish Ecology assessment (**Volume 2, Chapter 3: Fish and Shellfish Ecology**).	As per justification in **Volume 2, Chapter 3: Fish and Shellfish Ecology**.
Construction activities associated with export cable laying may lead to disturbance and displacement of species within the export cable corridor and different degrees of buffers surrounding it (ORN-C-3).	Tertiary Co88	Construction vessels within ECC: - 3 cable laying vessels (96 return trips) - 3 cable jointing vessels (72 return trips) - 3 cable burial vessels (96 return tips) - 15 support vessels (144 return trips) - 800 helicopter return trips	The assumption is that vessels would be in situ from start to finish, so any disturbance events would be throughout entire period.
Construction activities associated with trenching, laying and reburial of the export cable through the intertidal zone may lead to disturbance and displacement of waterbird species in close proximity to the works (ORN-C-4).	N/A	Open Cut Installation: - 1 to 3 m burial depth - Peak two-way daily Heavy Goods Vehicle (HGV) movements in one month: 1,097 - Peak two-way daily Large Goods Vehicle (LGV) movements: 368 Cable Laying: - Cable laying rate of 100 m per day	The assumption is that the trenching, cable laying and burial of the export cable would be throughout 32 consecutive months from the start to finish, so any disturbance events would be throughout the entire period.
Operation			
Operational activities associated with moving	Primary Co87	Array Area: - 600 km^2	Displacement would be assumed from the entire Array Area that contains WTGs

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
turbines and maintenance vessels may lead to disturbance and displacement of species within the array area and different degrees of buffers surrounding it (ORN-O-5).		Wind Turbine Generators: - 180 WTGs - Minimum height of lowest blade tip above MSL (m): 35m - Maximum rotor blade radius: 152.5m Vessels during Maintenance: - 3,525 return vessel visits per year - 2,580 return visits to wind turbines per year - 780 return visits to wind turbine foundations per year - 65 return visits to offshore platforms (structural scope) per year - 100 return visits to offshore platforms (electrical scope) per year - Vessels include: CTVs, SOVs, supply vessels, cable and remedial protection vessels and JUVs	and other associated structures, which maximises the potential for disturbance and displacement. Assessment of extent / varying displacement from Array Area and a buffer is species specific due to their sensitivity levels.
Seabirds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure. The result of such collisions may be fatal to the bird concerned (ORN-O-6).	Primary Co87 Co138	Array Area: - 600 km^2 area Wind Turbines: - 180 WTGs - Minimum height of lowest blade tip above MSL (m): 35m - Maximum rotor blade radius: 152.5m	This represents the maximum number of the largest WTGs, which represents the greatest total swept area to be considered for collision risk.
Migrant non-seabirds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure. The result of such collisions may be	Primary Co87	Array Area: - 600 km^2 area Wind Turbines: - 180 WTGs - Minimum height of lowest blade tip above MSL (m): 35m - Maximum rotor blade radius: 152.5m	This represents the maximum number of the largest WTGs, which represents the greatest total swept area to be considered for collision risk.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
fatal to the bird concerned (ORN-O-7).			
Indirect impacts within the array area during the operational phase through effects on habitats and prey species (ORN-O-8).	N/A	See MDS for Fish and Shellfish Ecology assessment (**Volume 2, Chapter 3: Fish and Shellfish Ecology**).	As per justification in **Volume 2, Chapter 3: Fish and Shellfish Ecology**.
The presence of WTGs could create a barrier to the migratory or regular foraging movements of seabirds. This may result in permanent changes in flying routes for birds concerned and an increase in energy demands associated with those movements may result in a lower rate of breeding success or survival chances for individuals affected (ORN-O-9).	Primary Co87	Array Area: - 600 km^2 area - 30 km north-south extent between the northernmost point of the array area and the southernmost point Wind Turbines: - 180 WTGs	The measurement would be North to South to define the additional effort required for birds to fly around the Array Area to the North or South from FFC colony during the breeding if assumed to be commuting to foraging areas beyond Array Area to the East.
The impact of attraction to lit structures by migrating birds in particular may cause disorientation, reduction in fitness and possible mortality (ORN-O-14).	Primary Co87	Wind Turbines: • 180 WTGs • Minimum height of lowest blade tip above MSL (m): 35m • Maximum rotor blade radius: 152.5m • Total array area of Hornsea Four of 600 km^2 • Minimum 810 m spacing Offshore substations: • 6 offshore transformer substations	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.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario / Rochdale Envelope	Justification
		• 3 offshore converter stations • 1 offshore accommodation platform • 3 HVAC booster stations (in the HVAC booster station area of search). Lighting outward and not directional on all structures, maximised intensity and range to provide best visibility for aviation and shipping purposes.	
Decommissioning			
Demolition activities associated with foundations and WTGs may lead to disturbance and displacement of species within the array area and different degrees of buffers surrounding it (ORN-D-12).	Primary Co86 Co87 Tertiary: Co88	Impacts assumed as per construction (or less): - 3,525 return vessel visits per year - 2,580 return visits to wind turbines per year - 780 return visits to wind turbine foundations per year - 65 return visits to offshore platforms (structural scope) per year - 100 return visits to offshore platforms (electrical scope) per year - Vessels include: CTVs, SOVs, supply vessels, cable and remedial protection vessels and JUVs	Maximum estimated number of vessel movements would cause greatest displacement to birds on site.
Indirect impacts during the decommissioning phase within the offshore export cable corridor and landfall through effects on habitats and prey species (ORN-D-13).	N/A	See MDS for Fish and Shellfish Ecology assessment (**Volume 2, Chapter 3: Fish and Shellfish Ecology**).	As per justification in **Volume 2, Chapter 3: Fish and Shellfish Ecology**.

5.10 Assessment methodology

5.10.1.1 The assessment methodology for Offshore and Intertidal Ornithology is consistent with the DMRM methodology presented in **Volume 1, Chapter 5: Environmental Impact Assessment Methodology** and Annex C of the Scoping Report.

5.10.2 Impact assessment criteria

5.10.2.1 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 DMRM 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 and intertidal ornithology. However, the general principles of determining potential impact significance from level of sensitivity of individual receptors and magnitude of effect are consistent with DMRB and are also aligned with the key guidance on ecological impact assessments from CIEEM (CIEEM, 2010).

Assessment criteria and assignment of significance

5.10.2.2 The sensitivity of the receptors to sources of effect is defined in **Table 5.18** below, through reference to an example potential impact from disturbance activities.

Table 5.18: Definition of Level of Sensitivity for Ornithological Receptors.

Sensitivity	Definition used in this chapter
Very High	Bird species has very limited tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people.
High	Bird species has limited tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people.
Medium	Bird species has some tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people.
Low	Bird species is generally tolerant of sources of disturbance such as noise, light, vessel movements and the sight of people.

5.10.2.3 The sensitivity of a receptor is one of the core components of the assessment of potential impacts and their effects on ornithological receptors. Account has also to be taken of each receptor's conservation value when coming to a reasoned judgement on the definition of the overall sensitivity of any particular receptor to any potential impact or effect. In that reasoned judgement account has to be taken on a species by species basis noting that any particular species with a high conservation value may not be sensitive to a specific effect and vice versa. An example of this is herring gull that is an interest feature of some SPAs and has a conservation concern listing of 'Red' because of recent population declines but cannot be judged to be sensitive to disturbance given its propensity to exploit food resources made available by people and to nest on buildings

even while considerable efforts are made to deter them. This reasoned judgement is an important part of the overall narrative used to determine the potential impact significance and can be used where relevant as a mechanism for modifying the sensitivity of an effect assigned to a specific receptor.

5.10.2.4 The conservation value of ornithological receptors is based on the population from which individuals are predicted to be drawn. This reflects current understanding of the movements of species, with site-based protection (e.g. SPAs) generally limited to specific periods of the year (e.g. the breeding season). Therefore, conservation value can vary through the year depending on the relative sizes of the number of individuals predicted to be at risk of impact and the population from which they are estimated to be drawn. Ranking therefore corresponds to the degree of connectivity which is predicted between the wind farm site and protected populations. Using this approach, the conservation importance of a species seen at different times of year may fall into any of the defined categories. The criteria for defining conservation value in this chapter are outlined in **Table 5.19** below.

Table 5.19: Definition of Conservation Value Levels for Ornithological Receptors.

Sensitivity	Definition used in this chapter
High	A species for which individuals at risk can be clearly connected to a particular SPA or is found in numbers of international importance within the Hornsea Four array area.
Medium	A species for which individuals at risk are probably drawn from particular SPA populations or found in numbers of national importance within the Hornsea Four array area, although other colonies (both SPA and non-SPA) may also contribute to individuals observed in the offshore and intertidal ornithology study area.
Low	A species for which it is not possible to identify in the SPAs and may be found in regionally or locally important numbers from which individuals on the wind farm have been drawn, or for which no SPAs are designated.

5.10.2.5 The criteria for defining magnitude in this chapter are outlined in **Table 5.20** below. In addition to those levels of magnitude defined in **Table 5.20**, additional consideration is given to circumstances of no change, where no loss of (or gain) in the size or extent of distribution of the relevant biogeographic population that is the interest feature of a protected site may occur.

Table 5.20: Definition of Levels of Potential Magnitude of Impact for Ornithological Receptors

Magnitude	Definition Used In This Chapter
High	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that is predicted to irreversibly alter the population in the short to long-term and to alter the long-term viability of the population and/ or the integrity of the protected site. Recovery from that change predicted to be achieved in the long-term (i.e. more than five years) following cessation of the development activity.
Medium	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that occurs in the short and long-term, but which is not predicted to alter the long-term viability of the population and/ or the integrity

Magnitude	Definition Used In This Chapter
	of the protected site. Recovery from that change predicted to be achieved in the medium-term (i.e. no more than five years) following cessation of the development activity.
Low	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that is sufficiently small-scale or of short duration to cause no long-term harm to the feature/ population. Recovery from that change predicted to be achieved in the short-term (i.e. no more than one year) following cessation of the development activity.
Negligible	Very slight change from the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site. Recovery from that change predicted to be rapid (i.e. no more than circa six months) following cessation of the development activity.

5.10.2.6 The potential significance of the effect upon offshore and intertidal ornithology receptors is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The method employed for this assessment is presented in **Table 5.21**. Where a range of significance of effect is presented in **Table 5.21**, the final assessment for each effect is based upon expert judgement.

5.10.2.7 For the purposes of this assessment, any effects with a significance level of 'minor' or less have been concluded to be not significant in terms of the EIA Regulations.

Table 5.21: Matrix used for the Assessment / Assignment of the Potential Significance of Effect.

		Magnitude of Impact/Degree of Change			
		Negligible	**Minor**	**Moderate**	**Major**
Value, Importance, Sensitivity	**Low**	Not Significant	Not Significant or Minor (Not Significant)	Minor (Not Significant)	Minor (Not Significant) or Moderate (Significant)
	Medium	Not Significant	Minor (Not Significant)	Moderate (Significant)	Moderate (Significant) or Major (Significant)
	High	Not Significant	Minor (Not Significant) or Moderate (Significant)	Moderate (Significant) or Major (Significant)	Major (Significant) or Substantial (Significant)
	Very High	Not Significant	Moderate (Significant) or Major (Significant)	Major (Significant) or Substantial (Significant)	Substantial (Significant)

5.10.2.8 Further modifications have been introduced in the interest of proportionate assessment and in accordance with guidance presented in BSI (2015) such that:

- a magnitude of impact of 'no change' is not assessed since it will always lead to a not significant effect;

- a negligible magnitude impact is not considered further since it will always lead to a not significant effect; and
- resources and receptors of negligible importance, value or sensitivity are not considered further since any magnitude of impact on them would not lead to a significant effect.

5.10.2.9 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 5.10** of this chapter (with the assessment on the site itself deferred to the RIAA).

5.10.2.10 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 HRA Report for Hornsea Four), 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 offshore and intertidal study area, an assessment of the impacts on the overall site is made in this chapter using the EIA methodology.

5.10.2.11 The RIAA is currently being prepared in accordance with Advice Note Ten: Habitats Regulations Assessment Relevant to Nationally Significant Infrastructure Projects (PINS, 2017) and will be submitted as part of the Application for Development Consent.

5.11 Impact Assessment

5.11.1 Construction

5.11.1.1 The impacts of the construction of Hornsea Four within the array area, the ECC and cable landfall have been assessed on offshore and intertidal ornithology. The environmental impacts arising from the construction of Hornsea Four are listed in the MDS (**Table 5.17**), against which each construction phase impact has been assessed.

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

Construction activities within the array area associated with foundations and WTGs may lead to disturbance and displacement of species within the array and different degrees of buffers surrounding it (ORN-C-1).

5.11.1.3 The activities within an array area associated within the construction of WTGs has the potential to directly disturb and displace seabirds that would normally reside within and around the area of sea where Hornsea Four is proposed to be developed. During this phase of the development, this in effect represents a temporary indirect habitat loss, which would potentially reduce the area available to those seabirds to forage, loaf and

/ or moult that currently occur within and around Hornsea Four and may be susceptible to displacement from such a development.

5.11.1.4 Displacement may contribute to individual birds experiencing fitness consequences, which at an extreme level could lead to the mortality of individuals, though during the construction phase of an OWF such activities are spatially and temporally restricted. In this instance a maximum of eight construction vessels within three to four blocks of 5 km^2 at one time may occur, from which each block may displace seabirds that are sensitive to vessel movements and construction activities.

5.11.1.5 Some species are more susceptible than others to disturbance, from construction activities, which may lead to subsequent displacement. Dierschke *et al.* (2016) noted both displacement and avoidance to varying degrees by some seabird species while others were attracted to offshore wind farms. A screening process was undertaken for Hornsea Four to identify those species that may be more susceptible than others and therefore which species may be considered for further assessment (**Table 5.22**). Of the seabirds recorded within the array area fulmar, gannet, large and small gulls are not considered susceptible to disturbance, as they are often associated with fishing boats (e.g. Camphuysen, 1995; Hüppop and Wurm, 2000;) and have been noted in association with construction vessels at the Greater Gabbard Offshore Wind Farm (GGOWL, 2011) and close to active foundation piling activity at the Egmond aan Zee (OWEZ) wind farm, where they showed no noticeable reactions to the works (Leopold and Camphuysen, 2007). Therefore, these species are not considered further for the potential impact of displacement from the array area during the proposed construction phase of Hornsea Four.

5.11.1.6 Auk species, in this instance guillemot, razorbill and puffin, have been noted to respond to OWF construction activities and be displaced as a consequence. Therefore, these species are considered further for the potential impact of displacement from the array area during the proposed construction phase of Hornsea Four.

5.11.1.7 There are a number of different measures used to assess bird disturbance and displacement from areas of sea in response to activities associated with an offshore wind farm. Garthe and Hüppop (2004) developed a scoring system for such disturbance factors, which is used widely in OWF EIAs. Furness and Wade (2012) developed disturbance ratings for particular species, alongside scores for habitat flexibility and conservation importance in Scottish waters. These factors were used to define an index value that highlights the sensitivity of a species to disturbance and displacement. As many of these references relate to disturbance from helicopter and vessel activities, these are considered relevant to this assessment. Bradbury *et al.* (2014) provided an update to the Furness and Wade (2012) paper to consider seabirds in English waters. More recently a joint SNCB interim displacement advice note (SNCBs, 2017) provides the latest advice for UK development applications on how to consider, assess and present information and potential consequences of seabird displacement from OWFs.

Table 5.22: Screening of seabird species recorded within Hornsea Four array area for risk of disturbance and displacement during the construction phase.

Receptor	Sensitivity to Disturbance & Displacement (During Construction Phase)	Screening Result (In or Out)
Fulmar	Very low	Out
Gannet	Very low	Out
Kittiwake	Very low	Out
Great black-backed gull	Very low	Out
Herring gull	Very low	Out
Lesser black-backed gull	Very low	Out
Guillemot	Medium / Low	In
Razorbill	Medium / Low	In
Puffin	Low	In

5.11.1.8 Following the screening process an assessment of displacement has been carried out for Hornsea Four, though the methods and results are based on the following set of scenarios that recognise construction activities being restricted;

- Construction activities being undertaken within only three to four blocks of 5 km^2 at any one time across the entire 600 km^2 array area;
- Any potential displacement is likely to only occur within the array area, where vessels and construction activities are present;
- Construction activities are restricted both temporally (over approximately 24 months); and
- Large parts of the array area not being influenced by construction activities.

5.11.1.9 In recognition of the potential disturbance activities being of a lesser extent to that of an active offshore wind farm then the levels of displacement are also of lesser extent. Evidence from recent seabird monitoring during the construction period of Thanet OWF (Royal HaskoningDHV, 2013) presented displacement rates of the following for guillemot and razorbill;

- Up to 63% of guillemots were displaced within the Thanet array area and 25% from a buffer out to 1 km (but not beyond); and
- Up to 89% of razorbills were displaced within the Thanet array area and 25% from a buffer out to 500 m (but not beyond).

5.11.1.10 For the purpose of this assessment an assumption of puffin being displaced by 50% within the array area only has been selected. This is based on puffin being less likely to be displaced by construction activities (Furness and Wade, 2012), but little evidence from UK offshore wind farm monitoring due to the majority of developments being located outside of areas where puffins are abundant. For all three species the level of mortality applied for this assessment is 1% of those displaced.

Guillemot

Evaluation of the potential magnitude of impact

5.11.1.11 The annual estimated mortality for guillemot is 318 individuals as a result of Hornsea Four construction activities and vessel movements within the array area and a 1 km buffer, which is further broken down into relevant bio-seasons in **Table 5.23**. The magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the regional populations. The overall baseline mortality rates are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

Table 5.23: Bio-season construction displacement estimates for guillemot for Hornsea Four.

Bio-season (months)	Seasonal abundance (array area & 1 km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		No. of guillemots displaced (individuals)	Estimated No. of guillemots subject to mortality (individuals)	Increase in baseline mortality (%)
		Population	Baseline mortality			
Return Migration (Dec-Mar)	4,214 + 988	1,617,306	226,423	2,901	29	0.013
Migration-free Breeding (Apr-Aug)	4,831 + 1,539	843,072	118,030	3,428	34	0.029
Post-breeding migration (Sep-Nov)	29,746 + 7,976	1,617,306	226,423	20,734	207	0.091
Migration-free Winter	6,714 + 2,198	1,617,306	226,423	4,779	48	0.021
Annual	**n/a**	**4,125,000**	**577,500**	**31,842**	**318**	**0.055**

5.11.1.12 During the return migration bio-season approximately 29 guillemots may be subject to mortality, which would present an increase of 0.013% relative to the current baseline mortality rate at a regional level.

5.11.1.13 This level of potential impact is considered to be of **negligible** magnitude during the return migration bio-season, as it represents only a slight difference to the baseline conditions due to a small number of individuals subject to potential mortality as a result of displacement.

5.11.1.14 During the non-migratory breeding bio-season approximately 34 guillemots may be subject to mortality, which would present an increase of 0.029% relative to the current baseline mortality rate at a regional level.

5.11.1.15 This level of potential impact is considered to be of **negligible** magnitude during the non-migratory breeding bio-season, as it represents between only a slight to a minor

difference to the baseline conditions due to the range of individuals subject to potential mortality as a result of displacement.

5.11.1.16 During the post-breeding migration bio-season approximately 207 guillemots may be subject to mortality, which would present an increase of 0.091% relative to the current baseline mortality rate at a regional level.

5.11.1.17 This level of potential impact is considered to be of **negligible** magnitude during the post-breeding migration bio-season, as it represents only a slight difference to the baseline conditions due to the number of individuals subject to potential mortality as a result of displacement.

5.11.1.18 During the migration-free wintering bio-season approximately 47 guillemots may be subject to mortality, which would present an increase of 0.021% relative to the current baseline mortality rate at a regional level.

5.11.1.19 This level of potential impact is considered to be of **negligible** magnitude during the migration-free wintering bio-season, as it represents only a slight difference to the baseline conditions due to a small number of individuals subject to potential mortality as a result of displacement.

5.11.1.20 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Razorbill

Magnitude of impact

5.11.1.21 The annual estimated mortality for razorbill is 40 individuals as a result of Hornsea Four construction activities and vessel movements within the array area and a 500 m buffer, which is further broken down into relevant bio-seasons in **Table 5.24**. The magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the regional populations. The overall baseline mortality rates are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

Table 5.24: Bio-season construction displacement estimates for razorbill for Hornsea Four.

Bio-season (months)	Seasonal abundance (based on 75% of array area & 2 km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality rate/s (individuals)	Increase in baseline mortality (%)
		Population	Baseline mortality		
Return Migration (Dec-Mar)	376 + 193	591,874	102,986	2-5	0.002-0.004
Migration-free Breeding (Apr-Aug)	271 + 64	268,377	46,698	2-28	0.005-0.061
Post-breeding migration (Sep-Nov)	3,377 + 171	591,874	102,986	12-32	0.011-0.031
Migration-free Winter	311 + 8	218,622	38,040	1-3	0.003-0.009
Annual	**n/a**	**1,707,000**	**297,018**	**17 – 69**	**0.005-0.023**

5.11.1.22 During the return migration bio-season approximately four razorbills may be subject to mortality, which would present an increase of 0.003% relative to the current baseline mortality rate at a regional level.

5.11.1.23 This level of potential impact is considered to be of **negligible** magnitude during the return migration bio-season, as it represents only a very slight difference to the baseline conditions due to a very small number of individuals subject to potential mortality as a result of displacement.

5.11.1.24 During the non-migratory breeding bio-season approximately three razorbills may be subject to mortality, which would present an increase of 0.006% relative to the current baseline mortality rate at a regional level.

5.11.1.25 This level of potential impact is considered to be of **negligible** magnitude during the non-migratory breeding bio-season, as it represents between only a very slight to slight difference to the baseline conditions due to the range of individuals subject to potential mortality as a result of displacement.

5.11.1.26 During the post-breeding migration bio-season approximately 30 razorbills may be subject to mortality, which would present an increase of 0.030% relative to the current baseline mortality rate at a regional level.

5.11.1.27 This level of potential impact is considered to be of **negligible** magnitude during the post-breeding migration bio-season, as it represents only a slight difference to the baseline conditions due to a number of individuals subject to potential mortality as a result of displacement.

5.11.1.28 During the migration-free wintering bio-season approximately three razorbills may be subject to mortality, which would present an increase of 0.007% relative to the current baseline mortality rate at a regional level.

5.11.1.29 This level of potential impact is considered to be of **negligible** magnitude during the migration-free wintering bio-season, as it represents only a very slight difference to the baseline conditions due to a small number of individuals subject to potential mortality as a result of displacement.

5.11.1.30 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Puffin

Magnitude of impact and significance of effect.

5.11.1.31 The annual estimated mortality rate for puffin is under one individual as a result of Hornsea Four construction activities and vessel movements within the array area.

5.11.1.32 The magnitude of this impact is therefore considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Indirect impacts during the construction phase within the array area through effects on habitats and prey species (ORN-C-2).

Potential magnitude of impact and significance of effect

5.11.1.33 During the construction phase of Hornsea Four there is the potential for indirect effects arising from the displacement of prey species due to increased noise and disturbance, or to disturbance of habitats from increased suspended sediment and physical disturbance to the seabed. Underwater noise may cause fish and mobile invertebrates to avoid the construction area and also affect their physiology and behaviour. Suspended sediments may cause fish and mobile invertebrates to avoid the construction area and may smother and hide immobile benthic prey. These mechanisms may result in less prey being available within the construction area to foraging seabirds.

5.11.1.34 However, as no significant impacts were identified to potential prey species (fish or benthic) or on the habitats that support them in the assessments on fish and benthic ecology (**Volume 2, Chapter 3: Fish and Shellfish Ecology** and **Volume 2, Chapter 2: Benthic and Intertidal Ecology**, respectively) then there is no potential for any indirect

impacts of an adverse significance to occur on offshore and intertidal ornithology receptors.

Construction activities associated with export cable laying may lead to disturbance and displacement of species within the export cable corridor and different degrees of buffers surrounding it (ORN-C-3).

5.11.1.35 The laying of the export cable between the array area and the cable landfall area for Hornsea Four would involve a cable laying vessel being in situ for the entire construction period of up to 14 months (potentially two consecutive non-breeding periods). There is the potential for construction activities associated with export cable laying, namely the physical presence of the cable laying vessel(s), to lead to disturbance and displacement of more sensitive species surrounding the cable laying vessel and out to differing buffers surrounding it dependent upon the species present.

5.11.1.36 This potential impact is only considered where an ECC runs through offshore areas that play host to higher densities of the more sensitive seabird species, so is not regularly included within OWF EIAs. Data sourced through the desk study for this PEIR identified that the Greater Wash SPA hosts two designated species that are considered sensitive to disturbance and displacement from vessel activity; red-throated diver and common scoter. However, the ECC does not run directly through the Greater Wash SPA, so would avoid the highest densities of both species. Of the two species it is also known that common scoter are not regularly recorded in abundances and densities that would warrant assessment, so this species is not considered further in this PEIR.

5.11.1.37 Following the screening process an assessment of displacement has been carried out for Hornsea Four, with detailed methods and results presented in **Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**, to provide information for red-throated diver identified as potentially at risk within the ECC and of interest for impact assessment. For the purpose of assessing the potential impact on red-throated diver it was agreed with Natural England that a 2 km buffer surrounding the cable laying vessel would be assumed to be the extent of any displacement (at Technical Panel Meeting 4 on 11.06.19).

5.11.1.38 Red-throated diver was agreed, in principle, as the species of focus for displacement within the ECC as a result of the cable laying vessel through the evidence plan process (at Technical Panel Meeting 3 on 10.04.19).

5.11.1.39 The data source identified as most appropriate for estimating the abundance and density of red-throated divers within the ECC is from the SeaMaST data set (Bradbury *et al.*, 2014). That source of data confirmed that for the majority of the ECC red-throated divers are estimated to be distributed in very low to low densities of between 0.000 and 0.007-0.064 birds per km^2. The data also suggests that the ECC may run through a small area where densities are estimated to be distributed at higher densities of between 0.065 and 0.641 birds per km^2. It was agreed that consideration should be given to red-throated divers within a 2 km buffer from the cable laying vessel.

Magnitude of impact

5.11.1.40 Using the SeaMaST data set (Bradbury *et al.*, 2014) it was estimated that for the majority of the ECC there would be less than 1 red-throated diver present within a 2 km buffer of the cable laying vessel. When using the same data set, but the higher densities it was estimated that for the minority of the ECC there would be between under one and eight red-throated diver present within a 2 km buffer of the cable laying vessel. Even if considering that 100% displacement would occur within the 2 km buffer area surrounding the cable laying vessel it is unlikely that any divers would be impacted by such a temporary and spatially restricted displacement impact, as there are large areas of equally suitable habitat surrounding the ECC. Therefore, it is predicted that no divers would be subject to mortality as a result of the cable laying through the ECC and that the magnitude of impact would be **negligible**.

5.11.1.41 The magnitude of this impact is considered to be of no change. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Construction activities associated with trenching, laying and reburial of the export cable through the intertidal zone may lead to disturbance and displacement of waterbird species in close proximity to the works (ORN-C-4).

5.11.1.42 The baseline assessment of the intertidal environment within and in close proximity to the cable landfall area shows that few waterbirds of any species reside within this coastal region in anything other than numbers of local importance. In this instance, the cable landfall area is the area of intertidal beach landward of MLWS tide level and seaward of MHWS tide level. In addition to the actual works area within the intertidal there are vehicle access routes to and from this construction works area and a landfall compound. Of those bird species recorded in peak numbers on migration or during the non-breeding (wintering) period, only sanderling may occur at levels exceeding 1% of the national population, the threshold widely considered as the basis for including a species in an impact assessment. All other intertidal bird species were recorded well below the national and international population level 1% importance thresholds, so were not considered further in this PEIR.

5.11.1.43 The assessment of the potential impacts and effects on intertidal ornithology receptors arising from the construction of Hornsea Four within the landfall area therefore includes one receptor species, i.e. the sanderling. This was agreed with Natural England and RSPB throughout the consultation process (**Table 5.3**).

5.11.1.44 Based on the MDS (**Table 5.17**), the key potential impacts from the construction activities within the intertidal environment are in relation to disturbance and displacement of sanderlings feeding or roosting within and near the construction site. Such potential impacts may be caused by noise and physical presence of workers, vehicles and machinery deployed during the construction phase within the active landfall works area, those within any works compounds immediately landward of the

MHWS mark and vehicles and people moving between the two areas. Any such considerations of the potential impacts from disturbance on sanderling also account for the works occurring over a maximum of three consecutive wintering periods also. The preferred method to install the export cable through the intertidal area is through the use of Horizontal Directional Drilling (HDD) techniques, which would avoid the majority of the construction activities within or in close proximity to the intertidal area. In the event that HDD is not possible (due to geological constraints) the MDS considers that open cut installation would result in the greatest level of disturbance to waterbirds.

Magnitude of impact

5.11.1.45 The potential disturbance of sanderlings during the non-breeding period through the activities associated with cable installation will be limited temporally to the hours of daylight, as the majority of machinery, vehicles and workforce would not be operating 24 hours a day or continuously through the hours of darkness. Furthermore, the majority of construction activities require dry access / working conditions, and works on the intertidal areas would, therefore, mostly take place during periods of mid to low tide. Consequently, during high tide periods when sanderlings may experience reduced foraging and / or roosting opportunity, they would encounter less or no disturbance through construction activities.

5.11.1.46 The MDS considers the assumption that the option that includes trenching, cable laying and burial of the offshore export cable through the intertidal area and connecting it with the onshore cable may take place anytime throughout a period of 32 consecutive months, potentially affecting sanderling during three consecutive non-breeding seasons.

5.11.1.47 The proposed construction activities are expected to take place only during day-light hours and no restrictions have been committed to at this stage to halt works temporarily during extreme cold weather events, though the likelihood is that for health and safety reasons works would not resume through extreme cold weather events in any case. It is known that sanderlings continue to feed through dusk into the night (Burger & Gochfeld 1991). Therefore, the significance of temporary anthropogenic disturbances occurring during short winter days is low in relation to the total amount of available time to forage.

5.11.1.48 The potential disturbance and displacement of sanderling through construction activities is spatially limited as the extent of the construction activities is limited to a very narrow corridor in relation to the length and width of the wider intertidal zone available to sanderling. As there is no pattern suggesting that sanderling occurrence is consistently at levels of national importance, within or in close proximity to the cable landfall area it is likely that this area is not of primary importance for either feeding or resting. Sanderling records fluctuate both in abundance and spatially along the coast between Bridlington to the north and Barmston to the south. As a consequence, and considering that this species spends considerable amounts of time along the coast during low water periods, it demonstrates that the food resources they utilise are widely distributed. Consequently, the limited zone of possible visual and acoustic influences from which sanderling may be displaced would not result in a significant reduction in the overall area available for them to forage or rest.

5.11.1.49 In accordance with construction activities from other cable landfall operations, it is assumed that the machinery used within the cable landfall area would not create an in-combination noise level of greater than 115 dB at source. The distance at which the noise level drops below the 55-dB disturbance threshold is estimated to lie between 360-400 m according to IECS (2012) wader sensitivity toolkit.

5.11.1.50 It is therefore concluded that any direct disturbance and/or displacement of sanderling caused by the planned construction activities (physical presence and noise of workers, vehicles, and machinery) is of local spatial extent, of short-term duration, intermittent and reversible. The magnitude of impact is therefore considered to be **negligible** to **minor**.

Sensitivity of the receptor

5.11.1.51 Sanderling are a long-distance seasonal migrant and non-breeding wintering visitor to the east coast of England, adapted to the ever-changing environmental conditions of its habitat. It is one of the most widespread shorebirds in the world, migrating south from Arctic breeding areas to non-breeding wintering areas along the coastlines of all continents except Antarctica (Delany *et al.* 2009). During the non-breeding season, sanderlings are mostly associated with sandy beaches, moving along the wash margin and feeding on food resources of the intertidal zone exposed by the falling water level (Reneerkens *et al.* 2009 and Summers *et al.* 2002).

5.11.1.52 With a maximum number of 295 sanderlings recorded during the Yorkshire Bird Survey in 2013 (YNU, 2018), the intertidal and nearshore habitat within the Hornsea Four landfall area from MHWS to MLWS may potentially accommodates over 1% of the national winter population and is therefore of national value for this species.

5.11.1.53 Sanderlings are considered to be tolerant to disturbance from anthropogenic activities and allow human approaches up to 12 m before flushing (Evans & Roberts 1993). They are also found to be not particularly sensitive to noise stimuli and habituate rapidly (IECS 2012), with sanderling likely to exhibit disturbance responses when subjected to noise levels of 55-dB or greater, so would not be subject to any influence at distances away from activities where noise levels drop below this level.

5.11.1.54 Within the context of the cable landfall area sanderling is deemed to be of low vulnerability to the construction works and have a medium conservation value level. Whilst it may be of national importance it is of low vulnerability leading to a sensitivity of receptor considered to be **low.**

Significance of the effect

5.11.1.55 The magnitude of disturbance from construction activities within the cable landfall area are defined as a negligible to minor adverse impact during the winter for sanderling and the sensitivity of the species considered to be negligible to low. Therefore, the significance of effect is considered **not significant** or **minor**, which is also not significant in EIA terms**.**

5.11.2 Operation and Maintenance

5.11.2.1 The impacts of the offshore operation and maintenance of Hornsea Four have been assessed on offshore and intertidal ornithology. The environmental impacts arising from the operation and maintenance of Hornsea Four are listed in **Table 5.17** along with the MDS against which each operation and maintenance phase impact has been assessed.

Operational activities associated with moving turbines and maintenance vessels may lead to disturbance and displacement of species within the array area and different degrees of buffers surrounding it (ORN-O-5)

5.11.2.2 The presence of WTGs has the potential to directly disturb and displace seabirds that would normally reside within and around the area of sea where Hornsea Four is proposed to be developed. This in effect represents indirect habitat loss, which would potentially reduce the area available to those seabirds to forage, loaf and / or moult that currently occur within and around Hornsea Four and may be susceptible to displacement from such a development. Displacement may contribute to individual birds experiencing fitness consequences, which at an extreme level could lead to the mortality of individuals.

5.11.2.3 Seabird species vary in their response to the presence of operational infrastructure associated with OWFs, such as WTGs and shipping activity related to maintenance activities. OWFs are a new feature in the marine environment and as a result there is limited evidence as to the effects of disturbance and displacement by operational infrastructure in the long-term.

5.11.2.4 Garthe and Hüppop (2004) developed a scoring system for such disturbance factors, which has been widely applied in offshore wind farm EIAs. Furness and Wade (2012) developed a similar system with disturbance ratings for particular species that was applied alongside scores for habitat flexibility and conservation importance to define an index value that highlights the sensitivity of each species to disturbance and displacement.

5.11.2.5 NE and JNCC issued a joint Interim Displacement Guidance Note (NE and JNCC 2012), which provides recommendations for presenting information to enable the assessment of displacement effects in relation to offshore wind farm developments. This has been superseded recently by a joint SNCB interim displacement advice note (SNCBs, 2017), which provides the latest advice for UK development applications on how to consider, assess and present information and potential consequences of seabird displacement from offshore wind farms. These guidance notes have shaped the assessment provided below.

5.11.2.6 A screening process was undertaken to identify those species of birds present within the array area (as described in **Volume 5, Annex 5.2: Offshore Ornithology Displacement Analysis**) that may be most at risk of displacement. The screening was based on those bird species found in highest densities within the array area and within the 2-4 km buffer surrounding it in the first instance, with further consideration given to their perceived risk from displacement, presented in **Table 5.25**. Where the risk from displacement is

assessed as very low or low or the species was recorded in low abundances / densities then these species were screened out.

Table 5.25: Screening of seabird species recorded within Hornsea Four array area and 2-4 km buffer for risk of disturbance and displacement.

Receptor	Sensitivity to Disturbance & Displacement	Displacement Rate based on OWEZ (Krigsveld *et al.*, 2011; & Leopold *et al.*, 2011)	Displacement Rates based on Robin Rigg (Walls *et al.*, 2013); & Thanet (Royal HaskoningDHV, 2013)	Bio-season with peak abundance / density in Hornsea Four array area and 2-4 km buffer	Screening Result (In or Out)
Fulmar	Low (to high)	28%	n/a	Migration-free breeding	Out
Gannet	Low (to high)	64%	50%	Migration-free breeding	In
Kittiwake	Low	18%	0%	Post-breeding	Out
Great black-backed gull	Low	18%	0%	Migration-free winter and Return migration	Out
Herring gull	Low	18%	0%	Very low in all bio-seasons	Out
Lesser black-backed gull	Low	18%	0%	Very low in all bio-seasons	Out
Guillemot	Medium	68%	30-79%	Post-breeding	In
Razorbill	Medium	68%	30-95%	Post-breeding	In
Puffin	Low	40-68%	n/a	Post-breeding	In

5.11.2.7 Following the screening process an assessment of displacement was carried out for Hornsea Four, with detailed methods and results presented in **Volume 5, Annex 5.2: Offshore Ornithology Displacement Analysis**, to provide information for four seabird species of interest identified as potentially at risk and of interest for impact assessment.

5.11.2.8 The four species that were agreed, in principle, as the species of focus for displacement through the evidence plan process (at Technical Panel Meeting 3 on 10.04.19) were; gannet, guillemot, razorbill and puffin.

5.11.2.9 For each of the four species an evidence led approach to quantifying the level of displacement led to the following rates of displacement being used to determine the overall number of birds within the areas defined as most appropriate for each species;

- Gannets - Between 60-70% displacement during the non-migratory breeding bio-season within the array area and 0% displacement beyond the array area. During the non-breeding bio-seasons 100% displacement from within the array area and 0% displacement beyond the array area;
- Guillemots - Between 30-80% displacement during all bio-seasons within the array area and 30% displacement out to a 2 km buffer;
- Razorbills - Between 30-95% displacement during all bio-seasons within the array area and 25% displacement out to a 2 km buffer; and
- Puffins - Between 50-70% displacement during all bio-seasons within the array area and 40% displacement out to a 2 km buffer.

5.11.2.10 For the purpose of this assessment a precautionary approach has been taken to estimating the potential mortality rates for all four species, dependent upon the bio-season being assessed. This includes a level of mortality applied for this assessment of 1% during all non-breeding bio-seasons for each species. A more precautionary set of mortality rates have been applied when considering potential impacts during the non-migratory breeding bio-season of 1-2% for gannet and 2-10% for guillemot, razorbill and puffin.

Gannet

5.11.2.11 Gannets show a low level of sensitivity to ship and helicopter traffic (Garthe and Hüppop, 2004, Furness and Wade, 2012). A study by Krijgsveld *et al.* (2011) using radar and visual observations to monitor the post-construction effects of the OWEZ established that 64% of gannets avoided entering the wind farm (macro-avoidance). The results of the post-consent monitoring surveys for Thanet OWF found that gannet densities reduced within the site in the third year, but the report did not quantify this (Royal HaskoningDHV, 2013). For the purpose of this assessment the level of displacement considered during the non-migratory breeding bio-season is between 60-70%.

5.11.2.12 A more recent study by APEM (APEM, 2014) provided evidence that during their migration most gannets would avoid flying into areas with operational WTGs (macro-avoidance), with the estimated macro avoidance being 95%. For the purpose of this assessment for Hornsea Four the level of displacement for the return migration and post-breeding migration bio-seasons considers a precautionary 100% displacement.

5.11.2.13 A complete range of displacement matrices are presented in **Volume 5 Annex 5.2: Offshore Ornithology Displacement Analysis**, whilst **Table 5.26** has been populated with data for gannets during each of the return migration, non-migratory and post-breeding migration bio-seasons within the Hornsea Four array area only, as there is no evidence that gannets are displaced beyond OWF site boundaries. However, displacement matrices are presented with abundances within a 1 km and 2 km buffer in **Volume 5, Annex 5.2: Offshore Ornithology Displacement Analysis**.

5.11.2.14 For the purpose of determining the level of potential impact on gannets during each bio-season different mortality rates have been considered. This is based on expert judgement supported by additional evidence that suggests that gannet have a large mean max (229.4 km) and maximum (590 km) foraging range (Thaxter *et al.*, 2012) and feed on a variety of different prey items that provide sufficient alternative foraging opportunities despite the potential loss of habitat within the Hornsea Four array area. The levels of mortality used to determine the potential impact from displacement are therefore 1% during the return migratory and post-breeding migratory bio-seasons and 1-2% within the non-migratory breeding bio-season.

Evaluation of the potential magnitude of impact

5.11.2.15 The annual estimated mortality rate for gannet is between 17 and 25 individuals, which is further broken down into relevant bio-seasons in **Table 5.26**. The magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the regional populations. The overall baseline mortality rates are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

Table 5.26: Bio-season displacement estimates for gannet for Hornsea Four.

Bio-season (months)	Seasonal abundance (array area only)	Regional baseline populations and baseline mortality rates (individuals per annum)		No. of gannets displaced (individuals)	Estimated No. of gannets subject to mortality (individuals)	Increase in baseline mortality (%)
		Population	Baseline mortality			
Return Migration (Dec-Mar)	449	248,386	47,442	449	4	0.009
Migration-free Breeding (Apr-Aug)	1,048	125,882	24,043	1,048	6-15	0.026-0.061
Post-breeding migration (Sep-Nov)	639	456,298	87,153	639	6	0.007
Migration-free Winter	n/a	n/a	n/a	n/a	n/a	n/a
Annual	**n/a**	**1,180,000**	**225,380**	**2,136**	**17*-25**	**0.008-0.011**

Table Note: *Annual total may be different to apparent sum of bio-seasons due to rounding.

5.11.2.16 During the return migration bio-season approximately four gannets may be subject to mortality, which would present an increase of 0.009% relative to the current baseline mortality rate at a regional level.

5.11.2.17 This level of potential impact is considered to be of **negligible** magnitude during the return migration bio-season, as it represents no discernible increase to baseline mortality levels as a result of displacement.

5.11.2.18 During the non-migratory breeding bio-season between approximately six to 15 gannets may be subject to mortality, which would present an increase of 0.026-0.061% relative to the current baseline mortality rate at a regional level.

5.11.2.19 This level of potential impact is considered to be of **negligible** magnitude during the non-migratory breeding bio-season, as it represents only a slight difference to the baseline conditions due to a small number of individuals subject to potential mortality as a result of displacement.

5.11.2.20 During the post-breeding migration bio-season approximately six gannets may be subject to mortality, which would present an increase of 0.007% relative to the current baseline mortality rate at a regional level.

5.11.2.21 This level of potential impact is considered to be of **negligible** magnitude during the post-breeding migration bio-season, as it represents no discernible increase to baseline mortality levels as a result of displacement.

5.11.2.22 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Guillemot

5.11.2.23 Guillemots show a medium level of sensitivity to ship and helicopter traffic (Garthe and Hüppop, 2004; Furness and Wade, 2012; Langston, 2010; and Bradbury *et al.*, 2014). However, a number of detailed studies (including Krijgsveld *et al.*, 2011, Walls *et al.*, 2013 and Royal HaskoningDHV, 2013) monitoring the post-construction effects of OWFs on guillemots suggest that the range of displacement may be between approximately 30-80% within OWF arrays, whilst lower rates of approximately 30% may be apparent out to a maximum of 1-2 km. For the purpose of this assessment for Hornsea Four the level of displacement for each bio-season will be based on these values derived from an evaluation of the published literature.

5.11.2.24 A complete range of displacement matrices are presented in **Volume 5, Annex 5.2: Offshore Ornithology Displacement Analysis**, whilst **Table 5.27** has been populated with data for guillemots during each of the return migration, non-migratory breeding, post-breeding migration and non-migration wintering bio-seasons within the Hornsea Four array area as well as out to a 1 km buffer and a 2 km buffer.

5.11.2.25 For the purpose of determining the level of potential impact on guillemot during each bio-season different mortality rates have been considered. This is based on expert judgement supported by additional evidence that suggests that most breeding guillemots feed closer inshore during the more sensitive non-migratory breeding bio-season and that outside of this season they feed on a variety of different prey items that provide sufficient alternative foraging opportunities despite the potential loss of habitat within the Hornsea Four array area. The levels of mortality used to determine the potential impact from displacement are therefore between 2-10% during the non-migratory breeding season and 1% during all other bio-seasons.

Evaluation of the potential magnitude of impact

5.11.2.26 The annual estimated mortality rate for guillemot is between 307 and 1,136 individuals, which is further broken down into relevant bio-seasons in **Table 5.27**. The magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the regional populations. The overall baseline mortality rates are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

Table 5.27: Bio-season displacement estimates for guillemot for Hornsea Four.

Bio-season (months)	Seasonal abundance (array area & 2 km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality rate/s (individuals)	Increase in baseline mortality (%)
		Population	Baseline mortality		
Return Migration (Dec-Mar)	5,618 + 2,783	1,617,306	226,423	25-53	0.011-0.024
Migration-free Breeding (Apr-Aug)	6,441 + 3,363	843,072	118,030	59-616	0.050-0.272
Post-breeding migration (Sep-Nov)	39,661 + 19,259	1,617,306	226,423	177-375	0.078-0.166
Migration-free Winter	8,952 + 6,457	1,617,306	226,423	46-91	0.020-0.040
Annual	**n/a**	**4,125,000**	**577,500**	**307 – 1,136**	**0.053-0.197**

5.11.2.27 During the return migration bio-season between approximately 25 to 53 guillemots may be subject to mortality, which would present an increase of 0.011-0.024% relative to the current baseline mortality rate at a regional level.

5.11.2.28 This level of potential impact is considered to be of **negligible** magnitude during the return migration bio-season, as it represents no discernible increase to baseline mortality levels as a result of displacement.

5.11.2.29 During the non-migratory breeding bio-season between approximately 59 to 616 guillemots may be subject to mortality, which would present an increase of 0.050-0.272% relative to the current baseline mortality rate at a regional level.

5.11.2.30 This level of potential impact is considered to be of **negligible** to **minor** magnitude during the non-migratory breeding bio-season, as it represents between only a slight to a minor difference to the baseline conditions due to the range of individuals subject to potential mortality as a result of displacement.

5.11.2.31 During the post-breeding migration bio-season approximately 177 to 375 guillemots may be subject to mortality, which would present an increase of 0.078-0.165% relative to the current baseline mortality rate at a regional level.

5.11.2.32 This level of potential impact is considered to be of **negligible** magnitude during the post-breeding migration bio-season, as it represents only a slight to minor difference to the baseline conditions due to a number of individuals subject to potential mortality as a result of displacement.

5.11.2.33 During the migration-free wintering bio-season approximately 46 to 91 guillemots may be subject to mortality, which would present an increase of 0.020-0.040% relative to the current baseline mortality rate at a regional level.

5.11.2.34 This level of potential impact is considered to be of **negligible** magnitude during the migration-free wintering bio-season, as it represents only a slight difference to the baseline conditions due to a small number of individuals subject to potential mortality as a result of displacement.

Sensitivity of the receptor

5.11.2.35 As the Hornsea Four array area is well within the maximum foraging range of guillemot from the FFC SPA this species is afforded with a conservation value level of high to reflect that. With respect to vulnerability to displacement it is considered to be medium (**Table 5.25**). Whilst it may be of low to medium vulnerability it is of high conversation value leading to a sensitivity of receptor being considered to be **high**.

Significance of the effect

5.11.2.36 The magnitude of this impact is considered to be **negligible** during the two non-breeding bio-seasons. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment for these two bio-seasons.

5.11.2.37 The magnitude of disturbance from operational and maintenance activities within the array area and 2 km buffer are defined as a maximum of minor adverse impact in the non-migratory breeding bio-season, whilst the sensitivity of the species considered to be high. Therefore, the potential effect from displacement to guillemot from Hornsea Four

may be of **minor** adverse significance during the non-migratory breeding bio-season, which is not significant in EIA terms.

Razorbill

5.11.2.38 Razorbills show a medium level of sensitivity to ship and helicopter traffic (Garthe and Hüppop, 2004; Furness and Wade, 2012; Langston, 2010; and Bradbury *et al.*, 2014). However, a number of detailed studies (including Krijgsveld *et al.*, 2011, Walls *et al.*, 2013 and Royal HaskoningDHV, 2013) monitoring the post-construction effects of OWFs on razorbills suggest that the range of displacement may be between approximately 30-95% within OWF arrays, whilst lower rates of approximately 25% may be apparent out to a maximum of 1-2 km. For the purpose of this assessment for Hornsea Four the level of displacement for each bio-season will be based on these values derived from an evaluation of the published literature.

5.11.2.39 A complete range of displacement matrices are presented in **Volume 5, Annex 5.2: Offshore Ornithology Displacement Analysis**, whilst **Table 5.28** has been populated with data for razorbills during each of the return migration, non-migratory breeding, post-breeding migration and non-migration wintering bio-seasons within the Hornsea Four array area as well as out to a 1 km buffer and a 2 km buffer.

5.11.2.40 For the purpose of determining the level of potential impact on razorbill during each bio-season different mortality rates have been considered. This is based on expert judgement supported by additional evidence that suggests that most breeding razorbills feed closer inshore during the more sensitive non-migratory breeding bio-season and that outside of this season they feed on a variety of different prey items that provide sufficient alternative foraging opportunities despite the potential loss of habitat within the Hornsea Four array area. The levels of mortality used to determine the potential impact from displacement are therefore between 2-10% during the non-migratory breeding season and 1% during all other bio-seasons.

Magnitude of impact

5.11.2.41 The annual estimated mortality rate for razorbill is between 23 and 91 individuals, which is further broken down into relevant bio-seasons in **Table 5.28**. The magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the regional populations. The overall baseline mortality rates are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

Table 5.28: Bio-season displacement estimates for razorbill for Hornsea Four.

Bio-season (months)	Seasonal abundance (array area & 2 km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality rate/s (individuals)	Increase in baseline mortality (%)
		Population	Baseline mortality		
Return Migration (Dec-Mar)	501 + 528	591,874	102,986	3-6	0.003-0.006

Bio-season (months)	Seasonal abundance (array area & 2 km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality rate/s (individuals)	Increase in baseline mortality (%)
		Population	Baseline mortality		
Migration-free Breeding (Apr-Aug)	361 + 147	268,377	46,698	3-38	0.006-0.081
Post-breeding migration (Sep-Nov)	4,502 + 926	591,874	102,986	16-43	0.015-0.042
Migration-free Winter	415 + 191	218,622	38,040	1-4	0.005-0.012
Annual	**n/a**	**1,707,000**	**297,018**	**23 – 91**	**0.006-0.031**

5.11.2.42 During the return migration bio-season between approximately three to six razorbills may be subject to mortality, which would present an increase of 0.003-0.006% relative to the current baseline mortality rate at a regional level.

5.11.2.43 This level of potential impact is considered to be of **negligible** magnitude during the return migration bio-season, as it represents no discernible increase to baseline mortality levels as a result of displacement.

5.11.2.44 During the non-migratory breeding bio-season between approximately three to 38 razorbills may be subject to mortality, which would present an increase of 0.006-0.081% relative to the current baseline mortality rate at a regional level.

5.11.2.45 This level of potential impact is considered to be of **negligible** magnitude during the non-migratory breeding bio-season, as it represents no discernible increase to baseline mortality levels as a result of displacement.

5.11.2.46 During the post-breeding migration bio-season approximately 16 to 43 razorbills may be subject to mortality, which would present an increase of 0.015-0.042% relative to the current baseline mortality rate at a regional level.

5.11.2.47 This level of potential impact is considered to be of **negligible** magnitude during the post-breeding migration bio-season, as it represents no discernible increase to baseline mortality levels as a result of displacement.

5.11.2.48 During the migration-free wintering bio-season approximately one to four razorbills may be subject to mortality, which would present an increase of 0.005-0.012% relative to the current baseline mortality rate at a regional level.

5.11.2.49 This level of potential impact is considered to be of **negligible** magnitude during the migration-free wintering bio-season, as it represents no discernible increase to baseline mortality levels as a result of displacement.

5.11.2.50 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in

the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Puffin

5.11.2.51 Puffins show a low level of sensitivity to ship and helicopter traffic (Garthe and Hüppop, 2004; Furness and Wade, 2012; Langston, 2010; and Bradbury *et al.*, 2014). However, a number of detailed studies (including Krijgsveld *et al.*, 2011 and Walls *et al.*, 2013) monitoring the post-construction effects of OWFs on puffins suggest that the range of displacement may be between approximately 50-70% within OWF arrays, whilst lower rates occur out to a maximum of 1-2 km. For the purpose of this assessment for Hornsea Four the level of displacement for each bio-season will be based on 40% within the array area and out to a 2 km buffer, which provides a sufficiently precautionary approach to a species that is less sensitive than other auks species.

5.11.2.52 A complete range of displacement matrices are presented in **Volume 5, Annex 5.2: Offshore Ornithology Displacement Analysis**, whilst **Table 5.29** has been populated with data for puffins during each of the return migration, non-migratory breeding, post-breeding migration and non-migration wintering bio-seasons within the Hornsea Four array area as well as out to a 1 km buffer and a 2 km buffer.

5.11.2.53 For the purpose of determining the level of potential impact on puffin during each bio-season different mortality rates have been considered. This is based on expert judgement supported by additional evidence that suggests that most breeding puffins feed closer inshore during the more sensitive non-migratory breeding bio-season and that outside of this season they feed on a variety of different prey items that provide sufficient alternative foraging opportunities despite the potential loss of habitat within the Hornsea Four array area. The levels of mortality used to determine the potential impact from displacement are therefore between 2-10% during the non-migratory breeding season and 1% during all other bio-seasons.

Magnitude of impact

5.11.2.54 The annual estimated mortality rate for puffin is between 5 and 8 individuals, which is further broken down into relevant bio-seasons in **Table 5.29**. The magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the regional populations. The overall baseline mortality rates are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

Table 5.29: Bio-season displacement estimates for puffin for Hornsea Four.

Bio-season (months)	Seasonal abundance (array area & 2 km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality rate/s (individuals)	Increase in baseline mortality (%)
		Population	Baseline mortality		
Return Migration (Dec-Mar)	17.4+ 63	231,957	38,737	1	0.002
Migration-free Breeding (Apr-Aug)	77 + 25	105,404	17,602	1-4	0.005-0.023
Post-breeding migration (Sep-Nov)	313 + 109	231,957	38,737	2	0.044
Migration-free Winter	188 + 97	231,957	38,737	1	0.009
Annual	**n/a**	**11,840,000**	**1,977,280**	**5 – 8**	**<0.001**

5.11.2.55 During the return migration bio-season approximately one puffin may be subject to mortality, which would present an increase of 0.002% relative to the current baseline mortality rate at a regional level.

5.11.2.56 This level of potential impact is considered to be of **negligible** magnitude during the return migration bio-season, as it represents no material difference to the baseline conditions as an insignificant number of individuals are subject to potential mortality as a result of displacement.

5.11.2.57 During the non-migratory breeding bio-season between approximately one to four puffins may be subject to mortality, which would present an increase of 0.005-0.023% relative to the current baseline mortality rate at a regional level.

5.11.2.58 This level of potential impact is considered to be of **negligible** magnitude during the non-migratory breeding bio-season, as it represents no discernible increase to baseline mortality levels as a result of displacement.

5.11.2.59 During the post-breeding migration bio-season approximately two puffins may be subject to mortality, which would present an increase of 0.004% relative to the current baseline mortality rate at a regional level.

5.11.2.60 This level of potential impact is considered to be a magnitude of **negligible** during the post-breeding migration bio-season, as it represents no discernible increase to baseline mortality levels as a result of displacement.

5.11.2.61 During the migration-free wintering bio-season approximately one puffin may be subject to mortality, which would present an increase of 0.003% relative to the current baseline mortality rate at a regional level.

5.11.2.62 This level of potential impact is considered to be a magnitude of **negligible** during the migration-free wintering bio-season, as it represents no material difference to the baseline conditions due to being an insignificant number of individuals subject to potential mortality as a result of displacement.

5.11.2.63 The magnitude of this impact is considered to be of no change or **negligible** at most. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Seabirds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure. The result of such collisions may be fatal to the bird concerned (ORN-O-6).

5.11.2.64 There is potential risk to birds from offshore wind farms through collision with WTGs and associated infrastructure described in the MDS (**Table 5.17**) resulting in injury or fatality. This may occur when birds fly through the Hornsea Four array area whilst foraging for food, commuting between breeding sites and foraging areas, or during migration.

5.11.2.65 CRM has been carried out for Hornsea Four, with detailed methods and results presented in **Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**, to provide information for five seabird species of interest identified as potentially at risk and of interest for impact assessment. A screening process was undertaken based on the density of flying birds recorded within the array area and consideration of their perceived risk from collision (identified from the published literature), and the result presented in **Table 5.30**. Where the risk of collision is assessed as very low, such as for fulmar, these species were screened out. Where the risk to species is assessed as low these species were screened out if their densities in flight within the array area were very low or low. Seabird species considered to be of medium to high risk of collision were screened in only if their density in flight was above very low. Following this screening process the five species agreed, in principle, as the species of focus for CRM through the evidence plan process (at Technical Panel Meeting 3 on 10.04.19) were; gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull.

Table 5.30: Screening of seabird species recorded in Hornsea Four array area for risk of collision.

Receptor	Risk of collision (Garthe & Huppop, 2004; Furness & Wade, 2012; Wade *et al.*, 2016)	Estimated density of birds in flight in Hornsea Four array area (No. birds/km^{2}from 24 months surveys data)	Screening Result (In or Out)
Manx shearwater	Very low	<0.01 birds/km^2 Very low (seasonally restricted)	Out
Fulmar	Low	0.06 birds/km^2 Low	Out
Gannet	Medium	<0.27 birds/km^2 Medium	In

Receptor	Risk of collision (Garthe & Huppop, 2004; Furness & Wade, 2012; Wade *et al.*, 2016)	Estimated density of birds in flight in Hornsea Four array area (No. birds/km^{2}from 24 months surveys data)	Screening Result (In or Out)
Arctic skua	Medium	<0.01 birds/km^2 Very low (seasonally restricted)	In*
Great skua	Medium	<0.01 birds/km^2 Very low (seasonally restricted)	In*
Kittiwake	Medium	0.94 birds/km^2 Medium to high	In
Little gull	Medium	0.01 birds/km^2 Very low	In*
Great black-backed gull	High	0.04 birds/km^2 Very low to low	In
Herring gull	High	0.01 birds/km^2 Very low	In**
Lesser black-backed gull	High	<0.01 birds/km^2 Very low	In**
'Commic' tern (common and / or Arctic tern)	Low	<0.01 birds/km^2 Very low to high (seasonally restricted)	In*
Guillemot	Very low	0.36 birds/km^2 Medium	Out
Razorbill	Very low	0.06 birds/km^2 Low	Out
Puffin	Very low	<0.01 birds/km^2 Very low	Out

Table Note: In* refers to species that may migrate through array area and considered in separate screening approach for collision risk. In** refers to species not recorded in abundances / densities initially considered high enough for CRM but screened in at the request of Natural England.

5.11.2.66 Following the principles of the proportionate approach to EIA, a number of seabird and non-seabird species that may migrate through the array area that were only recorded in very low abundances and / or densities but may be considered to be at risk from collision, are assessed in a less detailed manner.

5.11.2.67 CRM was undertaken using the Stochastic Collision Risk Model (sCRM), developed by Marine Scotland (McGregor, 2018) for each seabird species, to determine the risk of collision when in flight, in agreement with Natural England and the RSPB (Table 5.3). The development and testing of the sCRM was funded by Marine Scotland Science (MSS) and provides the most up-to-date version of the CRM originally created by Band (2012) and addressed the uncertainty in developments and other key input parameters as progressed initially by Masden (2015).

5.11.2.68 The sCRM is run through an online interface referred to as the 'shinyapp', which is a user-friendly graphical user interface accessible via a standard web-browser that uses an R

coded programme operating behind the interface to estimate collision risk. The advantages are that users are not required to use any R code themselves, are not required to install or maintain R and any updates to the model are made directly to the server, so are immediately available to users (Donovan, 2018).

5.11.2.69 CRM accounts for a number of different species-specific behavioural aspects of the seabirds being assessed, including the height at which birds fly, their ability to avoid moving or static structures and how active they are diurnally and nocturnally. Details of these considerations are provided in **Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.

5.11.2.70 Hornsea Four has taken significant measures to reduce the potential impacts from collision to seabirds through;

- Co138, as described in **Section 5.8.2** will provide a significantly reduced risk from collision to seabirds through incorporating a raised minimum swept height commitment (the distance between sea level and the lower turbine tip or air gap); and
- Co87, a reduction in the size of the proposed developable area, from that presented at Scoping to that forming the assessments at PEIR, informed by an analysis of risk to seabirds (as described in **Section 5.7.2**). This was based on assessing the distribution of core species (those recorded in the highest densities) throughout the original AfL that may be at risk from collision (gannet and kittiwake). Through the identification of seabird hotspot areas, a process of refining the Hornsea Four array area was completed and the revised developable area at PEIR was selected that avoids the areas of highest densities for these two species deemed most at risk from collision.

5.11.2.71 There are a number of areas of uncertainty with respect to the parameters that are input into the sCRM at present, due to this model not having previously been subject to use by a developer, and a review of outputs by stakeholders, within an EIA for an OWF in English waters to date. However, in order to advance the assessment process that considers the risk from collision to seabirds from OWFs, this PEIR presents the outputs of the sCRM that is run using the 'shinyapp' interface. The assessment of collision risk follows an evidence led approach making use of a mixture of site-specific data collected from within the Hornsea Four array area and the most recent literature on seabirds and their behaviour in relation to OWFs (**Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**).

5.11.2.72 Within this report the shinyapp outputs / results for two different Band Options are presented (Band Option 1 and 2), which form the basis of assessing the risk to seabirds from collision and are described as;

Band Option 1

5.11.2.73 The Basic Band model applies a uniform distribution of bird flights between the lowest and the highest levels of the rotors. The percentage of bird flights passing between the lowest and the highest levels of the rotors (i.e. the proportion of birds at potential collision height (PCH)) is determined from the observations of bird flight heights made

from the boat-based site-specific surveys. This Option has been considered for all five seabird species.

Band Option 2

5.11.2.74 The Basic Band model applies a uniform distribution of bird flights between the lowest and the highest levels of the rotors. The PCH was determined from the results of the SOSS-02 project (Cook *et al.,* 2012) that analysed the flight height measurements taken from boat surveys conducted around the UK. The project was updated following Johnston *et al.*, (2014), and the revised published spreadsheet[1] is used to determine the 'generic' percentage of flights at PCH for each species based on the proposed project's wind turbine parameters. This Option has been considered for all five seabird species.

5.11.2.75 Band Option 3 was also run for four out of five seabird species with the results presented in **Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**. The estimated monthly and annual CRM results for Hornsea Four are presented in **Table 5.31** for each of the model options applied for each species.

Table 5.31: Monthly collision risk estimates for seabirds for Hornsea Four.

Species	Gannet		Kittiwake		Lesser black-backed gull		Herring gull		Great black-backed gull	
Month / Band Option	BO1	BO2	BO1	BO2	BO1	BO2	BO1	BO2	BO1	BO2
Jan	1.474	1.484	0.079	0.649	0	0	0	0	2.181	2.185
Feb	0.392	0.392	0.182	1.481	0	0	0.001	0.001	0.267	0.267
Mar	2.069	2.087	0.167	1.362	0	0	0.139	0.17	0.772	0.775
Apr	0.836	0.858	0.998	8.171	0	0	0	0	0	0
May	3.399	3.473	1.4	11.409	0.119	0.177	0	0	0.265	0.266
Jun	11.588	11.691	0.934	7.605	0.477	0.704	0.65	0.791	0.499	0.503
Jul	9.431	9.624	0.628	5.116	0	0	0	0	0	0
Aug	8.528	8.615	1.5	12.254	0.115	0.169	0	0	0	0
Sep	2.397	2.442	0.454	3.666	0	0	0.142	0.174	0	0
Oct	2.594	2.666	0.064	0.523	0	0	0.017	0.021	0.189	0.188
Nov	4.33	4.427	0.131	1.068	0.002	0.003	0	0	1.67	1.666
Dec	3.194	3.352	0.335	2.715	0	0	0.162	0.199	1.864	1.868
Annual	**50.232**	**51.112**	**6.874**	**56.019**	**0.713**	**1.052**	**1.110**	**1.355**	**7.708**	**7.718**

5.11.2.76 A second iteration of the sCRM has been provided, in **Appendix A** of **Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**, which incorporates input parameters currently advocated by the SNCBs for use in CRM carried out by OWF developers. The sCRM was run for each species with these input parameters in agreement with Natural England and the RSPB through the evidence plan process (at

[1] Final_Report_SOSS02_FlightHeights2014.xls

Technical Panel Meeting 4 on 11.06.19) in order to provide their more precautionary range of outputs.

5.11.2.77 For the purpose of identifying and assessing the potential magnitude of impact from collision risk to the five seabirds in this PEIR the standard bio-seasons from Furness (2015) have been used. These bio-seasons are defined as;

- Return migration in UK waters (spring BDMPS);
- Migration-free breeding (UK breeding BDMPS);
- Post-breeding migration in UK waters (autumn BDMPS); and
- Migration-free winter (UK non-breeding BDMPS).

Gannet

sCRM prediction outputs

5.11.2.78 The monthly estimated mortality rates are presented in **Table 5.32**, which vary from a minimum of under one individual in February to a maximum of approximately 12 individuals in June. On an annual basis the estimated mortality rate for collision risk from Hornsea Four is of between 50 to 51 individuals (**Table 5.31**) and **Table 5.32**), which is further broken down into relevant bio-seasons in **Table 5.32**. The magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the regional BDMPS populations and their overall baseline mortality rates as described in **Section 5.7.4**, which are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

5.11.2.79 Mortality rates as described in **Section 5.6.1**, are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

Table 5.32: Bio-season collision risk estimates for gannet for Hornsea Four.

Bio-season (months)	Seasonal sCRM totals		Regional baseline populations and baseline mortality rates (individuals per annum)		Increase in baseline mortality (%)	
	BO1	BO2	Population	Baseline mortality	BO1	BO2
Return Migration (Dec-Mar)	7.129	7.315	248,385	47,438	0.015	0.015
Migration-free Breeding (Apr-Aug)	33.782	34.261	125,890	24,045	0.140	0.142
Post-breeding migration (Sep-Nov)	9.321	9.535	456,298	87,153	0.011	0.011
Migration-free Winter	n/a	n/a	n/a	n/a	n/a	n/a
Annual	**50.232**	**51.112**	**1,180,000**	**225,380**	**0.022**	**0.023**

Evaluation of the potential magnitude of impact

5.11.2.80 During the return migration bio-season approximately seven gannets may be subject to mortality, which would present an increase of 0.015% relative to the current baseline mortality rate at a regional level.

5.11.2.81 This level of potential impact is considered to be of **negligible** magnitude during the return migration bio-season, as it represents no discernible increase to baseline mortality levels due to a very small number of estimated collisions.

5.11.2.82 During the non-migratory breeding bio-season approximately 34 gannets may be subject to mortality, which would present an increase of 0.140-0.142% relative to the current baseline mortality rate at a regional level.

5.11.2.83 This level of potential impact is considered to be of **negligible** magnitude during the non-migratory breeding bio-season, as it represents only a slight difference to the baseline conditions due to a small number of estimated collisions.

5.11.2.84 During the post-breeding migration bio-season approximately nine gannets may be subject to mortality, which would present an increase of 0.011% relative to the current baseline mortality rate at a regional level.

5.11.2.85 This level of potential impact is considered to be of **negligible** magnitude during the post-breeding migration bio-season, as it represents no discernible increase to baseline mortality levels due to a very small number of estimated collisions.

5.11.2.86 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Kittiwake

CRM prediction outputs

5.11.2.87 The monthly estimated mortality rates are presented in **Table 5.32**, which vary from under one individual in October to a maximum of between 1.5-12 individuals in August. On an annual basis the estimated mortality rate for collision risk from Hornsea Four is of between seven and 56 individuals (**Table 5.31** and **Table 5.33**), which is further broken down into relevant bio-seasons in **Table 5.33.** The magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the regional BDMPS populations and the overall baseline mortality rates as described in **Section 5.8**, which are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

Table 5.33: Bio-season collision risk estimates for kittiwake for Hornsea Four.

Bio-season (months)	Seasonal sCRM totals		Regional baseline populations and baseline mortality rates (individuals per annum)		Increase in baseline mortality (%)	
	BO1	BO2	Population	Baseline mortality	BO1	BO2
Return Migration (Jan-Apr)	1.426	11.663	627,816	97,939	0.001	0.012
Migration-free Breeding (May-Jul)	2.962	24.13	400,027	62,404	0.005	0.039
Post-breeding migration (Aug-Dec)	2.484	20.226	829,937	129,470	0.002	0.016
Migration-free Winter	n/a	n/a	n/a	n/a	n/a	n/a
Annual	**6.874**	**56.019**	**5,100,000**	**795,600**	**0.001**	**0.007**

Evaluation of the potential magnitude of impact

5.11.2.88 During the return migration bio-season, between approximately one to 12 kittiwakes may be subject to mortality, which would present an increase of 0.001-0.012% relative to the current baseline mortality rate at a regional level.

5.11.2.89 This level of potential impact is considered to be of **negligible** magnitude during the return migration bio-season, as it represents no discernible increase to baseline mortality levels due to a very small number of estimated collisions.

5.11.2.90 During the non-migratory breeding bio-season, between approximately three to 24 kittiwakes may be subject to mortality, which would present an increase of 0.005-0.039% relative to the current baseline mortality rate at a regional level.

5.11.2.91 This level of potential impact is considered to be of **negligible** magnitude during the non-migratory breeding bio-season, as it represents no discernible increase to baseline mortality levels due to a very small to small number of estimated collisions.

5.11.2.92 During the post-breeding migration bio-season, between approximately two to twenty kittiwakes may be subject to mortality, which would present an increase of 0.002-0.02% relative to the current baseline mortality rate at a regional level.

5.11.2.93 This level of potential impact is considered to be of **negligible** magnitude during the post-breeding migration bio-season, as it represents no discernible increase to baseline mortality levels due to a very small number of estimated collisions.

5.11.2.94 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of**

an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology) and is not considered further in this assessment.

Lesser black-backed gull

CRM prediction outputs and evaluation of the potential magnitude of impact

5.11.2.95 The monthly estimated mortality rates are presented in Table 5.31, which vary from a minimum of zero individuals in eight out of twelve months to a maximum of 0.477-0.704 individuals in June. The predicted level of mortality during any bio-season is well under one individual and in total the annual mortality rate for lesser black-backed gull is between 0.713 to 1.052 individuals, which is approximately a single individual. As a consequence, there is a **negligible** impact predicted as a consequence of collision risk from Hornsea Four for this species.

5.11.2.96 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology) and is not considered further in this assessment.

Herring gull

CRM prediction outputs and evaluation of the potential magnitude of impact

5.11.2.97 The monthly estimated mortality rates are presented in Table 5.31, which vary from a minimum of zero individuals six out of twelve months to a maximum of 0.162-0.199 individuals in December. The predicted level of mortality during any bio-season is well under one individual and in total the annual mortality rate for herring gull is between 1.110 to 1.355 individuals, which is marginally over a single individual. As a consequence, there is a **negligible** impact predicted as a consequence of collision risk from Hornsea Four for this species.

5.11.2.98 The magnitude of this impact is considered to be **negligible** at most. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology) and is not considered further in this assessment.

Great black-backed gull

CRM prediction outputs

5.11.2.99 The monthly estimated mortality rates are presented in Table 5.31, which vary from a minimum of zero individuals in four out of twelve months to a maximum of approximately two individuals in January. On an annual basis the estimated mortality rate for collision risk from Hornsea Four is of approximately eight individuals (Table 5.31), which is further broken down into relevant bio-seasons in Table 5.34. The magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the regional BDMPS populations and the overall

baseline mortality rates as described in Section 5.7.4, which are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015).

Table 5.34: Bio-season collision risk estimates for great black-backed gull for Hornsea Four.

	Seasonal sCRM totals		Regional baseline populations and baseline mortality rates (individuals per annum)		Increase in baseline mortality (%)	
Bio-season (months)	BO1	BO2	Population	Baseline mortality	BO1	BO2
Return Migration (Jan-Apr)	3.220	3.227	91,339	6,394	0.050	0.050
Migration-free Breeding (May-Jul)	0.764	0.769	52,829	3,698	0.021	0.021
Post-breeding migration (Aug-Nov)	1.859	1.854	91,339	6,394	0.029	0.029
Migration-free Winter (Dec)	1.864	1.868	91,339	6,394	0.029	0.029
Annual	**7.708**	**7.718**	**235,000**	**16,450**	**0.047**	**0.047**

Evaluation of the potential magnitude of impact

5.11.2.100 During the return migration bio-season approximately three great black-backed gulls may be subject to mortality, which would present an increase of 0.050% relative to the current baseline mortality rate at a regional level.

5.11.2.101 This level of potential impact is considered to be of **negligible** magnitude during the return migration bio-season, as it represents no discernible increase to baseline mortality levels due to a very small number of estimated collisions.

5.11.2.102 The predicted level of mortality during the non-migratory breeding bio-season is estimated to be between 0.764 to 0.769 individuals, which is under a single individual, which would present an increase of 0.021% relative to the current baseline mortality rate at a regional level. As a consequence, the resulting magnitude of impact is considered to represent no discernible increase to baseline mortality levels for this species.

5.11.2.103 During the post-breeding migration bio-season approximately two great black-backed gulls may be subject to mortality (estimated to be between 1.859 to 1.854 individuals), which would present an increase of 0.029% relative to the current baseline mortality rate at a regional level.

5.11.2.104 This level of potential impact is considered to be of **negligible** magnitude during the post-breeding migration bio-season, as it represents no discernible increase to baseline mortality levels due to a very small number of estimated collisions.

5.11.2.105 During the migration-free winter bio-season approximately two great black-backed gulls may be subject to mortality (estimated to be between 1.864 to 1.868 individuals),

which would present an increase of 0.029% relative to the current baseline mortality rate at a regional level.

5.11.2.106 This level of potential impact is considered to be of **negligible** magnitude during the migration-free winter bio-season, as it represents no discernible increase to baseline mortality levels due to a very small number of estimated collisions.

5.11.2.107 The magnitude of this impact is considered to be **negligible** at most. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Migrant non-seabirds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure. The result of such collisions may be fatal to the bird concerned (ORN-O-7).

5.11.2.108 This section considers and reviews the approach to potential collision risk presented by the OWFs Hornsea Project One, Hornsea Project Two, Hornsea Three and Norfolk Vanguard and from those assessments draws conclusions about the potential scope and scale of collision risk to migrant seabirds and non-seabirds (waterbirds) presented by Hornsea Four. The purpose of undertaking this review for Hornsea Four was to identify if there is the potential for a significant effect to occur and therefore if this should be screened in or screened out of the final EIA Report in keeping with the proportionate approach.

Hornsea Project One

5.11.2.109 The approach to assessing the potential scope and scale of collision risk to migrant seabirds and non-seabirds (waterbirds) taken by Hornsea Project One was to scope which species were most likely to be passing through the proposed wind farm, apply the model Migropath developed by APEM and the migratory routes described by Wright et al. (2012) to calculate the numbers of these species passing through the proposed wind farm and then apply the Band CRM migrant variant to those numbers to predict potential mortality (SMartWind, 2013). The migratory seabirds and waterbirds that were considered in the assessment and the conclusions drawn on potential impact for each species are presented in **Table 5.35**.

Hornsea Project Two

5.11.2.110 The approach to assessing the potential scope and scale of collision risk to migrant non-seabirds (waterbirds) taken by Hornsea Project Two was the same as that for Hornsea Project One with the application of the APEM Migropath model and Band CRM migrant variant (SMartWind, 2015). For migrant seabirds a broad migratory front approach was taken, considering the proportion of the population that might be expected to pass through the proposed wind farm, informed by the migratory routes described by Wright et al. (2012) and the population estimates of Furness (2015). The migratory seabirds and waterbirds that were considered in the assessment and the conclusions drawn on potential impact for each species are presented in **Table 5.35**.

Hornsea Three

5.11.2.111 The approach to assessing the potential scope and scale of collision risk to migrant seabirds was the same as that for Hornsea Project Two with a broad migratory front approach being taken, considering the proportion of the population that might be expected to pass through the proposed wind farm (Ørsted, 2018b). For migrant non-seabirds (waterbirds) the approach taken followed the BTO SOSS Migration Assessment Tool (MAT) model (Wright and Austin, 2012) that is similar to Migropath in that it considers migration routes for specific species that move from the UK coast to continental Europe and vice versa. The migratory seabirds and waterbirds that were considered in the assessment and the conclusions drawn on potential impact for each species are presented in **Table 5.35**.

5.11.2.112 The approach to assessing the potential scope and scale of collision risk to migrant seabirds was the same as that for Hornsea Project Two with a broad migratory front approach being taken, considering the proportion of the population that might be expected to pass through the proposed wind farm (Ørsted, 2018b). For migrant non-seabirds (waterbirds) the approach taken followed the BTO SOSS Migration Assessment Tool (MAT) model (Wright and Austin, 2012) that is similar to Migropath in that it considers migration routes for specific species that move from the UK coast to continental Europe and vice versa. The migratory seabirds and waterbirds that were considered in the assessment and the conclusions drawn on potential impact for each species are presented in **Table 5.35**.

5.11.2.113 The approach to assessing the potential scope and scale of collision risk to migrant seabirds was the same as that for Hornsea Project Two with a broad migratory front approach being taken, considering the proportion of the population that might be expected to pass through the proposed wind farm (Ørsted, 2018b). For migrant non-seabirds (waterbirds) the approach taken followed the BTO SOSS Migration Assessment Tool (MAT) model (Wright and Austin, 2012) that is similar to Migropath in that it considers migration routes for specific species that move from the UK coast to continental Europe and vice versa. The migratory seabirds and waterbirds that were considered in the assessment and the conclusions drawn on potential impact for each species are presented in **Table 5.35**.

Norfolk Vanguard

5.11.2.114 The approach to assessing the potential scope and scale of collision risk to migrant seabirds and non-seabirds (waterbirds) taken by Norfolk Vanguard was first to scope which species were most likely to be passing through the proposed wind farm (Norfolk Vanguard Ltd, 2018). For migrant seabirds the approach taken followed the migrant corridor, rather than broad front, approach of Wildfowl & Wetlands Trust (WWT) and MacArthur Green (2013) which placed the proposed wind farm beyond the corridor in which migration of the relevant seabird species took place. For migrant non-seabirds (waterbirds) the approach taken followed the BTO SOSS MAT model (Wright and Austin, 2012), an approach that was the same as Hornsea Three. The migratory seabirds and waterbirds that were considered in the assessment and the conclusions drawn on potential impact for each species are presented in **Table 5.35**.

Table 5.35: Summary of Collision Risk Assessment on Migrant Seabirds and Waterbirds from other North OWF EIA Reports.

Species	Hornsea Project One Collisions per annum	Hornsea Project Two Collisions per annum	Hornsea Three Collisions per annum	Norfolk Vanguard Collisions per annum	Impact magnitude*	Significance of effect
Arctic skua	0	10	0	0	No Change / Negligible	Negligible or Minor Adverse
Great skua	1	1	0	0	No Change / Negligible	Negligible or Minor Adverse
Little gull	10	1	1	0	No Change / Negligible	Negligible or Minor Adverse
Common tern	0	9	1	0	No Change / Negligible	Negligible or Minor adverse
Arctic tern	0	50	0	0	No Change / Negligible	Negligible or Minor adverse
Bewick's swan	0	0	4	0	Negligible	Negligible or Minor adverse
Taiga bean goose	0	0	0	n/a	Negligible	Negligible or Minor adverse
Dark-bellied brent goose	1	0	23	1	Negligible	Negligible or Minor adverse
Shelduck	4	0	2	n/a	Negligible	Negligible or Minor adverse
Wigeon	20	0	11	13	Negligible	Negligible or Minor adverse
Gadwall	n/a	n/a	n/a	1	Negligible	Negligible
Teal	n/a	n/a	n/a	6	Negligible	Negligible
Pintail	n/a	n/a	n/a	1	Negligible	Negligible
Shoveler	n/a	n/a	n/a	1	Negligible	Negligible
Pochard	n/a	n/a	n/a	2	Negligible	Negligible
Tufted duck	n/a	n/a	n/a	3	Negligible	Negligible
Common scoter	n/a	n/a	n/a	0	Negligible	Negligible
Goldeneye	n/a	n/a	n/a	1	Negligible	Negligible
Marsh harrier	n/a	n/a	n/a	0	Negligible	Negligible
Oystercatcher	n/a	n/a	n/a	15	Negligible	Negligible
Avocet	n/a	n/a	n/a	1	Negligible	Negligible
Ringed plover	n/a	n/a	n/a	1	Negligible	Negligible
Golden plover	16	0	23	21	Negligible	Negligible or Minor adverse
Grey plover	2	0	2	2	Negligible	Negligible or Minor adverse
Lapwing	48	0	25	22	Negligible	Negligible or Minor adverse

Species	Hornsea Project One Collisions per annum	Hornsea Project Two Collisions per annum	Hornsea Three Collisions per annum	Norfolk Vanguard Collisions per annum	Impact magnitude*	Significance of effect
Knot	12	0	1	12	Negligible	Negligible or Minor adverse
Sanderling	n/a	n/a	n/a	1	Negligible	Negligible
Dunlin	10	0	23	27	Negligible	Negligible or Minor adverse
Bar-tailed godwit	2	0	2	2	Negligible	Negligible or Minor adverse
Curlew	n/a	n/a	n/a	10	Negligible	Negligible
Redshank	n/a	n/a	n/a	22	Negligible	Negligible
Turnstone	n/a	n/a	n/a	2	Negligible	Negligible

Table Note: *The Planning Inspectorate NSIP website section on the documents submitted for the Hornsea Project Two DCO application does not include Appendix D of the Offshore Ornithology Technical Report that contains the CRM output figures for waterbirds.

Conclusion on potential magnitude of impact and significance of effect

5.11.2.115 The conclusions from Hornsea Project One, Hornsea Project Two, Hornsea Project Three and Norfolk Vanguard of negligible collision risks (no change to negligible magnitude) and no significant effects provide a reliable guide to the potential risks for Hornsea Four. It can be concluded, based on the evidence available, that Hornsea Four will have an impact of **negligible** magnitude on migrant seabirds and migrant non-seabirds (waterbirds) passing either north-south or east-west on their annual migrations.

5.11.2.116 The converse that Hornsea Four will generate significant collision risks whilst virtually none were predicted for other projects in similar parts of the North Sea would not be a conclusion that is in accordance with the evidence available.

5.11.2.117 The magnitude of this impact is considered to be **negligible** at most. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Indirect impacts within the array area during the operational phase through effects on habitats and prey species (ORN-O-8).

Potential magnitude of impact and significance of effect

5.11.2.118 During the operational phase of Hornsea Four there is the potential for indirect effects arising from the displacement of prey species due to increased noise and disturbance or to disturbance to habitats from increased suspended sediment and physical disturbance to the seabed.

5.11.2.119 However, as no significant impacts were identified to potential prey species (fish or benthic) or on the habitats that support them in the assessments on fish and benthic ecology (**Volume 2, Chapter 3: Fish and Shellfish Ecology** and **Volume 2, Chapter 2: Benthic and Intertidal Ecology**, respectively) then there is no potential for any indirect impacts of an adverse significance to occur on offshore and intertidal ornithology receptors.

The presence of WTGs could create a barrier to the migratory or regular foraging movements of seabirds. This may result in permanent changes in flying routes for birds concerned and an increase in energy demands associated with those movements may result in a lower rate of breeding success or survival chances for individuals affected (ORN-O-9).

5.11.2.120 In the operational phase of Hornsea Four the presence of WTGs could create a barrier to the movements of seabirds. This may result in permanent changes in flight routes for the birds concerned and an increase in energy demands associated with those

movements. This might result in a lower rate of breeding success or in reduced survival chances for the individuals affected.

5.11.2.121 Ecological theory suggests that birds, while they are breeding, will take the shortest (energetically most efficient) route to and from known areas that provide good foraging resources. For birds breeding at the FFC SPA those routes would, if the location of food resources is known, result in straight-out-and-back flights from the breeding cliffs to known foraging areas. For the Hornsea projects in general, and Hornsea Four specifically, to create a barrier to such flights then they/it would need to be sited across such flight lines and the bird species concerned would have to be known, or suspected, not to enter an operational wind farm (i.e. exhibit a high degree of avoidance). Given the location of the Hornsea projects it is flights in an almost due east-west alignment from the FFC SPA that would encounter the under-construction, consented or proposed Hornsea projects.

5.11.2.122 The assessment of Hornsea Four and the potential for its construction and operation to create a barrier to the movement of seabirds breeding at the FFC SPA can be informed by knowledge of the existing routes that seabirds take as they commute back and forth from their breeding sites to forage offshore. The initial basis for identifying seabird species for the purpose of assessing for the potential barrier effect identified that only fulmar, gannet and kittiwake may forage on a regular basis out to a distance as far as or further than the Hornsea Four array area. Of these species, fulmar is not sensitive to potential barrier effects as they are such wide ranging foragers (Thaxter *et al.*,2012). It might be considered that auks species (guillemot, razorbill and puffin) nesting at the FFC SPA may be susceptible to a barrier effect from Hornsea Four, but due to the distance to the Hornsea Four array area to the FFC SPA (65 km at its closest point) being greater than the known mean max foraging range for razorbill (48.5 km) and at the outer limits of the known mean max foraging range for guillemot (84.2 km) and puffin (105.4 km) (Thaxter *et al.*, 2012) the presence of WTGs would not be the cause of a barrier effect on a regular basis, as very few auks forage in the waters to the east of the Hornsea Four array area. Therefore, due to the distance of the Hornsea Four array area from the FFC SPA there would be no barrier effect on auk species and so they are screened out of further assessment.

5.11.2.123 Knowledge of the routes that seabirds take from the FFC SPA has been gained through a programme of tracking studies that have been undertaken at the FFC SPA, co-ordinated and delivered by the RSPB and funded by organisations including the DECC and Ørsted. Those studies have examined the foraging flights made by gannet and kittiwake.

5.11.2.124 The known flight lines from tracking studies are examined for gannet and kittiwake below and a qualitative evaluation made of the likelihood that Hornsea Four would create a significant barrier to known movements.

Gannet

Potential magnitude of impact

5.11.2.125 Gannets from the FFC SPA were tracked in the breeding seasons of 2010 - 2012 and the results reported in Langston *et al.* (2013). Of the outputs from the tracking analysis presented, it is considered that the 'trip end point' provides the most applicable parameter for a potential barrier assessment (Figure 4 from Langston *et al.,* 2013).

5.11.2.126 This data set indicates that there are trip end points in the area of under-construction, consented or proposed Hornsea projects within the former Hornsea Zone creating the potential for a barrier effect. Gannets are known to avoid entering operational wind farms (e.g. Krijgsveld et al., 2011; APEM, 2014) further indicating the potential for a barrier effect. The alignment of gannet foraging trips east-west in the direction of the Hornsea Four array area and the alignment of Hornsea Four in relation to the other under-construction, consented or proposed Hornsea projects indicates that Hornsea Four would be creating a potential barrier to access those areas that will be/are occupied by under-construction, consented or proposed Hornsea projects.

5.11.2.127 Given the avoidance of operational wind farms this leads to the conclusion that a barrier effect would not be relevant in the period post-construction of Hornsea Projects One to Three as gannets would not be seeking to forage in the area they occupy to any significant extent. Rather it is the assessment of the potential in-combination displacement effect of the four Hornsea projects from west to east that should be undertaken. This data set indicates that there are very few commuting flights from gannets from the FFC SPA to beyond the eastern extent of the four Hornsea projects. Therefore, the potential for a barrier effect on gannet in the breeding season is limited at most and would not lead to an impact of more than negligible magnitude.

5.11.2.128 The magnitude of this impact is considered to be negligible. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

Kittiwake

Potential magnitude of impact

5.11.2.129 Kittiwakes from the FFC SPA were tracked in the breeding season of 2017 and the results reported in Wischnewski *et al.*, (2018). The analyses presented in this report did not include 'trip end point' but for the purposes of the assessment of the potential for barrier effect the identification of 'commuting' trips based on flight behaviour (low tortuosity and high speed) provides an equal alternative (Figure 10b from Wischnewski *et al.,* 2018).

5.11.2.130 This data set indicates that there are very few commuting flights across the Hornsea Four array area (and similarly few across the under-construction, consented or proposed Hornsea projects within the former Hornsea Zone). Kittiwakes are known to enter, rather than avoid, operational wind farms (e.g. Krijgsveld *et al.*, 2011; Walls *et al.*, 2013) further indicating the absence of a potential barrier effect created by Hornsea Four (or the under-construction, consented or proposed Hornsea projects). The alignment of kittiwake foraging trips from Wischnewski *et al.*, (2018) is predominantly north-east and south-east, avoiding Hornsea Four. This indicates that Hornsea Four would not create a potential barrier to kittiwake movement in the breeding season. Similarly, there would not be a potential in-combination barrier effect of the four Hornsea projects given the known commuting routes and the lack of avoidance behaviour.

5.11.2.131 Therefore, the potential for a barrier effect on kittiwake in the breeding season is limited at most and would not lead to an impact of more than **negligible** magnitude.

5.11.2.132 The magnitude of this impact is considered to be **negligible**. Irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Figure 5.3: Deriving the Level of Significance of an Impact; Volume 1, Chapter 5: Environmental Impact Assessment Methodology**) and is not considered further in this assessment.

The impact of attraction to lit structures by migrating birds in particular may cause disorientation, reduction in fitness and possible mortality (ORN-O-14).

Magnitude of impact

5.11.2.133 There is the potential for some species of birds to be attracted to artificially illuminated structures in the offshore environment, 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 WTGs, rotating blades. WTGs 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.

5.11.2.134 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).

5.11.2.135 Migrating birds are potentially susceptible to any adverse effects of lighting, as approximately two thirds of all bird species migrate during darkness, when collision risk is expected to be higher than during daylight (Hüppop *et al.*, 2006). However, the

evidence for this potential impact on migratory birds is mixed, with the ICES (2011) stating that birds are somewhat less inclined to avoid WTGs 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.

5.11.2.136 In terms of attraction to artificial illuminated structures, the MDS for Hornsea Four would involve 180 WTGs and up to 10 other offshore ancillary structures within the array area. For maximum visibility, each structure would be fitted with lighting requirements for aviation and shipping.

5.11.2.137 There is no evidence from any existing UK offshore wind farms to suggest mass collision events as a result of aviation lighting that is typical for UK 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. Therefore, it is likely that bird species in the marine environment would exhibit no more than a **low** sensitivity to lighting and any such potential magnitude of impacts would be no greater than **negligible** also, which would lead to a **not significant** effect.

5.11.3 Decommissioning

5.11.3.1 The impacts of the offshore decommissioning of Hornsea Four have been assessed for offshore and intertidal ornithology receptors. The environmental impacts arising from the decommissioning of Hornsea Four are listed in bullets below along with the MDS against which each decommissioning phase impact has been assessed.

5.11.3.2 The impacts of the offshore decommissioning of Hornsea Four may comprise:

- direct effects - bird disturbance and displacement from increased vessel activity and underwater noise may result in direct disturbance or displacement from important foraging and habitat areas of birds;
- direct effects - bird physical damage, disturbance and displacement from contact with/impacts of pollution during the decommissioning activities; and
- indirect effects - bird feeding disturbance due to fish being affected by decommissioning activities.

5.11.3.3 Demolition activities associated with foundations and WTGs may lead to disturbance and displacement of species within the array area and different degrees of buffers surrounding it. Impacts are assumed to be as described in the MDS (Table 5.17).

5.11.3.4 Indirect impacts during the decommissioning phase may arise within the offshore ECC and cable landfall through effects on habitats and prey species. However, these have been 'scoped out' of the impact assessment (Table 5.17).

Magnitude of impact - direct disturbance or displacement during decommissioning activities

5.11.3.5 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 scale to those presented for the construction phase above (Section 5.11.1). The magnitude and significance for each relevant receptor is presented in Table 5.36 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 **not significant** over the long term.

Table 5.36: Summary of the impact of decommissioning activities that may result in direct disturbance or displacement from accessing important foraging and habitat areas (highest magnitude shown).

Species	Sensitivity	Magnitude	Significance
Red-throated diver	High	Negligible	Not Significant
Gannet	Medium	Negligible	Not Significant
Guillemot	High	Negligible	Not Significant
Razorbill	High	Negligible	Not Significant
Puffin	Medium	Negligible	Not Significant

Potential magnitude of impact and significance of effect

5.11.3.6 During the decommissioning phase of Hornsea Four there is the potential for indirect effects arising from the displacement of prey species due to increased noise and disturbance or to disturbance to habitats from increased suspended sediment and physical disturbance to the seabed.

5.11.3.7 However, any such potential effects are to a lesser extent to that predicted for the construction phase. As no significant impacts were identified to potential prey species (fish or benthic) or on the habitats that support them in the assessments on fish and benthic ecology (**Volume 2, Chapter 3: Fish and Shellfish Ecology** and **Volume 2, Chapter 2: Benthic and Intertidal Ecology**, respectively) and no significant indirect effects were predicted during the construction phase then there is no potential for any indirect impacts of an adverse significance to occur on offshore and intertidal ornithology receptors.

Further mitigation

5.11.3.8 No further mitigation would be required given the minor adverse effects (at worst) predicted.

Future monitoring

5.11.3.9 No offshore ornithology monitoring to test the predictions made within the impact assessment for the decommissioning phase is considered necessary at this stage.

5.12 Cumulative effect assessment (CEA)

5.12.1 Cumulative Effect Introduction and Assessment Methodology

5.12.1.1 Cumulative effects can be defined as effects upon a single receptor from Hornsea Four when considered alongside other proposed and reasonably foreseeable projects and developments. This includes all projects that result in a comparative effect that is not intrinsically considered as part of the existing environment and is not limited to offshore wind projects.

5.12.1.2 A screening process has identified a number of reasonably foreseeable projects and developments which may act cumulatively with Hornsea Four. The full list of such projects that have been identified in relation to the offshore environment are set out in **Volume 4, Annex 5.3: Offshore Cumulative Effects** and are presented in a series of maps in **Volume 4, Annex 5.4: Location of Offshore Cumulative Schemes**.

5.12.1.3 In assessing the potential cumulative impacts for Hornsea Four, it is important to bear in mind that some projects, predominantly those 'proposed' or identified in development plans, may not actually be taken forward, or fully built out as described within their MDS. There is therefore a need to build in some consideration of certainty (or uncertainty) with respect to the potential impacts which might arise from such proposals. For example, those projects under construction are likely to contribute to cumulative impacts (providing effect or spatial pathways exist), whereas those proposals not yet approved are less likely to contribute to such an impact, as some may not achieve approval or may not ultimately be built due to other factors.

5.12.1.4 With this in mind, all projects and plans considered alongside Hornsea Four have been allocated into 'tiers' and 'sub-tiers' reflecting their current stage within the planning and development process. This allows the cumulative impact assessment to present several future development scenarios, each with a differing potential for being ultimately built out. This approach also allows appropriate weight to be given to each scenario (tier) when considering the potential cumulative impact. The proposed tier structure is intended to ensure that there is a clear understanding of the level of confidence in the cumulative assessments provided in the Hornsea Four PEIR. An explanation of each tier is included in **Table 5.37**.

Table 5.37: Description of tiers of other developments considered for CEA (adapted from PINS Advice Note 17).

Tier	Sub-Tier	Description of stage of development of project
Tier 1	Tier 1a	Project under operation
	Tier 1b	Project under construction
	Tier 1c	Permitted applications, whether under the Planning Act 2008 or other regimes, but not yet implemented
	Tier 1d	Submitted applications, whether under the Planning Act 2008 or other regimes, but not yet determined
Tier 2	N/A	Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has been submitted
Tier 3	Tier 3a	Projects on the Planning Inspectorate's Programme of Projects where a Scoping Report has not been submitted
	Tier 3b	Identified in the relevant Development Plan (and emerging Development Plans with appropriate weight being given as they move closer to adoption) recognising that much information on any relevant proposals will be limited
	Tier 3c	Identified in other plans and programmes (as appropriate) which set the framework for future development consents/approvals, where such development is reasonably likely to come forward

5.12.1.5 The plans and projects selected as relevant to the CEA of impacts to offshore and intertidal ornithology are based on an initial screening exercise undertaken on a long list (see **Volume 4, Annex 5.3: Offshore Cumulative Effects** and **Volume 4, Annex 5.4: Location of Offshore Cumulative Schemes**). A consideration of effect-receptor pathways, data confidence and temporal and spatial scales has been given to select projects for a topic-specific short-list. For the majority of potential effects for offshore and intertidal ornithology, planned projects were screened into the assessment based on there being a potential impact-receptor pathway from a project (during construction, operation and maintenance, and decommissioning) not considered part of the existing baseline environment. This included, where data is available, those potential effects identified during the breeding and non-breeding season from projects within the North Sea and English Channel.

5.12.1.6 Planned and operational projects were screened out of further consideration for potential cumulative effects on offshore and intertidal ornithology based on there not being a potential impact-receptor-pathway (during construction, operation and maintenance, and decommissioning) for the following reasons;

- There is no potential impact-receptor-pathway due to the project being outside of the North Sea (and English Channel);
- There is no temporal overlap between projects / activities;
- The project / activity is ongoing and is part of the current baseline;
- There is no data available or there is low confidence in the data.

5.12.1.7 The projects screened out included UK offshore wind farms evaluated as having low data confidence on the basis that no construction or operational period is known or are outside of the North Sea and English Channel. Other projects from non-offshore energy projects screened out included commercial fisheries as well as shipping and navigations, which due to already being present were evaluated as being part of the offshore and intertidal baseline.

5.12.1.8 The specific projects screened into the CEA for offshore and intertidal ornithology, which includes only offshore wind farm projects, as well as the tiers (and sub-tiers) into which they have been allocated are presented in **Table 5.38** below. The operational projects included within the table are included due to their completion/ commissioning subsequent to the data collection process for Hornsea Four and as such not included within the baseline characterisation. Note that this table only includes the projects screened into the assessment for offshore and intertidal ornithology based on the criteria outlined above. For the full list of projects considered, including those screened out, please see **Volume 4, Annex 5.3: Offshore Cumulative Effects** and **Volume 4, Annex 5.4: Location of Offshore Cumulative Schemes**.

Table 5.38 - Projects screened into the offshore and intertidal ornithology cumulative assessment (from Volume 4, Annex 5.3: Offshore Cumulative Effects).

Tier	Long List Project Name	Project Details/ Relevant dates (cf Hornsea Four Construction Period Of 2026-28)	Distance to Hornsea Four Array	Distance to Hornsea Four ECC	Distance to Hornsea Four HVAC Booster Area	Reason for Project Inclusion in Hornsea Four CEA
1a	Beatrice Demonstrator	Operational	497.86	484.58	493.60	Limited potential temporal overlap of operation with Hornsea Four as decommissioning planned for 2024-27, before Hornsea Four construction phase scheduled to be completed.
1a	Blyth Demonstration Site	Operational	174.71	139.88	155.81	Potential temporal overlap of operation with Hornsea Four
1a	Dudgeon	Operational	70.83	72.72	101.65	Potential temporal overlap of operation with Hornsea Four
1a	EOWDC	Operational	379.67	369.14	376.52	Potential temporal overlap of operation with Hornsea Four
1a	Galloper	Operational	219.97	223.34	251.02	Potential temporal overlap of operation with Hornsea Four
1a	Greater Gabbard	Operational	221.71	224.96	251.61	Potential temporal overlap of operation with Hornsea Four
1a	Humber Gateway	Operational	66.37	40.96	42.02	Potential temporal overlap of operation with Hornsea Four
1a	Lincs, Lynn & Inner Dowsing	Operational	96.62	83.65	89.25	Potential temporal overlap of operation with Hornsea Four
1a	Kentish Flats I	Operational	276.33	277.51	290.21	Potential temporal overlap of operation with Hornsea Four
1a	Kentish Flats II	Operational	277.24	278.22	290.25	Potential temporal overlap of operation with Hornsea Four

Tier	Long List Project Name	Project Details/ Relevant dates (cf Hornsea Four Construction Period Of 2026-28)	Distance to Hornsea Four Array	Distance to Hornsea Four ECC	Distance to Hornsea Four HVAC Booster Area	Reason for Project Inclusion in Hornsea Four CEA
1a	London Array	Operational	249.99	252.41	270.96	Potential temporal overlap of operation with Hornsea Four
1a	Race Bank	Operational	78.83	72.40	82.66	Potential temporal overlap of operation with Hornsea Four
1a	Rampion	Operational	378.30	368.41	374.28	Potential temporal overlap of operation with Hornsea Four
1a	Sheringham Shoal	Operational	89.51	88.65	106.44	Potential temporal overlap of operation with Hornsea Four
1a	Teesside	Operational	136.72	86.37	108.47	Potential temporal overlap of operation with Hornsea Four
1a	Thanet	Operational	277.04	279.59	298.70	Potential temporal overlap of operation with Hornsea Four
1a	Westermost Rough	Operational	62.75	21.63	25.40	Potential temporal overlap of operation with Hornsea Four
1b	Beatrice	Under Construction	>500.00	489.40	497.77	Potential temporal overlap of construction with Hornsea Four
1b	East Anglia One	Under Construction	194.09	198.56	236.63	Potential temporal overlap of construction with Hornsea Four
1b	Hornsea Project One	Under Construction	5.08	21.32	82.50	Potential temporal overlap of construction with Hornsea Four
1b	Hornsea Project Two	Under Construction	0.00	5.84	66.43	Potential temporal overlap of operation with Hornsea Four
1c	Dogger Bank Creyke Beck A	Consented– construction expected 2021-2024	65.86	83.65	107.52	Potential temporal overlap of operation with Hornsea Four

Tier	Long List Project Name	Project Details/ Relevant dates (cf Hornsea Four Construction Period Of 2026-28)	Distance to Hornsea Four Array	Distance to Hornsea Four ECC	Distance to Hornsea Four HVAC Booster Area	Reason for Project Inclusion in Hornsea Four CEA
1c	Dogger Bank Creyke Beck B	Consented– construction expected 2021-2024	76.14	94.18	111.26	Potential temporal overlap of operation with Hornsea Four
1c	Dogger Bank Teesside A	Consented - construction expected 2023-2026	120.86	135.62	170.16	Potential temporal overlap of construction with Hornsea Four
1c	East Anglia Three	Consented - construction expected 2020-2023	157.84	164.73	211.81	Potential temporal overlap of operation with Hornsea Four
1c	Hywind 2 Demonstration	Consented	381.06	379.01	383.20	Potential temporal overlap of operation with Hornsea Four
1c	Inch Cape	Consented	311.89	291.43	303.06	Potential temporal overlap of operation with Hornsea Four
1c	Moray East	Consented	494.29	484.40	491.93	Potential temporal overlap of operation with Hornsea Four
1c	Moray West	Consented	490.62	478.40	486.94	Potential temporal overlap of operation with Hornsea Four
1c	Neart na Gaoithe	Consented	296.16	271.32	284.45	Potential temporal overlap of operation with Hornsea Four
1c	Seagreen Alpha	Consented	312.11	295.09	304.91	Potential temporal overlap of operation with Hornsea Four
1c	Seagreen Bravo	Consented	312.11	295.09	304.91	Potential temporal overlap of operation with Hornsea Four
1c	Sofia	Consented - construction expected 2023-2026	97.75	113.14	143.26	Potential temporal overlap of construction with Hornsea Four
1c	Triton Knoll	Consented– construction expected 2019-2022	56.99	49.70	60.93	Potential temporal overlap of operation with Hornsea Four

Tier	Long List Project Name	Project Details/ Relevant dates (cf Hornsea Four Construction Period Of 2026-28)	Distance to Hornsea Four Array	Distance to Hornsea Four ECC	Distance to Hornsea Four HVAC Booster Area	Reason for Project Inclusion in Hornsea Four CEA
1d	Hornsea Three	In planning – construction expected 2024-2030	36.34	55.47	116.10	Potential temporal overlap of construction with Hornsea Four
1d	Norfolk Boreas	In planning construction expected 2023-2025	123.34	133.68	187.40	Potential temporal overlap of construction with Hornsea Four
1d	Norfolk Vanguard	In planning construction expected 2024-2028	123.39	130.86	175.94	Potential temporal overlap of construction with Hornsea Four
1d	Thanet Extension	In planning	275.87	278.37	279.02	Potential temporal overlap of construction with Hornsea Four
2	East Anglia One North	Pre-planning Application construction expected 2025-2028	178.58	182.88	219.69	Potential temporal overlap of construction with Hornsea Four
2	East Anglia Two	Pre-planning Application construction expected 2026-2029	187.28	191.13	224.09	Potential temporal overlap of construction with Hornsea Four

5.12.1.9 Certain impacts assessed for the project alone are not considered in the cumulative assessment due to:

- The highly localised nature of the impacts (i.e. they occur entirely within the Hornsea Four boundary only);
- Management measures in place for Hornsea Four will also be in place on other projects reducing their risk of occurring; and/or
- Where the potential significance of the impact from Hornsea Four alone has been assessed as negligible and considered not to contribute in any meaningful way to an existing potential cumulative impact.

5.12.1.10 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 effects are possible, the magnitude of these impacts is not considered to be significant at a population level for any offshore or intertidal ornithology receptor and is therefore not considered further within the CEA. The impacts excluded from the CEA for the above reasons are:

- Cable landfall construction impacts on intertidal ornithology due to no plans or projects being identified that may have a source-impact-pathway that coincide spatially or temporally with Hornsea Four;
- Export cable laying (construction) impacts on offshore ornithology receptors within or in close proximity to the ECC due to no plans or projects being identified that may have a source-impact-pathway that coincide spatially or temporally with Hornsea Four;
- Displacement of seabirds during the construction phase of Hornsea Four due to the potential impacts and effects predicted for Hornsea Four being negligible at most, spatially restricted and temporary for all species assessed;
- Indirect impacts during any phase of Hornsea Four, as they will be spatially limited and all were predicted as negligible at most at a project level;
- Displacement of gannet during the operational and maintenance phase of Hornsea Four due to the potential impacts and effects predicted for Hornsea Four being negligible at most for this species;
- Collision risk to herring gull and lesser black-backed gull due to the potential impacts and effects predicted for Hornsea Four being negligible at most for these two species assessed;
- Collision risk to migrant seabirds and non-seabirds due to the potential impacts and effects predicted for Hornsea Four being negligible at most for all species assessed;
- Barrier effect on seabirds due to the potential impacts and effects predicted for Hornsea Four being negligible at most for all species assessed; and
- All impacts during the decommissioning phase, as potential impacts during this phase were all predicted to be negligible and there is no data or low confidence in data in relation to other plans and projects with respect to this potential source of impact.

5.12.1.11 Therefore, the impacts that are considered in the CEA are as follows:

- Displacement of auk species (guillemot, razorbill and puffin) during the operational and maintenance phase of Hornsea Four in consideration with other planned, in-construction and operational offshore wind farms within the UK North Sea and English Channel (where appropriate); and
- Collision risk to gannet, kittiwake and great black-backed gull during the operational and maintenance phase of Hornsea Four in consideration with other planned, in-construction and operational offshore wind farms within the UK North Sea and English Channel (where appropriate).

5.12.1.12 The cumulative MDS described in **Table 5.39** have been selected as those having the potential to result in the greatest cumulative effect on an identified receptor group. The cumulative impacts presented and assessed in this section have been selected from the details provided in the project description for Hornsea Four (summarised for offshore and intertidal ornithology in the MDS (**Table 5.17**), as well as the information available on other projects and plans in order to inform a cumulative 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 compared to that assessed here, be taken forward in the final design scheme.

Table 5.39: Cumulative MDS for Offshore and Intertidal Ornithology.

Project Phase	Potential Impact	Maximum Design Scenario	Justification
Operation	Cumulative effect of displacement on auk species (guillemot, razorbill and puffin)	Maximum design scenario for Hornsea Four plus the cumulative full development of the following projects within the UK North Sea and English Channel (where appropriate): **Tier 1:** - Operational offshore wind farms in the North Sea and English Channel (where applicable); - Offshore wind farms under construction in the North Sea and English Channel (where applicable); - Permitted offshore wind farm projects not yet implemented; and - Offshore wind farm projects with submitted applications not yet determined. **Tier 2:** - Two Tier 2 projects identified, with quantitative data available from PEIRs on developer's website (not yet available via PINS). **Tier 3:** - No Tier 3 projects identified, as quantitative data not available on displacement of seabirds at this stage.	Maximum potential for interactive effects from maintenance activities associated with and the operational effects of the offshore wind farm(s) considered within the UK North Sea and English Channel (where appropriate) . This region was chosen as seabirds associated with Hornsea Four are expected to come from or move to other areas within this region, that are also subject to interaction with other projects within this region.
Operation	Cumulative effect of collision risk on seabirds (gannet, kittiwake and great black-backed gull)	Maximum design scenario for Hornsea Four plus the cumulative full development of the following projects within the UK North Sea and English Channel (where appropriate): **Tier 1:** - Operational offshore wind farms in the North Sea and English Channel (where applicable); - Offshore wind farms under construction in the North Sea and English Channel (where applicable); - Permitted offshore wind farm projects not yet implemented; and - Offshore wind farm projects with submitted applications not yet determined. **Tier 2:** - Two Tier 2 projects identified, with quantitative data available from PEIRs on developer's website (not yet available via PINS). **Tier 3:** - No Tier 3 projects identified, as quantitative data not available on displacement of seabirds at this stage.	Maximum potential for interactive effects from maintenance activities associated with and the operational effects of the offshore wind farm(s) considered within the UK North Sea and English Channel (where appropriate) . This region was chosen as seabirds associated with Hornsea Four are expected to come from or move to other areas within this region, that are also subject to interaction with other projects within this region.

5.12.2 Cumulative Effect Assessment

5.12.2.1 A description of the significance of cumulative effects upon offshore and intertidal ornithology arising from each identified impact is given below. The cumulative effects assessment has been based on information available in Environmental Statements and it is noted that the project parameters quoted within Environmental Statements are often refined during the determination period and in the post-consent phase. Where formal project refinements have been applied for and granted for any offshore wind farms the outcomes of their revised assessments were incorporated wherever possible. The assessment presented here is therefore considered to be conservative, with the level of impacts expected to be reduced compared to those presented here.

Operational Phase CEA – Potential impact from cumulative displacement

5.12.2.2 There is potential for cumulative displacement as a result of operational and maintenance activities associated with Hornsea Four and other projects (**Table 5.38**). The only projects identified for this CEA are those defined as being within Tier 1 (sub-tiers 1a to 1d) and Tier 2, as described in **Table 5.39**.

5.12.2.3 The presence of WTGs has the potential to directly disturb and displace seabirds that would normally reside within and around the area of sea where OWFs are located. This in effect represents indirect habitat loss, which would potentially reduce the area available to those seabirds to forage, loaf and / or moult that currently occur within and around OWFs and may be susceptible to displacement from such developments. Displacement may contribute to individual birds experiencing fitness consequences, which at an extreme level could lead to the mortality of individuals. Cumulative displacement therefore has the potential to lead to effects on a wider scale, which in this case is defined as the wider non-breeding BDMPS populations of auks species (adults and immature) within the UK North Sea and English Channel from Furness (2015).

5.12.2.4 Seabird species vary in their response to the presence of operational infrastructure associated with OWFs, such as WTGs and shipping activity related to maintenance activities. Garthe and Hüppop (2004) developed a scoring system for such disturbance factors, whilst Furness and Wade (2012) developed a similar system with disturbance ratings to define the sensitivity of seabirds to disturbance and displacement, both of which were considered and applied in **Section 5.11.2** and presented in **Table 5.27**.

5.12.2.5 Following the screening process an assessment of cumulative displacement was been carried out for three seabird species of interest identified as potentially at risk and of interest for this CEA. The three species are guillemot, razorbill and puffin. Gannet was not progressed beyond the assessment of Hornsea Four alone, as it was predicted to be subject to an effect of negligible significance only.

Guillemot

5.12.2.6 As determined in Section 5.11.2 guillemots show a medium level of sensitivity to maintenance activities from ship and helicopter traffic as well as to operational WTGs (Garthe and Hüppop, 2004; Furness and Wade, 2012; Langston, 2010; and Bradbury et al, 2014). However, a number of detailed studies (including Krijgsveld et al., 2011, Walls et al., 2013 and Royal HaskoningDHV, 2013) monitoring the post-construction effects of OWFs on guillemots suggest that the range of displacement may be between approximately 30-80% within OWF arrays, whilst lower rates of approximately 30% may be apparent out to a maximum of 1-2 km.

5.12.2.7 However, as it is difficult to split the data collated between the array area and 2 km buffer, for the majority of the other projects within this CEA a more standard approach has been taken for estimating displacement. Accounting for this difficulty in separating data from array areas and the 2 km buffers surrounding them (described in **Section 5.11.2.6**) for other projects considered in this CEA a precautionary displacement rate of 50% has been applied across both the array areas and 2 km buffer for all projects.

5.12.2.8 Due to limitations in the data for other offshore wind farm projects, seasonal population estimates have been collated for two separate bio-seasons covering the entire annual cycle, one for breeding and one for non-breeding. For some projects data are also not available for their array area plus 2 km buffer, so in these instances these data have been scaled up or down based on data from the project area alone. The subsequent bio-season and annual abundance estimates for guillemot associated with each of the projects identified in **Table 5.38** are presented in **Table 5.40**.

Table 5.40: Cumulative bio-season and total abundance estimates for guillemot from all Tier 1 & 2 projects' array areas and 2 km buffers and with / without Hornsea Four.

Project	Breeding	Non-breeding
Blyth Demonstration Site	1,220	1,321
Dudgeon	334	542
EOWDC	547	225
Galloper	305	593
Greater Gabbard	345	548
Humber Gateway	99	138
Lincs, Lynn & Inner Dowsing	582	814
London Array	192	377
Race Bank	361	708
Sheringham Shoal	390	715
Teesside	267	901
Thanet	18	124
Westermost Rough	347	486
Beatrice	13,610	2,755
East Anglia One	274	640

Project	Breeding	Non-breeding
Hornsea Project One	13,374	17,772
Hornsea Project Two	2,126	1,847
Dogger Bank Creyke Beck A	5,407	6,142
Dogger Bank Creyke Beck B	9,479	10,621
Dogger Bank Teesside A	3,283	2,268
East Anglia Three	1,744	2,859
Hywind 2 Demonstration	249	2,136
Inch Cape	4,371	3,177
Moray East	9,820	547
Moray West	24,426	38,174
Neart na Gaoithe	1,755	3,761
Seagreen Alpha	13,606	4,688
Seagreen Bravo	11,118	4,112
Sofia	5,211	3,701
Triton Knoll	425	746
Hornsea Three	4,183	1,847
Norfolk Boreas	7,767	13,777
Norfolk Vanguard	4,320	4,776
Thanet Extension	49	837
Seasonal Total (Excl. Hornsea Four	**141,604**	**134,675**
Annual Total (Excl. Hornsea Four)		**276,279**
Hornsea Four	**9,804**	**58,920**
Seasonal Totals (Incl. Hornsea Four)	**151,408**	**193,595**
Annual (Hornsea Four)		**68,724**
Annual Total (Incl Hornsea Four)		**345,003**

Evaluation of the potential magnitude of impact

5.12.2.9 The magnitude of impact is estimated by calculating the increase in baseline mortality within the UK North Sea and English Channel non-breeding BDMPS population, which is 1,617,306 individuals (adults and immatures). The overall BDMPS baseline mortality rates (14%) are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015), as described in **Section 5.6.1**, which provides an annual baseline mortality rate of 226,423 individuals.

5.12.2.10 When applying a precautionary 50% displacement rate to the data from both array areas and a 2 km buffer from all projects within this cumulative assessment, for guillemot a maximum of 75,704 individuals may be displaced during the breeding bio-season and 96,798 individuals during the non-breeding bio-season (**Table 5.40**). Should a 1% mortality rate be applied to these two cumulative bio-season totals then 757 and 968 individuals may be lost to the wider UK North Sea and English Channel non-breeding BDMPS population.

5.12.2.11 Therefore, if an estimated annual total of 1,725 guillemots were to be lost from the population, this would represent an increase of 0.76% relative to the current baseline mortality rate of the UK North Sea and English Channel non-breeding BDMPS.

5.12.2.12 This level of potential impact is considered to be of **minor** magnitude on an annual cumulative basis, as it represents under a 1% increase to the baseline mortality conditions of the UK North Sea and English Channel non-breeding BDMPS.

Sensitivity of the receptor

5.12.2.13 As the birds within the UK North Sea and English Channel non-breeding BDMPS are likely to be from multiple different designated sites (including UK SPAs), this species is afforded a conservation value level of high to reflect that. With respect to vulnerability to displacement it is considered to be medium (**Table 5.25**). Whilst it may be of medium vulnerability it is of high conservation value leading to a sensitivity of receptor of **high** value.

Significance of the effect

5.12.2.14 The magnitude of cumulative disturbance from operational offshore wind farms within the UK North Sea and English Channel are defined as being a minor adverse impact on an annual basis and the sensitivity of the species considered to be high. Therefore, the potential effect from cumulative displacement to guillemot from Hornsea Four and all other UK offshore wind farms in the North Sea may be of **minor** adverse significance in total per annum, which is not significant in EIA terms.

Razorbill

5.12.2.15 As determined in **Section 5.11.2** razorbills show a medium level of sensitivity to maintenance activities from ship and helicopter traffic as well as to operational WTGs (Garthe and Hüppop, 2004; Furness and Wade, 2012; Langston, 2010; and Bradbury et al, 2014). However, a number of detailed studies (including Krijgsveld et al., 2011, Walls et al., 2013 and Royal HaskoningDHV, 2013) monitoring the post-construction effects of OWFs on razorbills suggest that the range of displacement may be between approximately 30-95% within OWF arrays, whilst lower rates of approximately 25% may be apparent out to a maximum of 1-2 km.

5.12.2.16 However, as it is difficult to split the data between the array area and 2 km buffer for the majority of the other projects within this CEA, a more standard approach has been taken for estimating displacement. Accounting for this difficulty in separating data from array areas and the 2 km buffers surrounding them (described in **Section 5.11.2.6**), for other projects considered in this CEA a precautionary displacement rate of 50% has been applied across both the array areas and 2 km buffer for all projects.

5.12.2.17 For other projects the data on seasonal population estimates have been collated where available. For some projects data is not available for their array area plus 2 km buffer,

so in these instances the data has been scaled up or down based on data from the project area alone. The subsequent bio-season and annual abundance estimates for razorbill associated with each of the projects identified in Table 5.38 are presented in Table 5.41.

Table 5.41: Cumulative bio-season and total abundance estimates for razorbill from all Tier 1 & 2 projects' array areas and 2 km buffers and with / without Hornsea Four.

Project	Return Migration (Dec-Mar)	Migration-free Breeding (Apr-Aug)	Post-breeding migration (Sep-Nov)	Migration-free Winter
Blyth Demonstration Site	91	121	91	61
Dudgeon	346	256	346	745
EOWDC	26	161	64	7
Galloper	394	44	43	105
Greater Gabbard	84	0.0	0.0	387
Humber Gateway	20	27	20	13
Lincs, Lynn & Inner Dowsing	34	45	34	22
London Array	20	14	20	14
Race Bank	42	28	42	28
Sheringham Shoal	30	106	1343	211
Teesside	20	16	61	2
Thanet	21	3	0	14
Westermost Rough	91	91	121	152
Beatrice	833	873	833	555
East Anglia One	336	16	26	155
Hornsea Project One	1803	1109	4812	1518
Hornsea Project Two	1668	2511	4221	720
Dogger Bank Creyke Beck A	4149	1250	1576	1728
Dogger Bank Creyke Beck B	5119	1538	2097	2143
Dogger Bank Teesside A	1919	834.	310	959
East Anglia Three	1524	1807	1122	1499
Hywind 2 Demonstration	n/a	30	719	10
Inch Cape	n/a	1436	2870	651
Moray East	168	2523	1103	30
Moray West	3585	2808	3544	184
Neart na Gaoithe	n/a	331	5492	508
Seagreen Alpha	n/a	5876.0	n/a	1003.0
Seagreen Bravo	n/a	3698.0	n/a	1272.0
Sofia	2953	1153	592	1426
Triton Knoll	117	40	254	855
Hornsea Three	1236	630	2020	3694
Norfolk Boreas	345	630	263	1065
Norfolk Vanguard	924	879	866	627
Thanet Extension	50	0	0	34

Project	Return Migration (Dec-Mar)	Migration-free Breeding (Apr-Aug)	Post-breeding migration (Sep-Nov)	Migration-free Winter
Seasonal Total (Excl. Hornsea Four	**27,948**	**30,884**	**34,905**	**22,397**
Annual Total (Excl. Hornsea Four)				**116,134**
Hornsea Four	**1029**	**508**	**5,428**	**606**
Seasonal Totals (Incl. Hornsea Four)	**28,977**	**31,392**	**40,333**	**23,003**
Annual (Hornsea Four)				**7,571**
Annual Total (Incl. Hornsea Four)				**123,705**

Evaluation of the potential magnitude of impact

5.12.2.18 The magnitude of impact is estimated by calculating the increase in baseline mortality within the UK North Sea and English Channel non-breeding BDMPS population, which is 591,874 individuals (adults and immatures). The overall BDMPS baseline mortality rates (17.4%) are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015), as described in **Section 5.6.1**, which provides an annual baseline mortality rate of 102,986 individuals.

5.12.2.19 When applying a precautionary 50% displacement rate to the data from both array areas and a 2 km buffer from all projects within this cumulative assessment for razorbill a maximum of 61,853 individuals may be displaced across all four bio-seasons in total (**Table 5.41**). Should a 1% mortality rate be applied to this cumulative bio-season total, then 619 individuals may be lost to the wider UK North Sea and English Channel non-breeding BDMPS population.

5.12.2.20 Therefore, if an estimated annual total of 619 razorbills were to be lost from the population, this would represent an increase of 0.60% relative to the current baseline mortality rate of the UK North Sea and English Channel non-breeding BDMPS.

5.12.2.21 This level of potential impact is considered to be of **minor** magnitude on an annual cumulative basis, as it represents under a 1% increase to the baseline mortality conditions of the UK North Sea and English Channel non-breeding BDMPS.

Sensitivity of the receptor

5.12.2.22 As the birds within the UK North Sea and English Channel non-breeding BDMPS are likely to be from multiple different designated sites (including UK SPAs) this species is afforded a conservation value level of high to reflect that. With respect to vulnerability to displacement it is considered to be medium (**Table 5.25**). Whilst it may be of medium vulnerability it is of high conservation value leading to a sensitivity of receptor of **high** value.

Significance of the effect

5.12.2.23 The magnitude of cumulative disturbance from operational offshore wind farms within the UK North Sea and English Channel are defined as being a minor adverse impact on an annual basis and the sensitivity of the species considered to be high. Therefore, the potential effect from cumulative displacement to razorbill from Hornsea Four and all other UK offshore wind farms in the North Sea may be of **minor** adverse significance in total per annum, which is not significant in EIA terms.

Puffin

5.12.2.24 As determined in Section 5.11.2, puffins show a low level of sensitivity to maintenance activities from ship and helicopter traffic as well as to operational WTGs (Garthe and Hüppop, 2004; Furness and Wade, 2012; Langston, 2010; and Bradbury et al, 2014). However, a number of detailed studies (including Krijgsveld et al., 2011 and Walls et al., 2013) monitoring the post-construction effects of OWFs on puffins suggest that the range of displacement may be between approximately 50-70% within OWF arrays, whilst lower rates occur out to a maximum of 1-2 km.

5.12.2.25 In order to provide a precautionary approach to cumulative displacement, a rate of 40% for the array area and the 2 km buffer has been applied to all projects for a standard approach for estimating cumulative displacement.

5.12.2.26 Data for other projects' seasonal population estimates have been collated where available, but due to limited data sources available for puffin only two bio-seasons are collated that cover the entire annual cycle, one for breeding and for non-breeding. For some projects data are not available for their array area plus 2 km buffer, so in these instances the data has been scaled up or down based on data from the project area alone. The subsequent bio-season and annual abundance estimates for puffin associated with each of the projects identified in Table 5.38 are presented in Table 5.42.

Table 5.42: Cumulative bio-season and annual displacement estimates for puffin from all Tier 1 projects and with / without Hornsea Four.

Project	Breeding	Non-breeding
Blyth Demonstration Site	235	123
Dudgeon	1	3
EOWDC	42	82
Galloper	0	1
Greater Gabbard	0	1
Humber Gateway	15	10
London Array	0	1
Race Bank	1	10
Sheringham Shoal	4	26
Teesside	35	18
Thanet	0	0

Project	Breeding	Non-breeding
Westermost Rough	61	35
Beatrice	2,858	2,435
East Anglia One	16	32
Hornsea Project One	1,070	1,257
Hornsea Project Two	468	2,039
Dogger Bank Creyke Beck A	37	295
Dogger Bank Creyke Beck B	102	743
Dogger Bank Teesside A	34	273
East Anglia Three	181	307
Hywind 2 Demonstration	119	85
Inch Cape	2,956	2,688
Moray East	2,795	656
Moray West	1,115	3,966
Neart na Gaoithe	2,562	2,103
Seagreen Alpha	2,572	1,526
Sofia	35	329
Triton Knoll	23	71
Hornsea Three	253	127
Norfolk Boreas	0	23
Norfolk Vanguard	67	112
Thanet Extension	0	0
Seasonal Total (Excl. Hornsea Four	**21,242**	**23,244**
Annual Total (Excl. Hornsea Four)		**44,486**
Hornsea Four	**102**	**552**
Seasonal Totals (Incl. Hornsea Four)	**21,344**	**23,796**
Annual (Hornsea Four)		**654**
Annual Total (Incl. Hornsea Four)		**45,140**

Evaluation of the potential magnitude of impact

5.12.2.27 The magnitude of impact is estimated by calculating the increase in baseline mortality within the UK North Sea and English Channel non-breeding BDMPS population, which is 231,957 individuals (adults and immatures). The overall BDMPS baseline mortality rates (16.7%) are based on age specific demographic rates and age class proportions from Horswill and Robinson (2015), as described in **Section 5.6.1**, which provides an annual baseline mortality rate of 38,737 individuals.

5.12.2.28 When applying a precautionary 40% displacement rate to the data from both array areas and a 2 km buffer from all projects within this cumulative assessment for puffin a maximum of 8,538 individuals may be displaced during the breeding bio-season and 9,519 individuals during the non-breeding bio-season. Should a 1% mortality rate be applied to these two cumulative bio-season totals then 85 and 95 individuals may be lost to the wider UK North Sea and English Channel non-breeding BDMPS population.

5.12.2.29 Therefore, if an estimated annual total of 180 puffins were to be lost from the population, this would represent an increase of 0.46% relative to the current baseline mortality rate of the UK North Sea and English Channel non-breeding BDMPS.

5.12.2.30 This level of potential impact is considered to be of **minor** magnitude on an annual cumulative basis, as it represents under a 1% increase to the baseline mortality conditions of the UK North Sea and English Channel non-breeding BDMPS.

Sensitivity of the receptor

5.12.2.31 As the birds within the UK North Sea and English Channel non-breeding BDMPS are likely to be from multiple different designated sites (including UK SPAs) this species is afforded a conservation value level of high to reflect that. With respect to vulnerability to displacement it is considered to be low (**Table 5.25**). Whilst it may be of low vulnerability it is of high conservation value leading to a sensitivity of receptor of **medium** value.

Significance of the effect

5.12.2.32 The magnitude of cumulative disturbance from operational offshore wind farms within the UK North Sea and English Channel are defined as being a minor adverse impact on an annual basis and the sensitivity of the species considered to be medium. Therefore, the potential effect from cumulative displacement to puffin from Hornsea Four and all other UK offshore wind farms in the North Sea may be of **minor** adverse significance in total per annum, which is not significant in EIA terms.

Operational Phase CEA – Potential impact from cumulative collision risk

5.12.2.33 There is potential for cumulative collision risk to birds as a result of operational activities associated with Hornsea Four and other projects (**Table 5.38**). The risk to birds is through potential collision with WTGs and associated infrastructure from offshore wind farms, resulting in injury or fatality. This may occur when birds fly through the offshore wind farms whilst foraging for food, commuting between breeding sites and foraging areas, or during migration. The only projects identified for this CEA are those defined as being within Tier 1 (sub-tiers 1a to 1d) and Tier 2, as described in **Table 5.39**. The approach taken to assessing cumulative collision risk is a quantitative one, drawing upon the published information produced by the respective project developers. Such published, quantitative information on predicted collisions is not available at an early stage in the development of a project e.g. a project in Tier 3. The result is that the cumulative collision risk assessment addresses projects in Tiers 1 and 2 but not Tier 3 or below.

5.12.2.34 CRM has been carried out for Hornsea Four (**Section 5.11.2**) for five seabird species of interest identified as potentially at risk and of interest for impact assessment. Following a screening process for potential cumulative effects in **Section 5.12.1**, those species predicted to have very low risk from Hornsea Four alone (deemed to be of no material contribution cumulatively) were screened out of further assessment. Seabird species considered to be of more than a material contribution to potential cumulative effects

from collision risk were screened in, which were; gannet, kittiwake and great black-backed gull. The cumulative totals of collision risk from other projects have been amended and collated in order to be most representative of Band Option 1 (or 2 where that was presented) and standardised in accordance to the avoidance rates most appropriate to each species, as described in **Section 5.11.2** and in more detail within **Appendix A** of **Volume 5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.

Gannet

5.12.2.35 The subsequent bio-season and annual collision risk estimates for gannet associated with each of the projects identified in **Table 5.38** are presented in **Table 5.43**. The figures within this table are mostly composed of data from the final agreed cumulative tables submitted at Deadline VII for Norfolk Vanguard (Vattenfall, 2019). The differences to collision risk estimates are due to revisions to Hornsea Project Three and Thanet Extension, as their final submissions are now available. A single additional project, Norfolk Boreas, has also recently submitted its application including its EIA Report, whilst at the time of compiling this CEA only the data from the PEIR were available for two further projects; East Anglia ONE North and East Anglia Two.

Table 5.43: Cumulative bio-season and annual collision mortality estimates for gannet from all Tier 1 projects and with / without Hornsea Four.

Project	Return Migration	Breeding	Post-breeding Migration
Beatrice Demonstrator	0.7	0.6	0.9
Blyth Demonstration Site	2.8	3.5	2.1
Dudgeon	19.1	22.3	38.9
EOWDC	0.1	4.2	5.1
Galloper	12.6	18.1	30.9
Greater Gabbard	4.8	14.0	8.8
Humber Gateway	1.5	1.9	1.1
Kentish Flats	1.1	1.4	0.8
Lincs, Lynn & Inner Dowsing	1.9	2.3	1.4
London Array	1.8	2.3	1.4
Race Bank	4.1	33.7	11.7
Rampion	2.1	36.2	63.5
Sheringham Shoal	0.0	14.1	3.5
Teesside	0.0	4.9	1.7
Thanet	0.0	1.1	0.0
Westermost Rough	0.2	0.2	0.1
Beatrice	9.5	37.4	48.8
East Anglia One	6.3	3.4	131.0
Hornsea Project One	22.5	11.5	32.0
Hornsea Project Two	6.0	7.0	14.0
Dogger Bank Creyke Beck A & B	4.3	5.6	6.6

Project	Return Migration	Breeding	Post-breeding Migration
Dogger Bank Teesside A & Sofia	10.8	14.8	10.1
East Anglia Three	9.6	6.1	33.3
Hywind 2 Demonstration	0.8	5.6	0.8
Inch Cape	5.2	336.9	29.2
Moray East	8.9	80.6	35.4
Moray West	1.2	8.8	8.6
Neart na Gaoithe	23.0	143.0	47.0
Seagreen Alpha & Bravo	31.0	330	31.0
Triton Knoll	30.1	26.8	64.1
East Anglia ONE North	1.0	10.0	2.0
East Anglia TWO	1.3	8.8	5.5
Hornsea Three	8.0	18.0	12.0
Norfolk Boreas	15.0	54.1	48.5
Norfolk Vanguard	49.3	21.6	71.6
Thanet Extension	9.1	0.0	4.4
Seasonal Total (Excl. Hornsea Four	**265.7**	**1,290.8**	**784.7**
Annual Total (Excl. Hornsea Four)			**2,341.2**
Hornsea Four	**7.1**	**33.8**	**9.3**
Seasonal Totals (Incl. Hornsea Four)	**272.8**	**1,324.6**	**794.0**
Annual (Hornsea Four)			**50.2**
Annual Total (Incl Hornsea Four)			**2,391.4**

5.12.2.36 The estimated annual cumulative mortality rates, including Hornsea Four, for gannet of 2,391.4 individuals (**Table 5.43**) is most certainly an overestimate due to a number of reasons;

- Collision risk estimates for other OWFs were not based on as-built designs, but were calculated on the basis of consented designs. This is an important factor to recognise, as demonstrated through changes to Hornsea Project Two, which is being constructed as 165 WTGs and not the consented 300 WTGs within its consent. This single change affords reductions in collision risk of approximately 45%;
- A considerable number of the projects in this cumulative collision risk assessment relied on previous versions of the Band CRM and applied outdated input parameters, including the use of lower avoidance rates. Hornsea Four used a 98.9% avoidance rate as agreed with Natural England through the evidence plan process, whilst other projects applied avoidance rates of between 95% to 99%. When considering a reduction of 1% in avoidance rates (for instance from 99% to 98%) this leads to a reduction in mortality rates of half;
- Work undertaken by APEM (2014) using aerial digital survey methods, which was conducted during the post-breeding migratory bio-season, provided evidence that gannets avoided OWFs (in this instance Greater Gabbard) more strongly than previously considered. Of the 336 gannets observed within the study only 8 birds flew into the OWF, whilst those entering the OWF performed additional high levels

of meso and micro avoidance providing evidence that the overall avoidance rates were in excess of 99% compared to the current guidance of 98.9%.

- A recent analysis of nocturnal behaviour extracted from tagged individuals was undertaken by Furness et al. (2018) that provides evidence to suggest that they spend considerably less time in flight at sea during the evening and night time. The use of a nocturnal activity rate of 25% in all months within the CRM for other projects would appear to be over precautionary when considering Furness et al. (2018) estimated rates of just 8% for the breeding season and 4% during the non-breeding season. Therefore, the risk of gannets to collision is considerably less during nocturnal periods across the year;
- The Crown Estate's Headroom report (TCE, 2015) accounted, where possible for differing avoidance rates applied in other project's CRM, nocturnal activity rates used in their CRM and further considered the as-built scenarios for OWFs, where appropriate. This provided an overall reduction of 409 to the cumulative total for gannet mortality within the North Sea and English Channel; and
- Finally, it must be appreciated that many of the projects within this CEA are likely to be decommissioned during the operational lifetime of Hornsea Four, so consideration of their impacts are very much a precautionary estimate with respect to ongoing potential cumulative impacts from collision risk. Even in the event of decommissioned OWFs being replaced by new WTGs those available to the market in the future would no doubt be more efficient and less impacting than those available when they were built.

Evaluation of the potential magnitude of impact

5.12.2.37 The BDMPS for the North Sea and English Channel is 456,298 individuals (adults and immatures), whilst the wider bio-geographic population is 1,180,000 individuals (adults and immatures). The background mortality rates for these population scales are 87,153 and 225,380 individuals per annum, respectively.

5.12.2.38 The potential cumulative loss of 2,391.4 gannets would represent an increase of 2.74% relative to the baseline mortality rate at the BDMPS scale. The potential cumulative loss of 2,884.5 gannets would represent an increase of 1.06% relative to the baseline mortality rate at the wider bio-geographic population scale. Both of these levels of potential cumulative impacts represent increases of over 1% relative to baseline mortality rates, which is the 1% threshold for which further consideration is required.

5.12.2.39 For the purpose of this PEIR assessment consideration is given to evidence provided through the recent Hornsea Project Three, Norfolk Vanguard and Thanet Extension PINS examinations. All three of these projects submitted multiple documents providing account of the most recent assessment of potential impacts on gannets from cumulative collision risk. Each made reference to the WWT (2012) study on gannets that concluded that (using the density independent model) even when using the lower 95% confidence interval on population growth the British gannet population would remain on an average positive population growth until additional mortality exceeded 3,500 individuals. The risk of a 5% population decline was less than 5% for additional annual

mortalities below 5,000 (using either the density dependent or density independent model; WWT, 2012).

5.12.2.40 The gannet model forming the study by WWT (2012) is acknowledged as being based on the whole British population. Therefore, OWFs from the west coast of the Britain would also need to be factored in when considering its conclusions. Those OWFs along the west coast of the UK include Barrow, Burbo Bank, Burbo Bank Extension, Gwynt Y Mor, North Hoyle, Ormonde, Rhyl Flats, Robin Rigg, Walney (1 and 2), Walney Extension and West of Duddon Sands. The estimated annual total cumulative collision risk is of 32.4 individuals (when using an avoidance rate of 98.9%). This provides evidence that even when considering all British wind farms in this assessment, the conclusion that cumulative collisions are below a level at which a significant impact on the British gannet population would remain the result.

5.12.2.41 In addition, it is also acknowledged that the WWT (2012) study was based on a British gannet population estimated to be 261,000 breeding pairs in 2004 and not the current estimated population of 349,498 (Murray et al., 2015), which in itself is likely to be an underestimate given the continued population increases across Britain at all colonies since 2015. Therefore, the threshold at which a cumulative total would be deemed to cause a magnitude of impact of significance would further increase, providing additional headroom from potential collisions from OWFs.

5.12.2.42 Therefore, accounting for the evidence on population scales and the precautionary nature of the estimated cumulative collision total for gannets the magnitude of impact is deemed to be of a **minor** adverse nature.

Sensitivity of the receptor

5.12.2.43 As the majority of the gannets within the BDMPS are likely to be from designated sites (including UK SPAs) this species is afforded a conservation value level of high to reflect that. With respect to vulnerability to collision it is considered to be medium (**Table 5.30**). Whilst it may be of medium vulnerability it is of high conservation value leading to a sensitivity of receptor of **high** value.

Significance of the effect

5.12.2.44 The magnitude of cumulative disturbance from operational offshore wind farms within the UK North Sea and English Channel are defined as being a minor adverse impact on an annual basis and the sensitivity of the species is considered to be high. Therefore, the potential effect from cumulative collision risk to gannet from Hornsea Four and all other UK offshore wind farms in the North Sea may be of **minor** adverse significance in total per annum, which is not significant in EIA terms.

Kittiwake

5.12.2.45 The predicted level of annual mortality associated with collision risk for Hornsea Four of 6.9 individuals would suggest that this species would not warrant further consideration cumulatively if following the proportionate EIA methods. However, despite Hornsea Four's collision risk to kittiwake being very small a cumulative assessment was undertaken at the request of Natural England and the RSPB to the contribution to the overall cumulative impacts from collision to be identified.

5.12.2.46 The bio-season and annual collision risk estimates for kittiwake associated with each of the projects identified in **Table 5.38** are presented in **Table 5.44**. The figures within this table are mostly composed of data from the final agreed cumulative tables submitted at Deadline VII for Norfolk Vanguard (Vattenfall, 2019). The differences to collision risk estimates are due to revisions to Hornsea Project Three and Thanet Extension, as their final submissions are now available. A single additional project, Norfolk Boreas, has also recently submitted its DCO application, including EIA Report, whilst at the time of compiling this CEA only the data from the PEIR were available for two further projects; East Anglia ONE North and East Anglia Two.

Table 5.44: Cumulative bio-season and annual collision mortality estimates for kittiwake from all Tier 1 projects and with / without Hornsea Four.

Project	Return Migration	Breeding	Post-breeding Migration
Beatrice Demonstrator	1.7	0.0	2.1
Blyth Demonstration Site	1.4	1.4	2.3
Dudgeon	0.0	0.0	0.0
EOWDC	1.1	11.8	5.8
Galloper	31.8	6.3	27.8
Greater Gabbard	11.4	1.1	15.0
Humber Gateway	1.9	1.9	3.2
Kentish Flats	0.7	0.0	0.9
Lincs, Lynn & Inner Dowsing	0.7	0.7	1.2
London Array	1.8	1.4	2.3
Race Bank	5.6	1.9	23.9
Rampion	n/a	n/a	n/a
Sheringham Shoal	0.0	0.0	0.0
Teesside	2.5	38.4	24.0
Thanet	0.4	0.3	0.5
Westermost Rough	0.1	0.1	0.2
Beatrice	39.8	94.7	10.7
East Anglia One	46.8	1.8	160.4
Hornsea Project One	20.9	44.0	55.9
Hornsea Project Two	3.0	16.0	9.0
Dogger Bank Creyke Beck A & B	295.0	288.0	135.0

Project	Return Migration	Breeding	Post-breeding Migration
Dogger Bank Teesside A & Sofia	216.9	136.9	90.7
East Anglia Three	37.6	6.1	69.0
Hywind 2 Demonstration	0.9	16.6	0.9
Inch Cape	63.5	13.1	224.8
Moray East	19.3	43.6	2.0
Moray West	7.0	79.0	24.0
Neart na Gaoithe	4.4	32.9	56.1
Seagreen Alpha & Bravo	58	159	117
Triton Knoll	45.4	24.6	139.0
East Anglia ONE North	17.4	6.0	4.3
East Anglia TWO	9.3	13.6	2.9
Hornsea Three	40.0	121.0	76.0
Norfolk Boreas	56.3	29.9	116.6
Norfolk Vanguard	150.5	31.3	134.1
Thanet Extension	9.8	1.5	3.4
Seasonal Total (Excl. Hornsea Four	**1,202.9**	**1,224.9**	**1,541.0**
Annual Total (Excl. Hornsea Four)			**3,968.8**
Hornsea Four	**1.4**	**3.0**	**2.5**
Seasonal Totals (Incl. Hornsea Four)	**1,204.3**	**1,227.9**	**1,543.5**
Annual (Hornsea Four)			**6.9**
Annual Total (Incl Hornsea Four)			**3,975.7**

5.12.2.47 The estimated annual cumulative mortality rates, including Hornsea Four, for kittiwake of 3,975.7 individuals is most certainly an overestimate due to a number of reasons;

- Collision risk estimates for other OWFs were not based on as-built designs, but were calculated on the basis of consented designs. This is an important factor to recognise, as demonstrated through changes to Hornsea Project Two, which is being constructed as 165 WTGs and not the consented 300 WTGs within its consent. This single change affords reductions in collision risk of approximately 45%;
- A considerable number of the projects in this cumulative collision risk assessment relied on previous versions of the Band CRM and applied outdated input parameters, including the use of lower avoidance rates. Hornsea Four used a 99.4% avoidance rate as agreed with Natural England through the evidence plan process, whilst other projects applied avoidance rates of between 95% to 99%. When considering a reduction of 1% in avoidance rates (for instance from 99% to 98%) this leads to a reduction in mortality rates of half;
- An ongoing analysis of nocturnal behaviour extracted from tagged individuals is currently being undertaken by Furness (in prep) from which it is suggested that early results indicate evidence that kittiwake spend considerably less time in flight at sea during the evening and night time. The use of a nocturnal activity rate of 50% in all months within the CRM for other projects would appear to be over precautionary when considering Furness (in prep), as initial estimates suggest rates of 20% for the

breeding season and 17% during the non-breeding season. Therefore, the risk of kittiwakes to collision is considerably less during nocturnal periods across the year;

- The Crown Estate's Headroom report (TCE, 2017) accounted, where possible for differing avoidance rates applied in other project's CRM, nocturnal activity rates used in their CRM and further considered the as-built scenarios for OWFs, where appropriate. This provided an overall reduction of 554 to the cumulative total for gannet mortality within the North Sea and English Channel; and
- Finally, it must be appreciated that many of the projects within this CEA are likely to be decommissioned during the operational lifetime of Hornsea Four, so consideration of their impacts are very much a precautionary estimate with respect to ongoing potential cumulative impacts from collision risk. Even in the event of decommissioned OWFs being replaced by new WTGs those available to the market in the future would no doubt be more efficient and less impacting than those available when they were built.

Evaluation of the potential magnitude of impact

5.12.2.48 The BDMPS for the North Sea is 829,937 individuals (adults and immatures), whilst the wider bio-geographic population is 5,100,000 individuals (adults and immatures). The background mortality rates for these population scales are 129,470 and 795,600 individuals per annum, respectively.

5.12.2.49 The potential cumulative loss of 3,975.7 kittiwakes would represent an increase of 3.07% relative to the baseline mortality rate at the BDMPS scale. The potential cumulative loss of 3,975.7 kittiwakes would represent an increase of 0.50% relative to the baseline mortality rate at the wider bio-geographic population scale. Only the level of potential cumulative impact at the BDMPS scale represents an increase of over 1% relative to baseline mortality rates, which is the threshold for which further consideration would normally be required.

5.12.2.50 Evidence submitted for East Anglia Three (EATL, 2016), that was recently re-worked for Norfolk Boreas (Vattenfall, 2019), presented the case that when accounting for an additional annual mortality of 4,000 individuals, the density dependant model predicted that the population would be 3.6% to 4.4% smaller than that predicted in the absence of such additional mortality after 25 years. Such changes across a 25 year period are considered to be highly likely to be undetectable against a background of natural changes, which have fluctuated immensely between positive and negative change over the last 50 years. Therefore, such a potential cumulative impact from collision risk to the wider BDMPS population would be considered to be of **minor** adverse magnitude.

5.12.2.51 However, in this instance it is clear that the contribution of Hornsea Four of 6.9 individuals per annum to the overall cumulative total of 3,975.7 is of no material contribution. Therefore, it can be concluded that whilst the most precautionary estimates of cumulative collision risk may pose a magnitude of impact of significance, cumulatively

the contribution of Hornsea Four is so small that it would not materially affect the overall cumulative impact magnitude.

Sensitivity of the receptor

5.12.2.52 As kittiwakes within the wider BDMPS are likely to be from a variety of small and large colonies this species is afforded a conservation value level of medium. With respect to vulnerability to collision it is considered to be medium (**Table 5.30**). Whilst it may be of medium vulnerability it is of medium conservation value leading to a sensitivity of receptor of medium value.

Significance of the effect

5.12.2.53 The magnitude of cumulative collision risk from Hornsea Four and all other UK North Sea offshore wind farms are defined as minor adverse impact in all bio-seasons and the sensitivity of the species considered to be medium. Therefore, the potential effect from collision risk to kittiwake from Hornsea Four may be of minor adverse significance during each bio-season, which is not significant in EIA term.

5.12.2.54 However, in this instance it is clear that the contribution of Hornsea Four to the overall cumulative total is of no material contribution. Therefore, it can be concluded that whilst the most precautionary estimates of cumulative collision risk may pose an effect of significance cumulatively the contribution of Hornsea Four is so small that it would not materially affect the overall cumulative effect.

Great black-backed gull

5.12.2.55 The subsequent bio-season and annual collision risk estimates for great black-backed gull associated with each of the projects identified in **Table 5.38** are presented in **Table 5.45**. The figures within this table are mostly composed of data from the final agreed cumulative tables submitted at Deadline VII for Norfolk Vanguard (Vattenfall, 2019). The differences to collision risk estimates are due to revisions to Hornsea Project Three and Thanet Extension, as their final submissions are now available. A single additional project, Norfolk Boreas, has also recently submitted its DCO application including an EIA Report, whilst at the time of compiling this CEA only the data from the PEIR were available for two further projects; East Anglia ONE North and East Anglia Two.

Table 5.45: Cumulative bio-season and annual collision mortality estimates for great black-backed gull from all Tier 1 projects and with / without Hornsea Four.

Project	Breeding	Non-breeding
Beatrice Demonstrator	0.0	0.0
Blyth Demonstration Site	1.3	5.1
Dudgeon	0.0	0.0
EOWDC	0.6	2.4

Project	Breeding	Non-breeding
Galloper	4.5	18.0
Greater Gabbard	15.0	60.0
Humber Gateway	1.3	5.1
Kentish Flats	0.1	0.2
Lincs, Lynn & Inner Dowsing	0.0	0.0
London Array	0.0	0.0
Race Bank	0.0	0.0
Rampion	5.2	20.8
Sheringham Shoal	0.0	0.0
Teesside	8.7	34.8
Thanet	0.1	0.4
Westermost Rough	0.0	0.0
Beatrice	30.2	120.8
East Anglia One	0.0	46.0
Hornsea Project One	17.2	68.6
Hornsea Project Two	3.0	20.0
Dogger Bank Creyke Beck A & B	5.8	23.3
Dogger Bank Teesside A & Sofia	6.4	25.5
East Anglia Three	4.6	34.4
Hywind 2 Demonstration	0.3	4.5
Inch Cape	0.0	36.8
Moray East	9.5	25.5
Moray West	4.0	5.0
Neart na Gaoithe	0.9	3.6
Seagreen Alpha & Bravo	13.4	53.4
Triton Knoll	24.4	97.6
East Anglia ONE North	0.5	0.0
East Anglia TWO	2.2	0.5
Hornsea Three	16.0	50.0
Norfolk Boreas	7.8	85.4
Norfolk Vanguard	0.0	65.1
Thanet Extension	1.3	20.8
Seasonal Total (Excl. Hornsea Four	**184.3**	**933.6**
Annual Total (Excl. Hornsea Four)		**1,117.9**
Hornsea Four	**0.8**	**6.9**
Seasonal Totals (Incl. Hornsea Four)	**185.1**	**940.5**
Annual (Hornsea Four)		**7.7**
Annual Total (Incl Hornsea Four)		**1,125.6**

5.12.2.56 The estimated annual cumulative mortality rates for great black-backed gull of 1,125.6 individuals is most certainly an overestimate due to a number of reasons;

- Collision risk estimates for other OWFs were not based on as-built designs, but were calculated on the basis of consented designs. This is an important factor to recognise, as demonstrated through changes to Hornsea Project Two, which is being constructed as 165 WTGs and not the consented 300 WTGs within its consent. This single change affords reductions in collision risk of approximately 45%;
- A considerable number of the projects in this cumulative collision risk assessment relied on previous versions of the Band CRM and applied outdated input parameters, including the use of lower avoidance rates. Hornsea Four used a 99.5% avoidance rate as agreed with Natural England through the evidence plan process, whilst most projects' collision risk assessments submitted before the 2014 (i.e. before the JNCC et al., 2014 paper on avoidance rates) applied avoidance rates of between 98%. When considering a reduction of 1% in avoidance rates (for instance from 99% to 98%) this leads to a reduction in mortality rates of half;
- A review of nocturnal behaviour was for the East Anglia Three impact assessments (EATL, 2015) that provided evidence to suggest that great black-backed gulls spend considerably less time in flight at sea during the evening and night time. The use of a nocturnal activity rate of 50% in all months within the CRM for other projects would appear to be over precautionary when considering EATL (2015) estimated rates of 25% would be more appropriate. Therefore, the risk of great black-backed gulls to collision is considerably less during nocturnal periods across the year;
- The Crown Estate's Headroom report (TCE, 2015) accounted, where possible for differing avoidance rates applied in other project's CRM, nocturnal activity rates used in their CRM and further considered the as-built scenarios for OWFs, where appropriate. This provided an overall reduction of 262 to the cumulative total for great black-backed gull mortality within the North Sea and English Channel; and
- Finally, it must be appreciated that many of the projects within this CEA are likely to be decommissioned during the operational lifetime of Hornsea Four, so consideration of their impacts are very much a precautionary estimate with respect to ongoing potential cumulative impacts from collision risk. Even in the event of decommissioned OWFs being replaced by new WTGs those available to the market in the future would no doubt be more efficient and less impacting than those available when they were built.

Evaluation of the potential magnitude of impact

5.12.2.57 The BDMPS for the North Sea and English Channel is 91,399 individuals (adults and immatures), whilst the wider bio-geographic population is 235,000 individuals (adults and immatures). The background mortality rates for these population scales are 6,394 and 16,450 individuals per annum, respectively.

5.12.2.58 The potential cumulative loss of 1,125.6 great black-backed gulls would represent an increase of 17.60% relative to the baseline mortality rate at the BDMPS scale. The potential cumulative loss of 1,125.6 gannets would represent an increase of 6.84% relative to the baseline mortality rate at the wider bio-geographic population scale. Both of these levels of potential cumulative impacts represent increases of over 1%

relative to baseline mortality rates, which is the 1% threshold for which further consideration is required.

5.12.2.59 For the purpose of this PEIR assessment consideration is given to evidence provided through the recent Hornsea Project Three, Norfolk Vanguard and Thanet Extension PINS examinations as well as consenting decisions from East Anglia Three and Rampion. All of these projects submitted multiple documents providing account of the most recent assessment of potential impacts on great black-backed gulls from cumulative collision risk. For the two consented projects (East Anglia Three and Rampion) conclusions on cumulative assessments included the following;

- Rampion estimated 1,803 individuals as the cumulative collision risk to great black-backed gulls, whilst Natural England suggested the total was 3,025 individuals. However, the Examining Authority (Planning Inspectorate, 2014) concluded 'that the addition of Rampion OWF does not tip the balance in terms of exceeding a threshold that would otherwise be exceeded'. Despite the threshold being referred to being estimated using a Potential Biological Removal (PBR) population model, a population method no longer considered appropriate, the current value of 1,100.7 individuals estimated for Hornsea Four and other projects sits well below both Rampion values. The Secretary of State for Energy and Climate Change (the SoS) agreed with the findings of the Applicant's analysis and the ExA's conclusions in the Decision Letter and Statement of Reasons from the SoS (DECC, 2014). The SoS stated that they were satisfied that the additional mortality would not affect the great black-backed gull population in the long term.
- Population modelling was undertaken for East Anglia Three (EATL, 2016) that used a density dependent model to assess the impact of an additional 1,000 individuals to the population. This provided evidence that using the more precautionary density dependent model would only result in a 1.6% reduction in the population growth, which was not deemed to be significant. Natural England also concluded that whilst at that point they could not rule out a significant cumulative effect, the contribution of East Anglia Three was so small that it would not materially affect the overall cumulative impact magnitude.
- On the basis of the conclusions agreed during the consenting process for Rampion and East Anglia then Hornsea Four's contribution of 7.7 individuals per annum to the over precautionary cumulative collision mortality total of 1,100.7 would also be deemed to be so small that it would not materially affect the overall cumulative impact magnitude.

5.12.2.60 Therefore, accounting for the evidence on population scales, the precautionary nature of the estimated cumulative collision total for great black-backed gull and the conclusions of previous consenting decisions for other OWFs the magnitude of impact is deemed to be of a **minor** adverse nature.

Sensitivity of the receptor

5.12.2.61 As this species is not connected with a significant number of designated sites within the BDMPS or wider bio-geographic population scales this species is afforded a conservation value level of low to reflect that. With respect to vulnerability to collision it is considered to be high (Table 5.30). Whilst it may be of high vulnerability it is of low conservation value leading to a sensitivity of receptor of **medium** value.

Significance of the effect

5.12.2.62 The magnitude of cumulative disturbance from operational offshore wind farms within the UK North Sea and English Channel are defined as being a minor adverse impact on an annual basis and the sensitivity of the species considered to be medium. Therefore, the potential effect from cumulative collision risk to great black-backed gull from Hornsea Four and all other UK offshore wind farms in the North Sea may be of **minor** adverse significance in total per annum, which is not significant in EIA terms.

5.13 Transboundary effects

5.13.1.1 Transboundary effects are defined as those effects upon the receiving environment of other European Economic Area (EEA) states, whether occurring from Hornsea Four alone, or cumulatively with other projects in the wider area.

5.13.1.2 A transboundary screening exercise was undertaken at the EIA Scoping Stage (Annex K of the EIA Scoping Report), which identified that there was the potential for transboundary effects to occur in relation to offshore and intertidal ornithology.

5.13.1.3 Transboundary impacts upon ornithological receptors (seaward of the MHWS) are possible due to the wide foraging and migratory ranges of typical bird species in the North Sea. In addition, a number of bird species that have been recorded during previous surveys include those that are listed as qualifying features of European Sites in other EEA States. The bird species likely to be present in the Hornsea Four array area, offshore ECC and cable landfall area, based on the outputs of the Hornsea Project One, Hornsea Project Two and Hornsea Three boat-based surveys together with the site specific Hornsea Three and Hornsea Four aerial surveys are outlined in full in Section 6.6 of the Hornsea Four EIA Scoping Report (Offshore and Intertidal Ornithology), and include fulmar, gannet, kittiwake, guillemot, razorbill, puffin and large gulls.

5.13.1.4 The key direct potential impacts and effects for ornithological receptors are predicted to arise during the operation and maintenance phase as a result of potential collisions (with rotating turbine blades which may result in direct mortality of individuals), disturbance and barrier effects (caused by the physical presence of structures which may displace birds or prevent transit of birds between foraging and breeding sites, or on migration, respectively).

5.13.1.5 The final Hornsea Four DCO submission (including the ES) will include a summary of consultations conducted with other EU Member States surrounding the North Sea basin. Protected sites in countries beyond the UK that may have connectivity with Hornsea Four were listed in **Table 13.9** of the EIA Scoping Report and included, in order of distance from Hornsea Four; the Netherlands (84 km), Germany (222 km), Denmark (235 km), Belgium (243 km), Norway (247 km), France (271 km), Ireland (333 km) and Iceland (1,153 km).

5.13.1.6 To inform this PEIR assessment, consideration has been given to the consultation response received between the EIA Scoping Stage and the PEIR Stage. One response was received that raised a potential concern over transboundary impacts on ornithology receptors. This was provided by Rijkswaterstaat (RWS) in the Netherlands and noted that non-UK wind farms in the southern North Sea had not been included in the cumulative assessment. The response also noted that this would require an international cumulative approach, which has not been developed to date. Furthermore, owing to the different approaches to impact assessment adopted by each EU Member State it is not currently clear how this could be undertaken quantitatively.

5.13.1.7 With regards to the potential for transboundary cumulative impacts, there is some limited potential for collisions and displacement at offshore wind farms outside UK territorial waters. However, the operational offshore wind farms in Belgium, the Netherlands and Germany are comparatively small (collectively, these projects are of a similar size to no more than one to two of the more recent UK offshore wind farms, such as East Anglia ONE).

5.13.1.8 Since the spatial scope for a transboundary assessment would be much larger than that considered for Hornsea Four alone or cumulatively with other UK projects then any assessment of potential impacts and effects would be against larger seabird population sizes accounting for wider a BDMPS. Therefore, it is apparent that the scale of offshore wind farm developments within such a wider context would be relatively much smaller with respect to any potential impacts. Therefore, the inclusion of non-UK offshore wind farms is considered very unlikely to alter the conclusions of the existing cumulative assessment, and highly likely to reduce estimated impacts at population levels if calculated at larger spatial scales.

5.14 Inter-related effects

5.14.1 Introduction

5.14.1.1 Inter-related effects consider impacts from the construction, operation or decommissioning of Hornsea Four on the same receptor (or group). Such inter-related effects include both:

- Project lifetime effects: Assessment of the scope for effects that occur throughout more than one phase of the project (construction, operational 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); and

- 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 and intertidal ornithology, such as collision risk, disturbance and displacement, barrier effect and indirect effects 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.

5.14.1.2 A description of the process to identify and assess Inter-Related Effects is presented in **Section 5.8** of **Volume 1 Chapter 5: Environmental Impact Assessment Methodology**.

5.14.1.3 Consideration of the inter-relationships between EIA topics that may lead to environmental effects, is required under Schedule 4 of The Infrastructure EIA Regulations. Guidance on inter-related effects is provided within **Section 4.13** of PINS Advice Note Nine: Rochdale Envelope (PINS, 2018), which states that "*inter-relationships consider impacts of the proposals on the same receptor. These occur where a number of separate impacts, (e.g. noise and air quality), affect a single receptor such as fauna*". The approach to inter-related effects has taken into account this Advice Note, along with all other guidance that exists at present.

5.14.1.4 The approach to the assessment of inter-related effects considers receptor-led effects; that is effects that interact spatially and/or temporally resulting in interrelated effects upon a single receptor.

5.14.1.5 The assessment of inter-related effects has been undertaken with specific reference to the potential for such effects to arise in relation to receptor groups. The term 'receptor group' is used to highlight the fact that the proposed approach to inter-relationships assessment has not, in the main, assessed every individual receptor assessed at the EIA stage, but rather, potentially sensitive groups of receptors.

5.14.1.6 The broad approach to inter-related effects assessment has followed the following key steps:

1. Review of effects for individual EIA topic areas;
2. Review of the assessment carried out for each EIA topic area, to identify "receptor groups" requiring assessment;
3. Potential inter-related effects on these receptor groups identified via review of the assessment carried out across a range of topics;
4. Development of lists for all potential receptor-led effects; and
5. Qualitative assessment on how individual effects may combine to create interrelated effects.

5.14.1.7 It is important to note that the inter-relationships assessment has only considered effects produced by Hornsea Four, and not those from other projects (these will be

considered within the CEA in Section 5.12). Note that for receptors/impacts scoped out of the EIA process based on the findings of the Impacts Register (see Section 5.9 and Annex A) and the EIA Scoping Report, no inter-related assessment has been undertaken.

5.14.1.8 Table 1.1 and Table 1.2 in the EIA Scoping Report present an initial screening of inter-related effects that have informed this assessment. This screening has been updated as scoping has continued into the PEIR and ES Stages so that the consideration of inter-related effects remains proportional.

5.14.1.9 The construction, operation and decommissioning phases of the proposed Hornsea Four may cause a range of effects on offshore ornithological interests. The magnitude of these effects has been assessed individually using expert judgement, drawing from a wide science base that includes project-specific surveys and previously acquired knowledge of the bird ecology of the North Sea.

5.14.1.10 These effects have the potential to form an inter-relationship, directly impact the terrestrial and seabird receptors and have the potential to manifest as sources for impacts upon receptors other than those considered within the context of offshore ornithology.

5.14.1.11 In terms of how impacts to offshore and intertidal ornithological interests may form inter-relationships with other receptor groups, assessments of significance are provided in the chapters listed in the second column of Table 5.46 below. In addition, the table shows where other chapters have been used to inform the offshore and intertidal ornithology inter-relationships assessment.

Table 5.46: Chapter Topic Inter-Relationships

Topic and description	Related Chapter	Where addressed in this Chapter
Indirect impacts through effects on habitats and prey during construction	Volume 2, Chapter 2: Benthic and Intertidal Ecology Volume 2, Chapter 3: Fish and Shellfish Ecology	Section 5.11.1.33
Indirect impacts through effects on habitats and prey during operation		Section 5.11.2.1
Indirect impacts through effects on habitats and prey during decommissioning		Section 5.11.3.4

5.14.1.12 However, as none of the offshore impacts on birds were assessed ***individually*** to have any greater than a minor adverse impact, with the majority assessed individually as negligible, it is considered highly unlikely that they would inter-relate to form an overall significant impact on offshore and intertidal ornithology receptors.

5.15 Conclusion and summary

5.15.1.1 Table 5.47 overleaf presents a summary of the significant impacts assessed within this PEIR, any mitigation and the residual effects.

Table 5.47: Summary of potential impacts assessed for Offshore and Intertidal Ornithology

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
Construction				
Construction activities within the array area associated with foundations and WTGs may lead to disturbance and displacement of species within the array and different degrees of buffers surrounding it (ORN-C-1).	Guillemot High	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Razorbill High	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Puffin Medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
Indirect impacts during the construction phase within the array area through effects on habitats and prey species (ORN-C-2).	All species Not applicable	Not applicable	None proposed beyond existing Commitments	Not Significant
Construction activities associated with export cable laying may lead to disturbance and displacement of species within the export cable corridor and different degrees of buffers surrounding it (ORN-C-3).	Red-throated diver Medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
Construction activities associated with trenching, laying and reburial of the export cable through the intertidal zone may lead to disturbance and displacement of waterbird species in close proximity to the works (ORN-C-4).	Sanderling Low	Negligible / Minor Not Significant / Minor	None proposed beyond existing Commitments	Not Significant / Minor

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
Operation				
Operational activities associated with moving turbines and maintenance vessels may lead to disturbance and displacement of species within the array area and different degrees of buffers surrounding it (ORN-O-5).	Gannet Medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Guillemot High	Negligible / Minor Not Significant / Minor (Not Significant)	None proposed beyond existing Commitments	Not Significant / Minor (Not Significant)
	Razorbill High	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Puffin Medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
Seabirds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure. The result of such collisions may be fatal to the bird concerned (ORN-O-6).	Gannet High	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Kittiwake High	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Lesser black-backed gull Medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Herring gull Medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Great black-backed gull Medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
Migrant non-seabirds flying through the array area during the operational phase are at risk of	All species Low to High	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
collision with WTG rotors and associated infrastructure. The result of such collisions may be fatal to the bird concerned (ORN-O-7).				
Indirect impacts within the array area during the operational phase through effects on habitats and prey species (ORN-O-8).	All species Not applicable	Not applicable	None proposed beyond existing Commitments	Not Significant
The presence of WTGs could create a barrier to the migratory or regular foraging movements of seabirds. This may result in permanent changes in flying routes for birds concerned and an increase in energy demands associated with those movements may result in a lower rate of breeding success or survival chances for individuals affected (ORN-O-9).	Gannet Low	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Kittiwake Low to medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
The impact of attraction to lit structures by migrating birds in particular may cause disorientation, reduction in fitness and possible mortality (ORN-O-14).	All species Low	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
Decommissioning				
Demolition activities associated with foundations and WTGs may lead to disturbance and displacement of species within the	Red-throated diver Medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
array area and different degrees of buffers surrounding it (ORN-D-12).	Guillemot High	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Razorbill High	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Puffin Medium	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
Indirect impacts during the decommissioning phase within the offshore export cable corridor and landfall through effects on habitats and prey species (ORN-D-13).	All species Not applicable	Not applicable	None proposed beyond existing Commitments	Not Significant

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