Hornsea Four Environmental Statement (ES) A2.5

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Prepared APEM Ltd, July 2021
Checked GoBe Consultants Ltd, August 2021
Accepted Eleni Antoniou, Orsted. September 2021
Approved Julian Carolan, Orsted. September 2021

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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 and enhancement measures. The purpose of Commitments is to reduce and/or eliminate Likely Significant Effects (LSEs), in EIA terms. Primary (Design) or Tertiary (Inherent) are both embedded within the assessment at the relevant point in the EIA (e.g. at Scoping, Preliminary Environmental Information Report (PEIR) or ES). Secondary commitments are incorporated to reduce LSE to environmentally acceptable levels following initial assessment i.e. so that residual effects are acceptable.
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 Statement.
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) and compensatory measures.
Hornsea Four array area	The proposed area for Hornsea Four within which the Wind Turbine Generators (WTGs) would be installed.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind

Term	Definition
	turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Hornsea Zone	The former Hornsea Zone was one of nine offshore wind generation zones around the UK coast identified by TCE during its third round of offshore wind licensing. In March 2016, the Hornsea Zone Development Agreement was terminated and project specific agreements, AfLs, were agreed with TCE 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 ES 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).
In-Combination Effect	The combined action of different environmental topic-specific impacts on the same resource/receptor.
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 Springs (MHWS)	The height of mean high water during spring tides in a year.
Mean Low Water Springs (MLWS)	The height of mean low water during spring tides in a year.
Mean Max Foraging Range	The mean max foraging range is calculated as the maximum reported range that a species for each colony is known to have foraged, averaged across all colonies from the literature review undertaken by Woodward et al. (2019).
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 or ES).
Marine Renewables Strategic environmental assessment (MRSea)	Statistical package to model spatial count data and predict spatial densities / abundances; developed by the Centre for Research into Ecological and Environmental Modelling (CREEM) specifically for dealing with data collected for offshore wind farm projects.
National Site Network	The network of sites in the United Kingdom's territory consisting of such sites that formed part of Natura 2000 and are European sites or European offshore marine sites for the purposes of the Conservation of Habitats and Species Regulations 2017 and/or the Conservation of Offshore Marine Habitats and Species Regulationts 2017.
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.
Orsted Hornsea Project Four Ltd.	The 'Applicant' for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
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.

Term	Definition
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.

Acronyms

Acronym	Definition
AfL	Agreement for Lease
BO1	Band Option 1
BO2	Band Option 2
BO3	Band Option 3
BDMPS	Biologically Defined Minimum Population Scale
BEIS	Department for Business, Energy and Industrial Strategy
BoCC	Birds of Conservation Concern
BSI	British Standards Institute
BTO	British Trust for Ornithology
CEA	Cumulative Effects Assessment
CI	Confidence Interval
CIEEM	Chartered Institute of Ecology and Environmental Assessment
CoCP	Code of Construction Practice
CREEM	Centre for Research into Ecological and Environmental Modelling
CRM	Collision Risk Model
CTV	Crew Transport Vessel
DAA	Developable Area Approach
DAS	Digital Aerial Survey
DCO	Development Consent Order
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges
EATL	East Anglia Three Limited
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
EOWDC	European Offshore Wind Development Centre
EP	Evidence Plan
ES	Environmental Statement
EU	European Union
ExA	Examining Authority
FFC	Flamborough and Filey Coast
GES	Good Environmental Status
GSD	Ground Sample Distance
HDD	Horizontal Directional Drilling
HRA	Habitats Regulations Assessment
HUM	Habitat Utilization model
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IALA	International Association of marine aids to navigation and Lighthouse Authorities

Acronym	Definition
IBM	Individual Based Model
IECS	Institute of Estuarine and Coastal Studies
IPC	Infrastructure Planning Commission (now the Planning Inspectorate)
JNCC	Joint Nature Conservation Committee
JUV	Jack Up Vessel
LAT	Lowest Astronomical Tide
MAT	Migration Assessment Tool
MCA	Maritime and Coastguard Agency
MDS	Maximum Design Scenario
MERP	Marine Ecosystems Research Programme
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MPS	Marine Policy Statement
MRSea	Marine Renewables Strategic Environmental Assessment
MSFD	Marine Strategy Framework Directive
MSL	Mean Sea Level
MSS	Marine Scotland Science
NEWS	Non-Estuarine Waterbird Survey
NMC	Non-Material Change
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
ORJIP	Offshore Renewables Joint Industry Programme
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OSS	Offshore Substation
OWEZ	Egmond aan Zee Offshore Wind Farm
OWF	Offshore Wind Farm
PBR	Potential Biological Removal
PCH	Proportion of Birds at Potential Collision Risk Height
PEIR	Preliminary Environmental Information Report
PEMMP	Project Environmental Management and Monitoring Plan
PINS	Planning Inspectorate
pSPA	Potential Special Protection Area
PVA	Population Viability Analysis
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
SD	Standard Deviation
SeaMaST	Seabird Mapping and Sensitivity Tool
SMP	Seabird Monitoring Programme
SNCB	Statutory Nature Conservation Body
SoS	Secretary of State
SOSS	Strategic Ornithological Support Services
SPA	Special Protection Area
SSSIs	Sites of Special Scientific Interest
UD	Utilisation Distribution
UK	United Kingdom

Acronym	Definition
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 Orsted Hornsea Project Four Limited (hereafter the 'Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four') which will be located approximately 69 km from the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume A1, Chapter 1: Introduction** for further details on the Hornsea Zone). 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 A1, Chapter 4: Project Description** for full details on the Project Design).

5.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has given due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

5.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the array area taken forward at the point of DCO application. Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is summarised in **Section 5.5.1** with respect to offshore ornithology considerations and detailed more widely in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

5.1.1.4 This chapter of the ES presents the results of the EIA for the potential impacts of Hornsea Four on offshore and intertidal ornithology. Specifically, this chapter considers the potential impact of Hornsea Four on birds within the array area (plus 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 A3, Chapter 3: Ecology and Nature Conservation**.

5.1.1.5 This chapter summarises information contained within the following technical reports:

- **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**;
- **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis**;
- **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**;
- **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis**;
- **Volume A5, Annex 5.5: Offshore Ornithology Migratory Birds Report**; and
- **Volume A5, Annex 5.6: Offshore Ornithology MRSea Report**.

5.2 Purpose

5.2.1.1 The primary purpose of the ES is to support the DCO application for Hornsea Four under the Planning Act 2008 (the 2008 Act).

5.2.1.2 The ES has been finalised following the completion of the pre-application consultation (see **B1.1: Consultation Report** and **Table 5.4**) and will accompany the application to the Planning Inspectorate (PINS) for Development Consent.

5.2.1.3 This ES chapter:

- Summarises 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;
- Identifies any assumptions and limitations encountered in compiling the environmental information; and
- Highlights any necessary monitoring and/or mitigation measures which could avoid, prevent, reduce or offset the possible environmental effects identified in the EIA process.

5.3 Planning, Policy and Legislative Context

5.3.1 Overarching National Policy Statement

5.3.1.1 Planning policy 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 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 ES
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 or geological conservation 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 Hornsea Four is presented in **B2.2 Report to Inform Appropriate Assessment**.
EN-1 Paragraph 5.3.6 – states that the Infrastructure Planning Commission (IPC) [hereafter the Secretary of State (SoS)] *"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*	Hornsea Four will deliver benefits as a nationally significant renewable energy infrastructure development (**F1.6: Statement of Need**) and does include benefits for bird biodiversity interests. Climate change is a significant threat

Summary of NPS EN-1 and EN-3 scope provisions with respect to Offshore and Intertidal Ornithology	How and where considered in the ES
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."	to bird biodiversity interests (Pearce-Higgins & Crick 2019). Hornsea Four will deliver in the region of 2.6 GW of renewable energy (**Volume A1, Chapter 4: Project Description**), contributing to the UK Government's target of producing 40GW of renewable energy from offshore wind by 2030 and achieving net zero by 2050 (BEIS 2020). The weighting of benefit versus harm is addressed in the **F1.1 Planning Statement**.
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 (such as the reduction in the developable area (Co87) and the increase lower air draft for turbine blades (Co138) as detailed in the commitments listed in **Section 5.8.2**) and consideration of reasonable alternatives (as detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives**).
EN-1 Paragraph 5.3.8 – intimates that *"the [SoS] 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 considered 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 assessment of the potential for Hornsea Four to impact protected sites is presented in **B2.2 Report to Inform Appropriate Assessment**.
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 considered in **Section 5.7.3.** More details of the biodiversity features of protected sites are given in **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**. Assessment of the potential effects of Hornsea Four on the features of these protected sites is provided in **Section 5.10**. Further assessment of the potential for Hornsea Four to impact protected sites is presented in **B2.2 Report to Inform Appropriate Assessment**.
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 [SoS] 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 the commitments listed in **Section 5.8.2**.
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. Relevant legislation is detailed in **Section 5.3**. Where relevant, this legislation is taken into account in

Summary of NPS EN-1 and EN-3 scope provisions with respect to Offshore and Intertidal Ornithology	How and where considered in the ES
	the impact assessments as detailed in the assessment methodology given in **Section 5.10**.
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 [SoS] 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 [SoS] should give substantial weight to any such harm to the detriment of biodiversity features of national or regional importance which it considers may result from a proposed development."*	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. Relevant species and habitats are identified in **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report.** 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 as part of the consenting process, as detailed in the commitments listed in **Section 5.8.2**. Any residual impacts are assessed and described in **Sections 5.11, 5.12** and **5.13**. Climate change is a significant threat to bird biodiversity interests (Pearce-Higgins & Crick 2019). Hornsea Four will deliver in the region of 2.6 GW of renewable energy (**Volume A1, Chapter 4: Project Description**), contributing to the UK Government's target of producing 40GW of renewable energy from offshore wind by 2030 and achieving net zero by 2050 (BEIS 2020), as outlined in **F1.1: Planning Statement** and **F1.6: Statement of Need**.
EN-1 Paragraph 5.3.18 – states that EIAs should include effects on and opportunities to enhance and mitigation for biodiversity	Potential effects 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 (DAA) (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…"*	Potential impacts from all stages of the lifespan of Hornsea Four are assessed; during construction (**Section 5.11.1**), operation and maintenance (**Section 5.11.2**) and decommissioning (**Section 5.11.3**).
EN-3 Paragraph 2.6.65 - states that the *"Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate."*	Hornsea Four has carried out formal and informal consultation with statutory consultees and other stakeholders as described in **Section 5.4** and responses, including discussion of the assessment methodologies, are given in **Table 5.4**.
EN-3 Paragraph 2.6.66 - states that the *"Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational offshore wind farms should be referred to where appropriate."*	All relevant data sources, including data that has been collected as part of post-construction monitoring of other windfarms, have been identified in **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation**

Summary of NPS EN-1 and EN-3 scope provisions with respect to Offshore and Intertidal Ornithology	How and where considered in the ES
	Report, and those data have informed the impact assessments carried out in Sections 5.11, 5.12 and 5.13.
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;* • *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."*	These impacts are assessed in Section 5.10.
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 (OFF-ORN-1.18) with Natural England and Royal Society for the Protection of Birds (RSPB) through the EP 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 (OWFs) has been referred to in the Hornsea Four EIA including this chapter Volume A2, Chapter 5: Offshore and Intertidal Ornithology and B2.2 Report to Inform Appropriate Assessment. 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 EIAs should include all project stages, consultation regarding survey data and Collision Risk Model (CRM) assessments.	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 EIA through the consultation process detailed in Section 5.4. The survey methods and CRM parameters were discussed and agreed with Natural England through the EP Process (see Section 5.4). Potential impacts from collision risk are presented and assessed in Section 5.11.2.

5.3.1.3 NPS EN-3 also highlights 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 ES
NPS EN-3 Paragraph 2.6.68 – states that *"the [SoS] 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 **Sections 5.11**, **5.12** and **5.13**.
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 the national site network, including through commitments to minimise impacts as detailed in **Section 5.8.2**. Further assessment regarding impacts on the national site network is detailed in **B2.2 Report to Inform Appropriate Assessment**.
NPS EN-3 Paragraph 2.6.70– states that *"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 the national site network, including through the commitments detailed in **Section 5.8.2**.
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 then be mitigated and to enable further useful information to be published relevant to future projects."*	Future monitoring has been considered within the Hornsea Four assessment and presented within **F2.19: Outline Ornithological Monitoring Plan**.
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. Commitments to minimise the impacts of lighting are given in **Section 5.8.2**, primarily Co87. Assessment of the residual impact of lighting is given in **paragraphs 5.11.2.162** to **5.11.2.170**.
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 (Co87). The process of assessing the developable area and the changes accommodated between Scoping and the PEIR and then between PEIR and final DCO Application are described in **Section 5.5.1**. Further commitments to minimise the risk of collision, including raising the minimum blade tip height (Co138), are given in **Section 5.8.2**.
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.

Summary of EN-3 decision making relevant provisions with regards to Offshore and Intertidal Ornithology	How and where considered in the ES
	Relevant commitments (Co88) are given in **Section 5.8.2**.
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 (**Sections 5.11**, **5.12** and **5.13**).

5.3.2 Other Relevant Policies

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

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

5.3.2.3 Guidance provided within the Marine Strategy Framework Directive (MSFD), which was implemented in the UK by the Marine Strategy Regulations 2010/1627, has also been considered in the Hornsea Four assessment for offshore ornithology. The overarching goal of the MSFD was to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment. To this end, Annex I of the Directive identifies 11 high level qualitative descriptors for determining GES. Those descriptors relevant to the offshore ornithology assessment for Hornsea Four are listed in **Table 5.3** including a brief description of how and where these have been addressed in the assessment. With respect to bird populations, the UK has achieved its aim of GES for non-breeding waterbirds in the Greater North Sea, but not in the Celtic Seas (DEFRA 2019). Some populations of seabirds are achieving GES, such as gannet, cormorant and auks, but most of the UK marine bird populations are not achieving GES. The reasons for not achieving the GES are stated as being poorly understood in the updated assessment of GES (DEFRA 2019), though it is suggested that it is likely to be a combination of the effects of climate change and human activity.

Table 5.3: Summary of the Marine Strategy Framework Directive's (MSFD) high level descriptors of Good Environmental Status (GES) relevant to offshore ornithology and consideration in the Hornsea Four assessment.

Summary of MSFD high level descriptors of GES relevant to offshore ornithology	How and where considered within the Environmental Statement
Descriptor 1: Biological diversity Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.	The effects on biological diversity have been described and considered within the assessment for Hornsea Four alone and in the Cumulative Effects Assessment (CEA) (see **Sections 5.11** and **5.12** respectively).
Descriptor 4: Elements of marine food webs All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long term abundance of the species and the retention of their full reproductive capacity.	The effects on biological diversity have been described and considered within the assessment for Hornsea Four alone and in the CEA (see **Sections 5.11** and **5.12** respectively).
Descriptor 6: Sea floor integrity Seafloor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.	The indirect effects as a result of impacts on benthic ecology and on fish and shellfish ecology that may affect offshore ornithological receptors have been described and considered within the assessment for Hornsea Four alone and in the CEA (see **Sections 5.11** and **5.12** respectively).
Descriptor 8: Contaminants Concentrations of contaminants are at levels not giving rise to pollution effects.	The effects of contaminants on offshore ornithology are expected to be negligible and have been scoped out of assessment within this report in line with the approach to proportionate assessment (Orsted 2018).
Descriptor 10: Marine litter Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	A Code of Construction Practice (CoCP) will be developed and implemented to cover the construction phase and an appropriate Project Environmental Management and Monitoring Plan (PEMMP) will be produced and followed to cover the operation and maintenance phase of Hornsea Four. The latter will include planning for accidental spills, address all potential contaminant releases and include key emergency contact details (e.g. the Environmental Agency, Natural England and Maritime and Coastguard Agency (MCA)). A Decommissioning Programme will be developed to cover the decommissioning phase (see **Section 5.11**).
Descriptor 11: Energy including Underwater Noise Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	The effects of underwater noise on offshore ornithology have been assessed as indirect impacts through effects on habitats and prey species (see **Section 5.11**).

5.3.3 International Conventions

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

5.3.3.2 Statutory protection for wild birds and the habitats that support them is provided for by national legislation which originally implemented key European Union (EU) directives. Within the EU, 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').

5.3.3.3 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.

5.3.3.4 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 UK through the Conservation of Habitats and Species Regulations 2017 and the Conservation of Offshore Marine Habitats and Species Regulations 2017 for waters beyond 12 nm and form part of the UK's national law.

5.3.3.5 The Conservation of Habitats and Species Regulations 2017 (hereafter called the 'Habitats Regulations') transposed 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 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 SoS).

5.3.3.6 The Conservation of Offshore Marine Habitats and Species Regulations 2017 (hereafter called the 'Offshore Regulations') transposed 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 SoS).

5.3.3.7 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.

5.3.3.8 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, the EIA scoping process (Orsted 2018) and formal Section 42 and Section 47 consultation, informed by the production of the PEIR. An overview of the project consultation process is presented in **Volume A1, Chapter 6: Consultation**.

5.4.1.2 The consideration of offshore and intertidal ornithology for Hornsea Four has been discussed with consultees through the Hornsea Four Evidence Plan (EP) process; specifically, with the Offshore and Intertidal Ornithology EP Technical Panel (hereafter EP Technical Panel) of which Natural England and the RSPB are members. Agreements made with consultees within the EP process are set out in the topic specific EP Logs which are appendices to the Hornsea Four Evidence Plan (**B1.1.1: Evidence Plan**), an annex of the Hornsea Four Consultation Report (**B1.1: Consultation Report**). All agreements within the EP Logs have unique identifier codes which have been used throughout this document to signpost to the specific agreements made (e.g. OFF-ORN-2.1).

5.4.1.3 A summary of the key issues raised during consultation, specific to Offshore and Intertidal Ornithology is outlined in **Table 5.4**, together with how these issues have been considered in the production of this ES.

Table 5.4: Consultation Responses.

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
Natural England and RSPB	12 September 2018 EP Technical Panel Meeting 1	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.	Tracking studies and data have been incorporated **Section 5.7** (Baseline Environment) and **Section 5.10** (Impact Assessment).
Natural England and RSPB	12 September 2018 EP Technical Panel Meeting 1	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.	Non-breeding species and seasons are considered in **Section 5.6.1** (Biological seasons, populations and demographics for offshore ornithology receptors) and **Section 5.10** (Impact Assessment) (OFF-ORN-2.1).
Natural England and RSPB	12 September 2018 EP Technical Panel Meeting 1	Requested that further data be provided on migrant non-seabird assessments before agreement could be reached on scoping out of future assessment.	Migratory non-seabirds are considered in detail in **Volume A5, Annex 5.5: Offshore Ornithology Migratory Birds Report**, **Section 5.7** (Baseline Environment) with a summary of the results presented in **Section 5.10** (Impact Assessment).
Natural England and RSPB	12 September 2018 EP Technical Panel Meeting 1	Agreed that a 24-month survey period was standard and was pleased that the project had this ahead of Scoping.	The Evidence Plan Technical Panel agreed (OFF-ORN-1.19) that the 24 months of aerial digital survey data collected for Hornsea Four are fit for the purpose of baseline characterisation and use in impact assessments, as described in **Section 5.5.2** (Site-Specific Surveys).
Natural England and RSPB	12 September 2018	Request that all population estimates are provided with information on precision to allow Natural England and the RSPB to	Information relating to precision is presented in **Volume A5, Annex 5.1: Offshore and Intertidal**

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
	EP Technical Panel Meeting 1	judge what reliance can be placed on the population estimate.	**Ornithology Baseline Characterisation Report** and **Volume A5, Annex 5.6: Offshore Ornithology MRSea Report** where applicable.
Natural England and RSPB	12 September 2018 EP Technical Panel Meeting 1	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 approach to individual species-specific bio-seasons in the draft RIAA and final EIA Report. Both Natural England and the RSPB agreed in principle to this approach (OFF-ORN-2.2).	This is addressed throughout the ES, including **Section 5.6.1** (Biological seasons, populations and demographics for offshore ornithology receptors) and **Section 5.10** (Impact Assessment).
RSPB	17 September 2018 EP Technical Panel Meeting 2	RSPB agreed for the intertidal section to consider sanderling alone (OFF-ORN-2.6). RSPB noted that additional data from further two cameras would be beneficial and supported the undertaking of precision analysis Marine Renewables Strategic Environmental Assessment (MRSea) to investigate precision and aid the DAA process.	The impacts on sanderling are considered in **Section 5.11.1.49.** A review of additional two camera analysis was undertaken and found that the two camera dataset was sufficient for defining the baseline conditions (OFF-ORN-1.19). The results of the MRSea analysis are presented in **Volume A5, Annex 5.6: Offshore Ornithology MRSea Report**.
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 Seabird Mapping & Sensitivity Tool (SeaMaST), to fully characterise the importance of the Hornsea Project Four site for SPA species.	These data and literature are considered within **Volume A5, 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.	A review of potential impacts on migrating seabirds and non-seabirds is presented in **Volume A5, Annex 5.5: Offshore Ornithology Migratory Birds Report** and the findings summarised in **Section 5.10**.
Natural England	13 November 2018	Natural England questioned whether it is appropriate to scope out intertidal ornithology without further data being made	Impacts on intertidal ornithology (specifically sanderling) are considered within **Section 5.10**

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
	Scoping Opinion	available, due to the Yorkshire Naturalist Union (YNU) reports specifying nationally important numbers of sanderling within the intertidal area.	(Impact Assessment) and further intertidal data presented in **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**.
Natural England	13 November 2018 Scoping Opinion	Requested precision of population estimates before being able to conclude that the stated minimum 10% Digital Aerial Survey (DAS) coverage is sufficient.	Information relating to precision is presented in **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report** and **Volume A5, Annex 5.6: Offshore Ornithology MRSea Report.**
Natural England	13 November 2018 Scoping Opinion	Requested a 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), the view is that it would be more appropriate to scope such impacts in.	Consideration of potential indirect impacts is presented within **Section 5.10** (Impact Assessment).
Natural England	13 November 2018 Scoping Opinion	Requested scoping in of the potential impacts of construction and operational phase lighting from turbines and associated structures on offshore ornithology receptors (including migratory passerines).	Consideration of the potential impacts from lit structures on birds is presented within **Section 5.10** (Impact Assessment).
Natural England	13 November 2018 Scoping Opinion	A buffer zone around the ECC 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. 2016, SeaMaST, and Marine Ecosystems Research Programme (MERP) density maps.	Potential impacts on red-throated diver out to a 2 km buffer surrounding cable laying activities within the ECC (making use of SeaMaST data) is presented within **Section 5.10** (Impact Assessment).
Natural England and RSPB	10 April 2019 EP Technical Panel Meeting 3	Natural England confirmed outputs from the deterministic use of the MSS sCRM tool could be used provided the issues of flight height data >300m were addressed, and that the variance between the MSS model outputs and the Band (2012) outputs are shown to be negligible. [OFF-ORN-2.38] Natural England confirmed that they have not shifted from the use of the avoidance rates set out in the Statutory Nature Conservation Bodies (SNCB) guidance for	The collision risk modelling input parameters and justification are detailed in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**. With respect to flight heights above 300m, this issue was resolved at EP#9 concluding height bands between 300 – 500m should be set as zero.

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		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. Agreed the DAS methodology is acceptable, if clearly demonstrated in the baseline technical report (OFF-ORN-1.7).	Further consultation on the accuracy of the sCRM in comparison to the Band 2012 with Natural England and DMP stats concluded negligible differences between the results from the two models (OFF-ORN-2.26).. Dates, timings and methodology of the aerial digital surveys are detailed in **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**. Cumulative collision risk species selection and impacts are addressed in **Section 5.12**.
Natural England and RSPB	11 June 2019 EP Technical Panel Meeting 4	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. Natural England did highlight that the only query is about the amount of data that is being used (10% and not the 20% collected).	Any concerns regarding the baseline data has been ratified through the EP Process, concluding that analysis of the 20% collected would not make a difference to the overall confidence (OFF-ORN-1.19).
Natural England	11 June 2019 EP Technical Panel Meeting 4	Natural England agreed 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, Natural England 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.	A 'benchmark' method was used to calculate the number of red-throated divers at risk, details of which can be found in **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis** (OFF-ORN-2.39).
Natural England and RSPB	11 June 2019 EP Technical Panel Meeting 4	Natural England and the RSPB recommended that a range of input parameters be modelled deterministically using the stochastic CRM (sCRM) for the five key species of note. Natural England's position in regard to recommended	The avoidance rates used for collision risk modelling are derived from JNCC et al. (2014) (OFF-ORN-2.9) as detailed in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		avoidance rates is to use those presented in the JNCC et al (2014).	
Natural England	23 September 2019 Section 42 Responses	Natural England requested clearer definition of the Rochdale envelope in relation to turbine specification for the worst-case scenario.	The maximum design scenarios for Hornsea Four can be found in Table 5.17.
Natural England	23 September 2019 Section 42 Responses	Natural England are not sure whether there is adequate sampling to characterise the baseline. This is due to the precision being consistently below (0.16) and removal of 54% of observations due to reduction in the AfL. To address this uncertainty Natural England have suggested analysis of the additional two camera data and producing model-based estimates over design-based estimates.	The Applicant addressed these concerns through the Evidence Plan process, agreeing that analysis of the 20% of data collected (compared to 10%) did not significantly change the results of baseline data and agree the baseline is fit for purpose (OFF-ORN-1.19). 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 5.6.2 (Site-Specific Surveys).
Natural England	23 September 2019 Section 42 Responses	Recommend revisiting and amending the seasonal definitions for species accordingly using only the seasons marked in bold for assessment only. Due to the nature of monthly data collection, puffin seasons may need to be interpreted as Breeding = April – July, and non-breeding = August – March	Biologically Defined Minimum Population Scale (BDMPS) bio-seasons presented in Table 5.11 have been amended accordingly.
Natural England	23 September 2019 Section 42 Responses	Greater clarity is needed over the determination of age ratios and the source reference used.	The method and sources used to calculate age ratios are provided in Section 5.7.5.
Natural England	23 September 2019 Section 42 Responses	For non-breeding birds apportionment within the breeding season, Natural England recommend following the approach used by Norfolk Boreas and Vanguard.	Non-breeding bird apportionment approach is presented in Section 5.7.5.
Natural England	23 September 2019 Section 42 Responses	Figures for the Flamborough and Filey Coast (FFC) SPA guillemot and razorbill feature appear to be incorrect due to the absence of Filey colony counts.	The FFC SPA guillemot and razorbill feature counts in Table 5.13 have been updated accordingly.
Natural England	23 September 2019 Section 42 Responses	Natural England do not agree with the use of the biogeographic population scale for assessment of annual regional impact.	Annual regional impacts in Section 5.11 and 5.12 have been assessed against both the biogeographic and largest BDMPS.
Natural England	23 September 2019 Section 42 Responses	Information is needed on the intended route of vessel and helicopter movements.	Currently details of sites are not confirmed, so the Maximum Design Scenario (MDS) provides an overview of possible locations. The location of potential construction

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
			and operation ports and harbours is presented in Figure 4.14 of **Volume A1, Chapter 4: Project Description**.
Natural England	23 September 2019 Section 42 Responses	Natural England query the usefulness of the Design Manual for Roads and Bridges (DMRB) matrix approach to EIA for an offshore wind farm and instead, recommend the use of Chartered Institute of Ecology and Environmental Assessment (CIEEM) (2018) guidance.	Justification in relation to the assessment methodology is provided in **Section 5.10**.
Natural England	23 September 2019 Section 42 Responses	Natural England disagree with the exclusion of gannet from assessment of displacement during construction as there will be the same displacement stimulus during the construction phase.	Gannet has now been included in construction phase displacement analysis presented in **Section 5.11**.
Natural England	23 September 2019 Section 42 Responses	The sensitivities to disturbance and displacement during the construction phase should be the same as the operational phase.	The Applicant does not agree that sensitivities should be the same for different potential impact pathways between construction and operations. An evidence led approach has been undertaken for this assessment as described in **Section 5.11.1**.
Natural England	23 September 2019 Section 42 Responses	Natural England do not agree with the construction assessment parameters currently advocated by the Applicant. Due to uncertainty regarding level of impact during the construction phase, Natural England suggested a simplistic assessment of 50% of the operational impact.	Construction phase displacement assessment in **Section 5.11** now follows the simplistic approach of 50% the operational impact.
Natural England	23 September 2019 Section 42 Responses	Displacement impact tables should be included for puffin and gannet as provided for the other auk species.	Displacement impact tables for puffin and gannet have been included in **Section 5.11**.
Natural England	23 September 2019 Section 42 Responses	The SeaMast tool was not designed to be used to calculate abundance estimates. Natural England recommend the tool be used to create a 'benchmarking' approach with a known area of red-throated diver density.	A detailed account of the 'benchmark' method used to calculate the number of red-throated divers at risk can be found in **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis**.
Natural England	23 September 2019 Section 42 Responses	Greater explanation is needed to the extent the ECC falls within the Greater Wash SPA.	The ECC will not fall within the Greater Wash SPA (Co86 in **Table 5.17**). A map was provided through the Evidence Plan Process by email on 13/11/2019 after Technical Panel Meeting 5 to illustrate the distances between

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
			the Greater Wash SPA boundary and the ECC.
Natural England	23 September 2019 Section 42 Responses	Natural England believe that sanderling sensitivity should be changed to moderate.	Justification for sanderling sensitivity is provided in **Section 5.1.1.1**.
Natural England	23 September 2019 Section 42 Responses	The joint SNCB Displacement advice (SNCB 2017) should be followed which states: - Seasonal impacts should be summed; - Displacement and collision impacts should be summed; - Annual mortality should be assess against the largest population scale in the annual cycle for EIA; - No gradient of impact should be applied for to the buffer zones; - Full displacement matrices should be presented, including the upper and lower confidence limits; and - Mortality levels should not vary between seasons. This applies for both Hornsea Four alone and cumulatively with other projects.	The updated displacement impact assessments in **Sections 5.11** and **5.12** follow the guidance set out in the Joint SNCB Displacement Advice (SNCB 2017). The Joint SNCB Displacement Advice (SNCB 2017) requests that a range of displacement values are used (e.g. 30% to 70% displacement for auk species) to assses potential impacts to be based on seabird abundances. It does not require the use of the upper and / or lower confidence limits of the abundance estimates to present additional displacement matrices within impacts assessments and as such these are not considered within this assessment.
Natural England	23 September 2019 Section 42 Responses	Provide justification for the sensitivity ratings and displacement rates presented for Hornsea Four alone and cumulatively with other projects.	The evidence base for sensitivity ratings and displacement rates can be found in **Section 5.11.2.**
Natural England	23 September 2019 Section 42 Responses	Natural England do not agree it is appropriate that no assessment of migration collisions has been undertaken.	An assessment of migratory collision risk is now included in **Sections 5.11.2**and **5.12.2**, with further details provided in **Volume A5, Annex 5.5: Offshore Ornithology Migratory Birds Report**.
Natural England	23 September 2019 Section 42 Responses	Natural England welcome the use of the sCRM. However, to ensure the model is running correctly, a robust audit trail and output comparison with the Band 2012 model should be provided.	Extensive testing of the sCRM has been conducted by the Applicant with agreement now gained that the model is fit for purpose with Natural England (OFF-ORN-2.26).
Natural England	23 September 2019 Section 42 Responses	Greater clarification is needed on the boat-based surveys used to calculate the Potential Collision Height (PCH) values. Furthermore, due to the PCH values being calculated from boat-based surveys and baseline data collected from aerial surveys it	The Applicant has used Band Option 2 results for assessments within **Sections 5.11.2** and **5.12.2**.

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		is not applicable to use Band Option 3 for assessment.	
Natural England	23 September 2019 Section 42 Responses	Natural England do not agree with the following parameters used for CRM assessment: - The avoidance rates and stand deviations presented to not follow the guidance set out in SNCB (2014), with the exception of gannet. - Clarification is needed on how the standard deviations around the species biometrics presented have been calculated for all species. - Kittiwake flight speed based on Masden (2015), Natural England advise that the Pennycuick (1987, 1997) and Alerstam et al. (2007) should be used for flight speeds until a full review of other literature sources has been completed. - The interpretation of the Garthe and Hüppop (2004) nocturnal activity rates, Natural England should a range of nocturnal activity factors should be considered.	The avoidance rates, flight speeds and nocturnal activity factors applied for all CRM assessments are now in line with the recommendations made by Natural England and have been agreed through the EP process (OFF-ORN-2.18, 2.19 and 2.20). Full details of each CRM assessment input parameters are detailed in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.
Natural England	23 September 2019 Section 42 Responses	Natural England require further clarification on the following aspects of the collision risk modelling input parameters: - How the Standard deviations have been calculated around the density estimates. - The number and MW of turbines used in the assessment. - What parameters are classified as the worst-case scenario Rochdale Envelope. - Clearer presentation of Natural England's CRM parameters.	The background to justification for the assessment of collision risk and a table summarising the difference between the Applicant's position and Natural England's position for each input parameter are detailed in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.
Natural England	23 September 2019 Section 42 Responses	Natural England do not agree with little gull not included for CRM, as the impact is needed to inform assessments of cumulative impacts; especially relating to Greater Wash SPA.	Little gull has been included in the migration collision risk analysis and impacts relating to the Greater Wash SPA have been addressed in **B2.2 Report to Inform Appropriate Assessment**.
Natural England	23 September 2019 Section 42 Responses	Greater consideration is needed of the effects of lighting impacts.	Consideration of lighting impacts is presented in **Section 5.11.2**.
Natural England	23 September 2019 Section 42 Responses	Ongoing concerns in relation to the baseline data for Hornsea Three should be flagged in assessments.	Any concerns regarding the baseline data has been ratified through the EP Process (OFF-ORN-1.19 & OFF-ORN-1.24).

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
Natural England	23 September 2019 Section 42 Responses	Methil, Kincaridne, Scroby Sands and Gunfleet Sands OWFs should be included in cumulative assessments.	These projects have now been included in assessments presented in **Section 5.12**.
Natural England	23 September 2019 Section 42 Responses	For cumulative assessment Natural England disagree with the following assessments being excluded: - Construction displacement - Gannet displacement - Gannet combined CRM and displacement - Large gull species collision risk - Migrant bird collision risk	Gannet displacement, gannet combined CRM and displacement, large gull species collision risk and migrant bird collision risk have now been included in **Section 5.12**. The justification for the exclusion of construction displacement is provided in **Section 5.12.1**.
Natural England	23 September 2019 Section 42 Responses	East Anglia One North and East Anglia Two projects should be included for cumulative assessments.	These projects have now been included in assessments presented in **Section 5.12**.
Natural England	23 September 2019 Section 42 Responses	More detail is needed on the scaling up / down of project abundances for displacement impacts out to a 2 km buffer.	Details on the derivation of all project figures for cumulative assessments is provided in **Section 5.12**.
Natural England	23 September 2019 Section 42 Responses	Natural England do not agree with the final figures for some projects used for cumulative collision risk assessment, welcoming further discussion on the matter through the Evidence Plan process.	The Applicant has sought agreement on the final cumulative figures presented in **Section 5.12** through the EP process. The values for latest cumulative assessment have been agreed up to the point of Norfolk Vanguard for consented projects (OFF-ORN-4.2 to 4.7) with updates based on those agreed by Natural England during the East Anglia One North and Two projects at Deadline 11 (SPR 2021).
Natural England	23 September 2019 Section 42 Responses	Natural England do not agree with the Population Viability Analysis (PVA) data sources used for cumulative collision impact assessments presented and advise that the applicant should run their own PVA analysis using the Natural England Seabird PVA Tool.	The Applicant has conducted PVA analysis using the Natural England Seabird PVA with details and methods provided in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis**.
Natural England	23 September 2019 Section 42 Responses	All recently announced 'extension' projects should be included in the projects screened in for cumulative assessment.	These projects have now been included in assessments presented in **Section 5.12**.
Natural England and RSPB	29 October 2019 EP Technical Panel Meeting 5	Natural England queried how the precision has been calculated for the comparison of two vs four cameras datasets. Natural England and RSPB requested further analysis of June 2016, June 2017, August 2016 and August 2017, as these were regarded as the key months in order to get a greater understanding of baseline data precision and variability.	Further analysis of two vs four camera datasets was undertaken and Natural England were content that the two camera dataset was sufficient to define the baseline conditions based on the review (OFF-ORN-1.19).

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
Natural England and RSPB	29 October 2019 EP Technical Panel Meeting 5	Natural England requested that alternatives to SeaMaST data should be used in conjunction with the SeaMaST dataset to 'Benchmark' red-throated diver densities and provide a scaled density against known figures.	A detailed account of the 'benchmark' method used to calculate the number of red-throated divers at risk can be found in **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis**.
Natural England and RSPB	29 October 2019 EP Technical Panel Meeting 5	Natural England advised that focus should be given to Band Option 2 (BO2) for CRM results instead of Band Option 3 (BO3) and Band Option 1 (BO1) due to reservations regarding the way in which site-specific flight heights had been calculated.	The Applicant has used BO2 results for assessments within **Sections 5.11.2** and **5.12.2**.
Natural England and RSPB	29 October 2019 EP Technical Panel Meeting 5	RSPB raised concerns regarding unresolved issues with the sCRM. To address these issues RSPB requested the applicant calculates CRM using the Band 2012 model, sCRM stochastically and sCRM deterministically for comparison.	The Applicant setup a supplementary EP meeting in relation to the use of the sCRM with the app developers and relevant SNCBs; a summary of the conclusions from that meeting are provided in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.
Natural England and RSPB	29 October 2019 EP Technical Panel Meeting 5	Natural England requested further explanation on how the confidence internals for the Bowgen & Cook Confidence Intervals (CIs) had been calculated.	Explanation as to how the collision risk modelling input parameters are derived can be found in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.
Natural England and RSPB	29 October 2019 EP Technical Panel Meeting 5	Natural England suggested that for calculating the Standard Deviation (SD) around density data, the Applicant could use nested bootstrapping and select randomly from each year to get a double bootstrapped estimate for the month.	The method used to calculate the SDs around density estimates is detailed in **Volume A5, Annex 5.1: Offshore Ornithology Baseline Characterisation Report**.
Natural England and RSPB	29 October 2019 EP Technical Panel Meeting 5	Natural England disagreed with a qualitative approach to migratory waterbirds assessment based on other OWFs in the area, stating that the issue is cumulative so a qualitative assessment would be insufficient for Natural England to conduct an adequate assessment.	A full quantitative assessment of migratory birds is presented in **Volume A5, Annex 5.5: Offshore Ornithology Migratory Birds Report**.
Natural England and RSPB	12 November 2019 EP Technical Panel Meeting 6	Both RSPB and Natural England stated that it would be useful to add text in relation as to why the DMRB matrix had been selected for assessment over other approaches.	The DMRB approach is presented alongside justification in **Volume A1, Chapter 5: Environmental Impact Assessment Methodology** and **Section 5.10**.
Natural England and RSPB	12 November 2019 EP Technical	Natural England requested that despite minimal impacts from Hornsea Four alone for herring gull and lesser black-backed gull that	The final results from the CRM (**Table 5.37**) determined that both herring gull and lesser black-

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
	Panel Meeting 6	cumulative and in-combination assessments should take place.	backed gull are at very low risk from Hornsea Four. This very low level of risk is considered to be of no material contribution to any cumulative impacts for these two species, so they are not assessed cumulatively. However, the CRM data presented in **Table 5.37** will be available for any future considerations of cumulative level effects for other plans and projects.
Natural England and RSPB	21 April 2020 EP Technical Panel Meeting 9	Natural England reiterated that Hornsea Four should follow their standard advice in regard to calculation of bio-season mean peaks. If Hornsea Four wish to use a different method for calculation of the bio-season mean peaks, then a clear rationale and justification would need to be presented.	The bio-season totals and calculation methods are presented in **Volume A5, Annex 5.1: Offshore Ornithology Baseline Characterisation Report** for key species.
Natural England and RSPB	21 April 2020 EP Technical Panel Meeting 9	As the intertidal landfall for Hornsea Four is not within a designated site, site specific surveys are not required. Natural England suggested that the applicant should look at the latest Yorkshire bird reports in-case they have additional information that could feed into intertidal assessments.	The latest Yorkshire bird reports (2015 and 2016) are summarised in **Volume A5, Annex 5.1: Offshore Ornithology Baseline Characterisation Report**.
Natural England and RSPB	9 June 2020 EP Technical Panel Meeting 10	Natural England queried why the 'Global' productivity rate had been selected for the PVA, suggesting that the Horswill and Robinson (2015) datasets might be more applicable. In any case whichever demographic rates are selected suitable justification will be needed as to why they were selected.	Final selected productivity rates and corresponding rationale is presented in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis Report**.
Natural England and RSPB	9 June 2020 EP Technical Panel Meeting 10	Narrative should be provided as to how age structures have been calculated within the ES for seabird demographic rates.	Explanation of how the demographic rates are calculated is presented in **Section 5.7.4**.
Natural England and RSPB	15 July 2020 EP Technical Panel Meeting 11	With the inclusion of the narrative regarding a reduction in the Order Limits it would be useful to include stating whether number of transect lines and coverage has been reduced due to the reduction in the array area, including the number of zonal transects used for generation of BO1 flight heights.	The MRSea modelling uses the original AfL datasets for abundance estimation as detailed in **Volume A5, Annex 5.6: Offshore Ornithology MRSea Report**. The data used for generating flight heights remains from the wider AfL plus 4 km buffer, so no change to the BO1 flight heights as a consequence of the reduced Order Limits.

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
Natural England and RSPB	15 July 2020 EP Technical Panel Meeting 11	Natural England advocated that assessments should be based on a range-based approach using the mean value and upper and lower CI in order to reduce the risk of false precision of using a single figure.	The use of a range-based approach has been incorporated within **Section 5.11.2** (displacement and collision risk), though final assessments are typically undertaken on the mean value in order to align with industry best practice.
Natural England and RSPB	15 July 2020 EP Technical Panel Meeting 11	For displacement analysis Natural England stated their preference for a range-based approaching using 30 – 70% displacement and up to 10% mortality for auk species and 60 – 80% displacement for gannet. Natural England stated that Hornsea Four are at liberty to present the figures that they consider to be the most appropriate with the evidence to support those figures, so long as the full matrix is provided.	Displacement matrices have been presented for Hornsea Four alone and cumulative assessments for all auk species within **Volume A5, Annex 5.2 Offshore Ornithology Displacement Analysis** and **Sections 5.11.2** and **5.12.2**.
Natural England and RSPB	15 July 2020 EP Technical Panel Meeting 11	Natural England queried how the numbers of birds at risk modelled in the PVA tool were derived, stating that the numbers modelled are lower than that presented in the Norfolk Boreas examinations. Natural England recommended comparing against the Natural England's Boreas submission for Deadline 4 and Deadline 8 for Vanguard.	The final cumulative assessment totals assessed against in **Volume A5, Annex 5.4 Offshore Ornithology Population Viability Analysis** are presented in **Section 5.12.2**, with narrative explaining how the values were derived.
Natural England	19 October 2020 EP Technical Panel Meeting 12	Natural England request that the upper and lower 95% CIs should be used for assessing displacement impacts within the ES.	The Applicant considers that sufficient precaution is included with the current assessments of displacement to not warrant consideration of upper (overly precautionary) or lower (under precautionary) levels and as such, has not provided for this request.
Natural England and RSPB	23 November 2020 EP Technical Panel Meeting 13	Natural England and RSPB confirmed that they are confident in the Hornsea Four baseline characterisation but to fully agree with the use of MRSea a couple of queries required answering. Natural England requested that further narrative was needed on smoothing terms, model testing and diagnostics.	Further insight in relation to the MRSea methodology and testing has been provided in **Volume A5, Annex 5.6: Offshore Ornithology MRSea Report**.
Natural England	04 March 2021 EP Technical Panel Meeting 14	Natural England recommended that when reviewing displacement rates observed from post construction monitoring of other OWFs it would be useful to use rates from comparable projects and ecologically similar areas of sea.	Further justifcation has been provided on the deriviation of auk displacement rates applicable for assessment as detailed in **Section 5.11.2**.

Consultee	Date, Document, Forum	Comment	Where addressed in the ES
		Natural England stated that there is no evidence regarding mortality rates and so a ranged based approach with understanding of level of risk is the best approach.	
Natural England	04 March 2021 EP Technical Panel Meeting 14	Natural England advise that both the counterfactuals of population growth and size should be presented for assessment purposes.	As detailed in **Volume A5, Annex 5.4 Offshore Ornithology Population Viability Analysis** the counterfactual of population size should not be used for assessments when using a density independent model as models can grow exponentially without any sort of denity dependence population regulation. Therefore, all PVA results assessed within this ES are based on the counterfactual of growth rate only.
Natural England advice note ref 357238, 21/06/2021	Natural England	Natural England provided detailed comments and recommendations based on drafts of the offshore ornithology ES, RIAA and associated annexes and appendices from early 2021. These documents were provided in order for Natural England to see how previous consultation and comments from 2020 had been incorporated and in order for their new advisors to review the project to this point in time.	These comments and recommendations are subject to further discussion between the Applicant and Natural England, as many of the assessments have been superceded inline with the comments made by Natural England in the final offshore ornithology ES Chapter, RIAA and associated annexes and appendices.

5.5 Study Area

5.5.1 Changes to the Array Area between Scoping and DCO Application

5.5.1.1 As set out in **Section 5.1**, the area for which Wind Turbine Generators (WTGs) are proposed to be developed for Hornsea Four (the array area) has been modified between the Scoping Report and DCO Application. The modifications through three separate developable area reviews, 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 (e.g. kittiwakes, *Rissa tridactyla*, gannets, *Morus bassanus*, and guillemots, *Uria aalge*) within the 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.

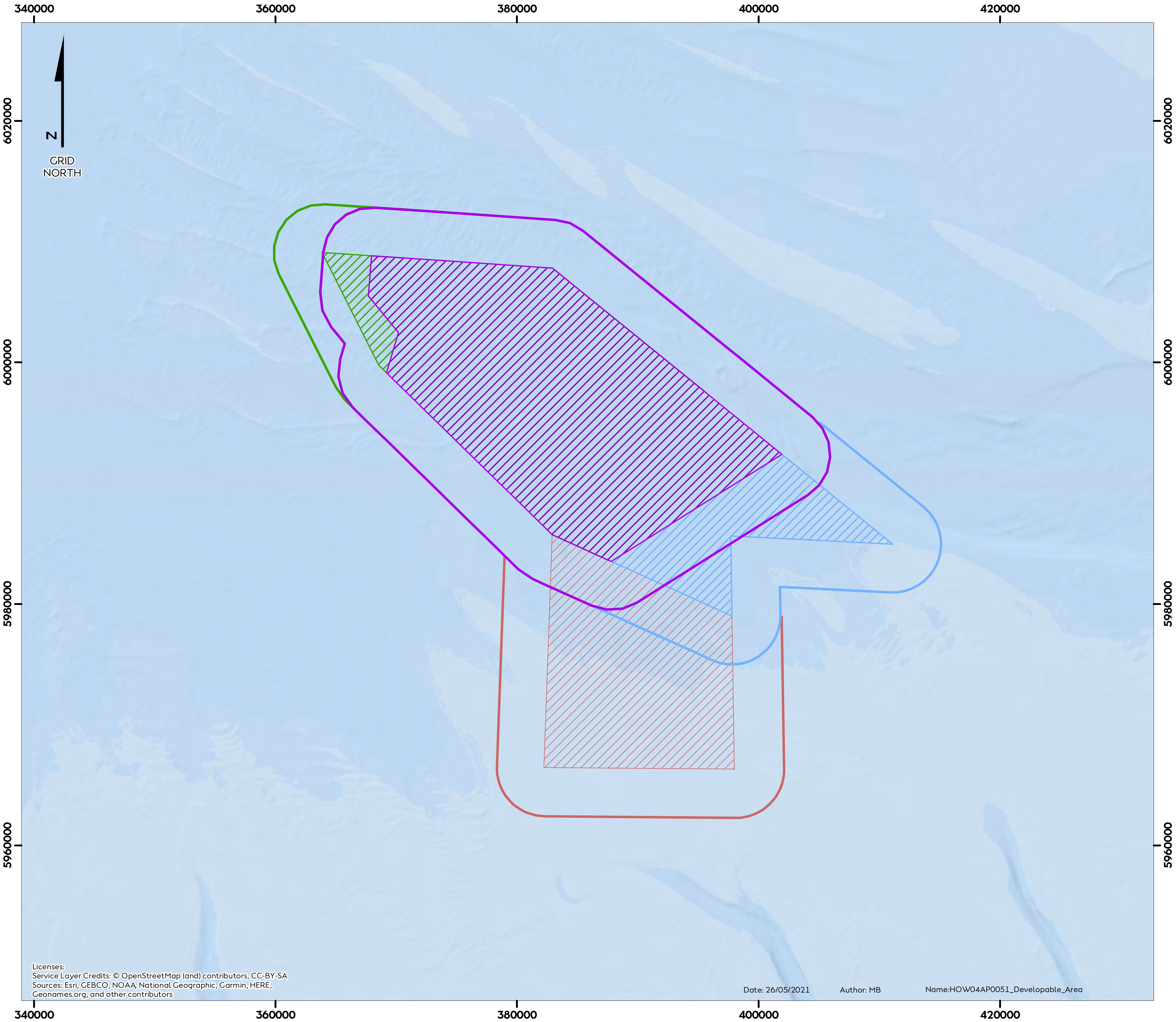
5.5.1.2 The species identified for analysis in this process (gannet, kittiwake and auk species) were selected as they were the most abundant within the AfL area and a 4 km buffer throughout 24 months of survey data and potentially most sensitive to impacts associated with the construction and operation 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 these species, and by way of reducing the array area to mitigate any potential adverse impacts from Hornsea Four.

5.5.1.3 Species-specific temporal patterns in usage of the AfL area were investigated by creating peak seasonal cumulative density distribution maps using the 24 months of site-specific data. For the species considered their densities for the months of March to September (extended breeding bio-season) were reviewed to refine the array area. Qualitative examination was used to determine whether patterns were recorded for these species during the breeding season and the non-breeding period.

5.5.1.4 The cumulative density of all species considered 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 species considered was relatively high in the southern part of the AfL area. Areas of relatively high concentrations also existed in the north-west and south-east corners of the AfL area but occurred in relatively lower densities than what was recorded in the southern part.

5.5.1.5 Overall, the highest relative density for all species considered combined occurred in the southern part (54% of all observations over the 24-month survey period for the 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 gannet, kittiwake and auk populations, such as the breeding colonies closest to Hornsea Four at the FFC SPA. Further consideration was provided to the in the higher densities of the key species found in the north-west and south-east corners of the AfL area The results of a further two DAA reviews resulted in two further areas being withdrawn from the developable area for Hornsea Four. By way of demonstrating the benefits of this process it is clear to see that the Hornsea Four array area now avoids the higher densities of kittiwakes (**Figure 5.2**) and auks combined (**Figure 5.3**), therefore reducing potential impacts on these and other species.

5.5.1.6 The DAA process has involved further consideration of project design, so as to reduce the risk to birds from collision with wind turbines through engineering solutions. One such measure has been to increase the air gap between the sea surface and the lowest swept area of the turbines (from a minimum of 35 m to 42.43 m measured against the Lowest Astronomical Tide (LAT) (see Co138 in **Table 5.17** or **Volume A4, Annex 5.2: Commitment Register**) in order to provide an increased space for birds to fly without the risk of colliding with wind turbines.



Hornsea Four

Figure 5.1

Evolution Of The Array Area
From Scoping To DCO Application

- DCO Array Area
- DCO Array Area Plus 4 km Buffer
- DAA2 Array Area (Dropped)
- DAA2 Array Area (Dropped) Plus 4 km Buffer
- PEIR Array Area (Dropped)
- PEIR Array Area (Dropped) 4 km Buffer
- Scoping Array Area (Dropped)
- Scoping Array Area (Dropped) 4 km Buffer

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:300,000

0 5 10 Kilometres

0 2 4 Nautical Miles

REV	REMARK	DATE
	First Issue	27/06/19
A	Updated following PIER consultations, for DCO	26/05/2021

Evolution Of The Array Area
From Scoping To DCO Application
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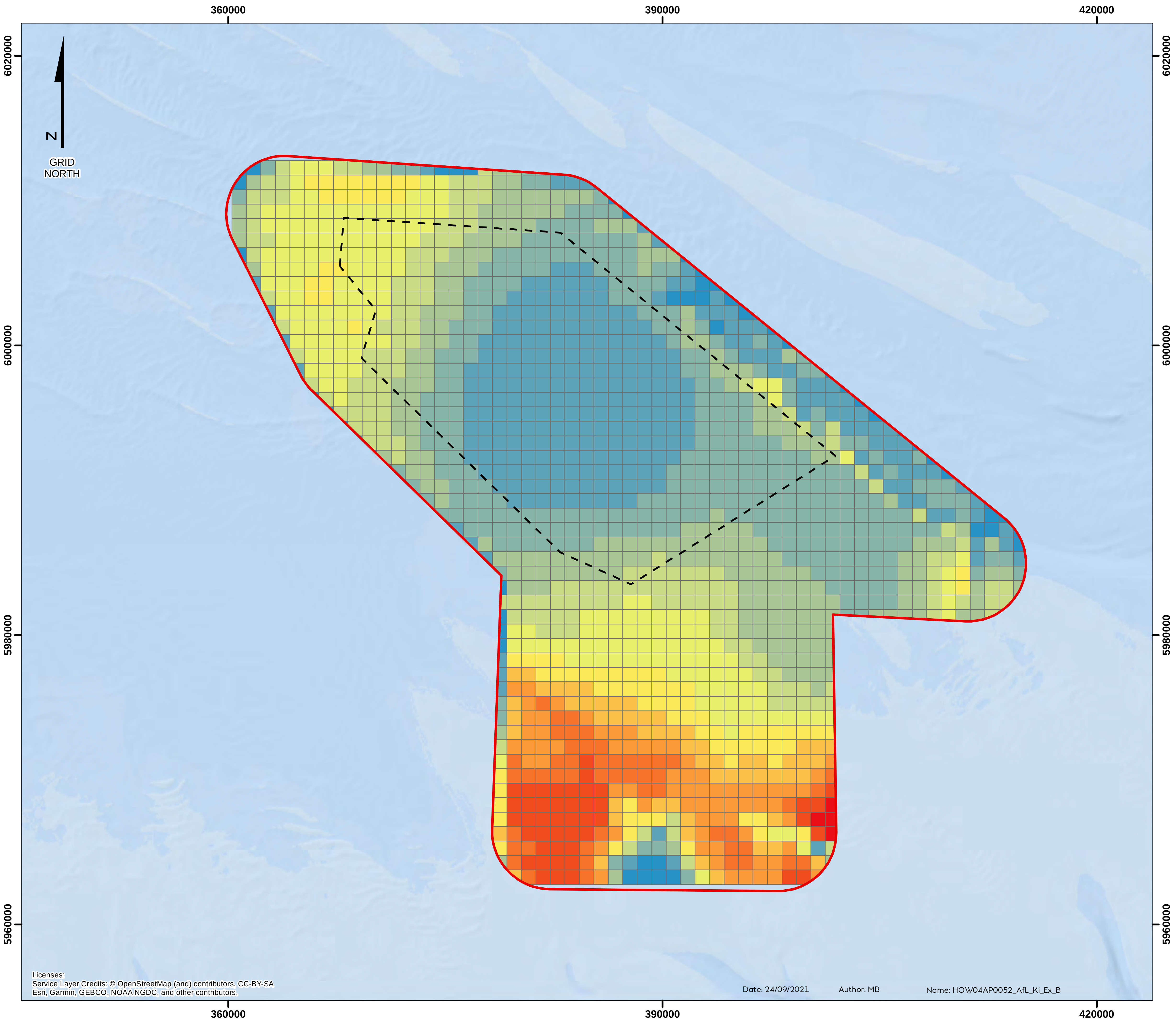

Hornsea Four

Figure 5.2

Predicted Density of All Kittiwakes for the Extended Breeding Bio-Season for the Entire AfL

Array Area

AfL Plus 4 km Buffer

Predicted Kittiwake Density (birds / km²)

- 0.00 - 0.88
- 0.89 - 1.95
- 1.96 - 2.97
- 2.98 - 4.15
- 4.16 - 5.82
- 5.82 - 7.87
- 7.87 - 10.88
- 10.89 - 14.97
- 14.97 - 19.52
- 19.52 - 24.29
- 24.30 - 30.27
- 30.28 - 49.16

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:250,000

0 5 10 Kilometres

0 2 4 Nautical Miles

REV	REMARK	DATE
	First Issue	24/09/2021

Predicted Density of All kittiwakes for the Extended Breeding Bio-season for the Entire AfL
Document no: HOW04AP0052
Created by: MB
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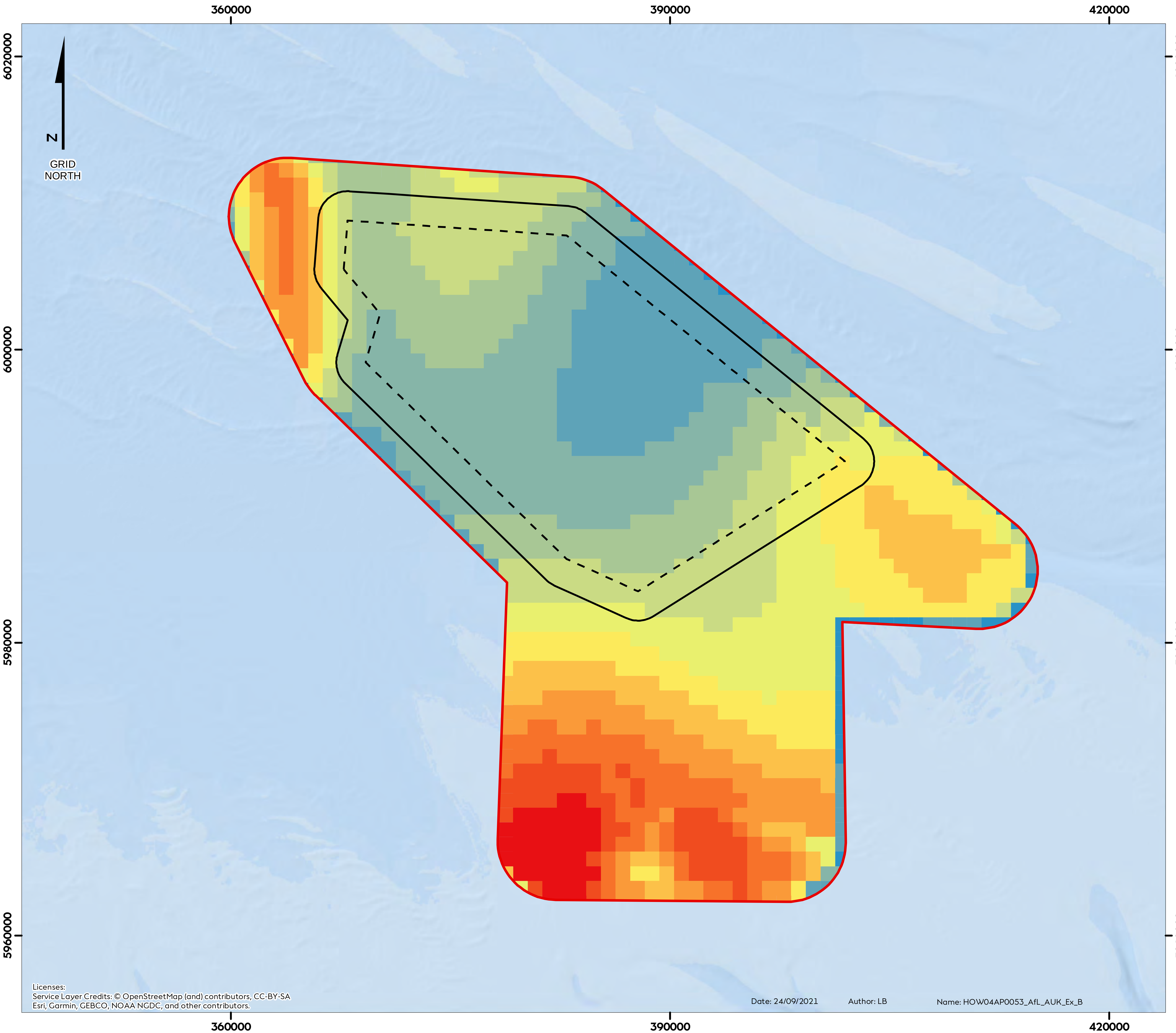
Approved by: SS



Hornsea Four

Figure 5.3

Predicted Density of All Auks for the Extended Breeding Bio-Season for the Entire AfL

Array Area

Array Area plus 2 km Buffer

AfL Plus 4 km Buffer

Predicted Auk Density (birds / km²)

- 0.00 - 5.11
- 5.12 - 10.08
- 10.09 - 13.14
- 13.15 - 16.37
- 16.38 - 20.06
- 20.07 - 24.49
- 24.50 - 29.18
- 29.19 - 34.73
- 34.74 - 41.28
- 41.29 - 48.68
- 48.69 - 58.52
- 58.53 - 73.91

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:250,000

0 5 10 Kilometres

0 2 4 Nautical Miles

REV	REMARK	DATE
	First Issue	24/09/2021

Predicted Density of All Auks for the Extended Breeding Bio-season for the Entire AfL
Document no: HOW04AP0053
Created by: LB
Checked by: MB
Approved by: SS

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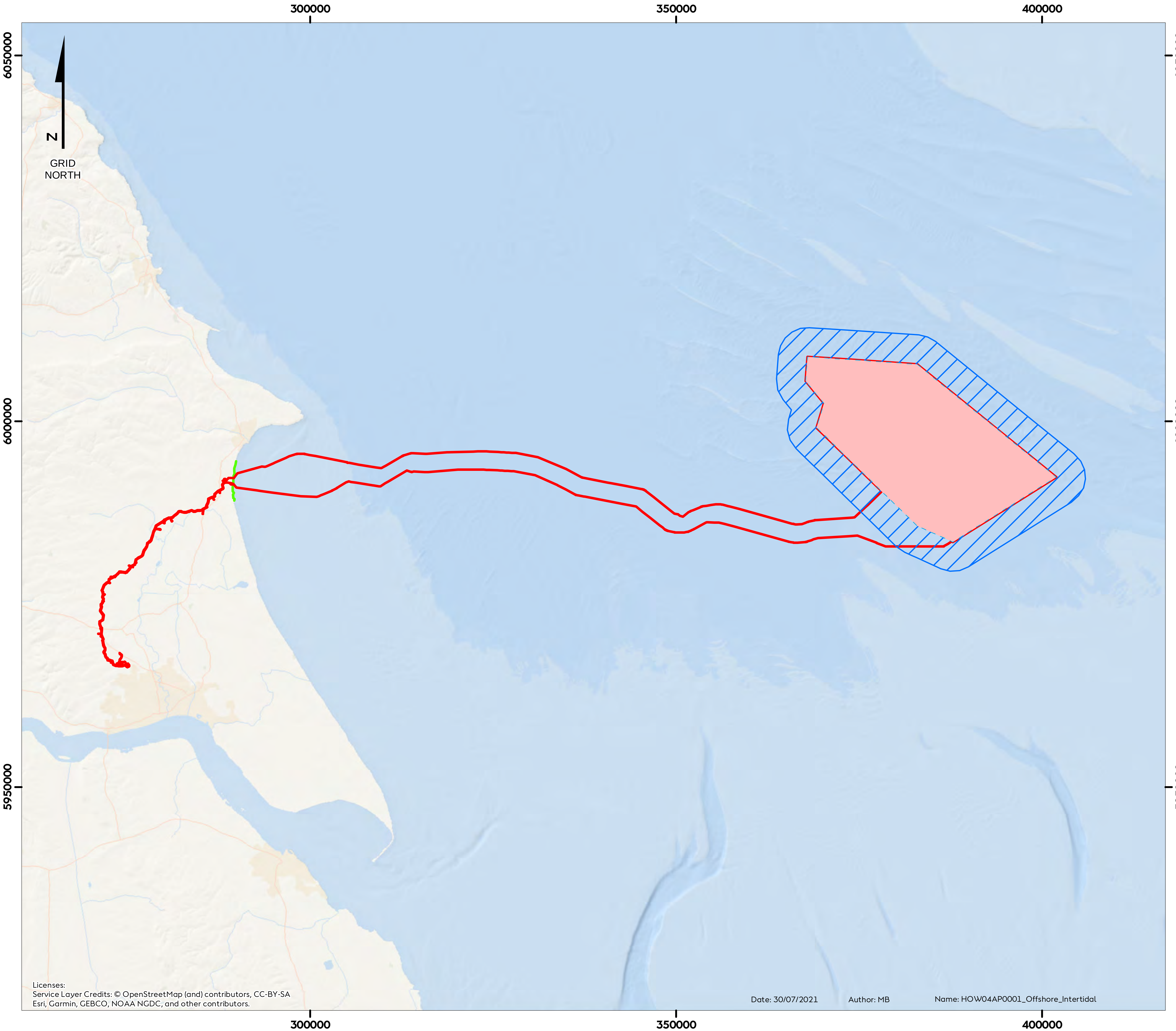
5.5.2 Study Area for Hornsea Four DCO Application

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 'Hornsea Four Offshore and Intertidal Ornithology Study Area' is delineated on **Figure 5.4** and specifically consists of the:

- Hornsea Four array area (and 4 km buffer): 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 (OSS) 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 MHWS and landward of MLWS where works, vehicles and plant machinery will be located for connecting the offshore ECC to the onshore ECC.

5.5.2.2 The limits and extent of the 'Hornsea Four Offshore and Intertidal Ornithology Study Area' were agreed as appropriate for the purpose of this assessment with Natural England and the RSPB through the EP process (OFF-ORN 1.5 – 1.8).

5.5.2.3 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.



Hornsea Four

Figure 5.4

The Hornsea Four Offshore and Intertidal Ornithology Study Area

- Array Area
- Array Area 4 km buffer
- Order Limits
- Intertidal Study Area

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
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A	Updated following PEIR consultations, for DCO	30/07/2021

The Hornsea Four Offshore and Intertidal Ornithology Study Area
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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 5.4**.

5.6.1.2 The sources of information given in **Table 5.5** below were consulted to obtain information on intertidal avifauna. Following confirmation through the Scoping Opinion (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 5.5: Key sources of information on intertidal avifauna used for Hornsea Four.

Source	Summary	Coverage of Hornsea Four array and ECC
British Trust for Ornithology (BTO) (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' (NEWS).	Each of the four winter surveys had consistent coverage of the stretch of coast from Hilderthorpe to Skipsea that coincides with the Hornsea Four Order Limits.
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 cable landfall area of the Hornsea Four Order Limits 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 Hornsea Four Order Limits and immediate surrounds.
Dogger Bank Creyke Beck (hereafter Dogger Bank A & B) 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 A & B survey area overlaps with some of the cable landfall area within the Hornsea Four Order Limits.

5.6.1.3 The sources of information on offshore avifauna given in **Table 5.6** below were consulted to characterise the wider region for the purpose of impact assessment as recommended in **Table 5.4** and agreed with Natural England and the RSPB.

Table 5.6: Key sources of information on offshore avifauna used for Hornsea Four.

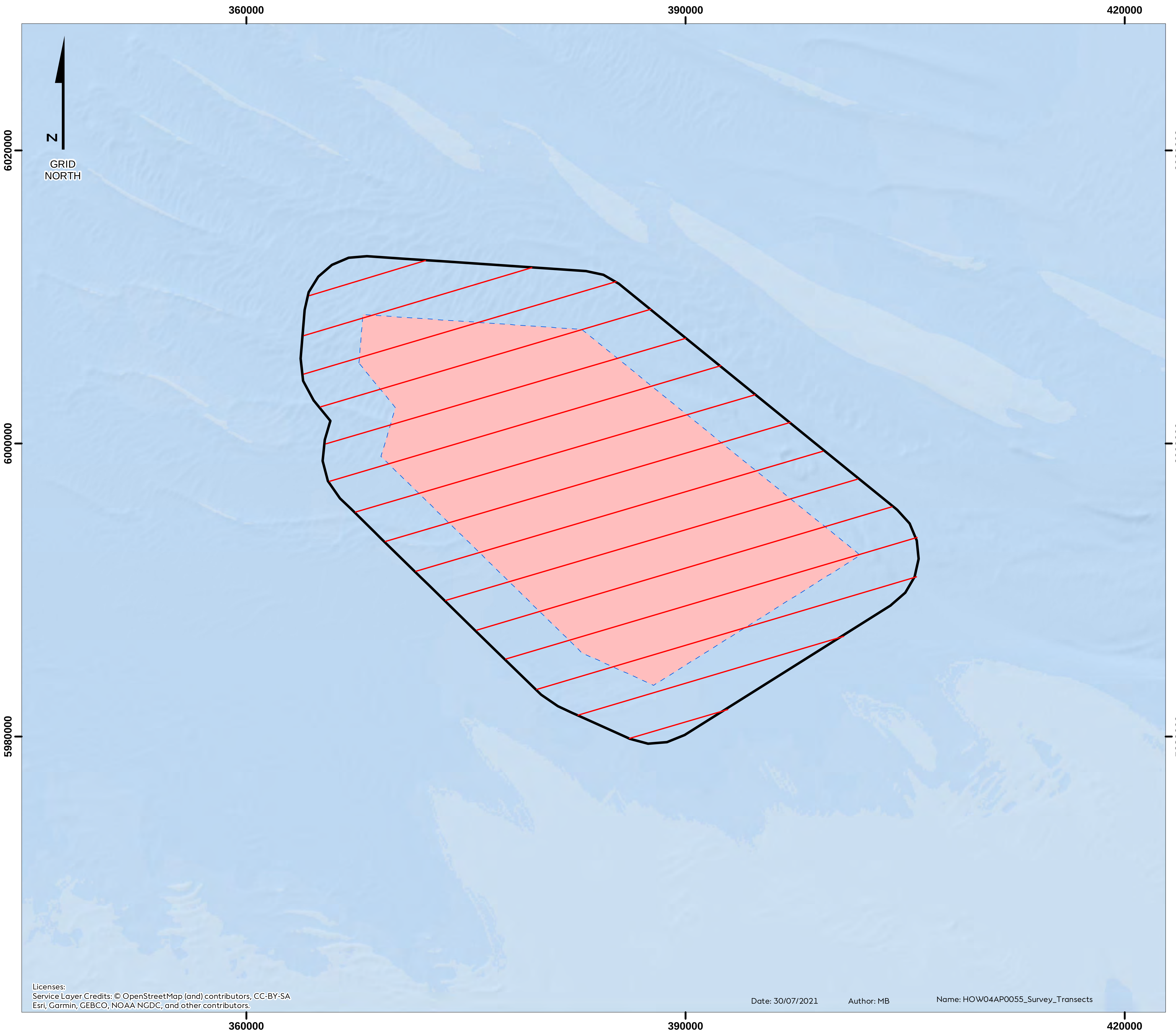
Title, year and reference	Summary	Relevance to Hornsea Four offshore ornithology receptors
Peer reviewed literature	Published, peer reviewed scientific papers on seabird behaviour and characteristics (e.g. Robinson 2018; Furness et al. 2018; Woodward et al. 2019; Dierschke et al. 2016; Cleasby et al. 2020 (OFF-ORN-2.52); Peschko et al. 2020).	These papers cover areas of marine waters or species of interest that are specific to Hornsea Four and other OWFs in the North Sea. Those studies conducted on a North Sea or UK waters basis are generally most relevant to the Hornsea Four array area and ECC.
OWF grey literature	Post-consent monitoring reports on seabirds and OWFs (e.g. Royal Haskoning 2013; Nelson et al. 2014; Vanermen et al. 2016 & 2017; APEM 2021).	These covered the array areas of particular OWFs plus a buffer, providing data and monitoring results for species relevant to Hornsea Four with respect to displacement rates and avoidance.
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 been 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; MERP (OFF-ORN-2.52); SeaMaST(OFF-ORN-2.52))	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 Wetland Bird Survey (WeBS) online 2019; Furness 2015 (OFF-ORN-2.1); 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 aerial digital surveys of the wider AfL area for the Hornsea Four array area plus 4 km buffer carried out between 2016 and 2018 (**Section 5.7.2**), from which the data relevant to this ES on the revised array area has been extracted (see **Figure 5.5**, and **Table 5.7**).

5.6.2.2 Supplementary data from aerial digital 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 5.7**.

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 5.4**). The technical and methodological detail is provided in **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report** and **Volume A5, Annex 5.6: Offshore Ornithology MRSea Report**).



Hornsea Four

Figure 5.5

Hornsea Four Offshore Ornithology Data Collection Transect Lines of Aerial Digital Surveys

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:250,000

0 5 10 Kilometres

0 2 4 Nautical Miles

REV	REMARK	DATE
	First Issue	22/05/2019
A	Updated following PEIR consultations, for DCO	30/07/2021

Hornsea Four Offshore Ornithology
Data Collection Transect Lines
of Aerial Digital Surveys
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Table 5.7: Summary of survey data (2010-2018) of relevance to Hornsea Four.

Title, year and reference	Summary	Relevance to Hornsea Four
Hornsea Four - aerial digital surveys	2018: Three monthly aerial digital surveys (video) carried at 2 cm Ground Sample Distance (GSD) out in January, February, March; 2017: Twelve monthly aerial digital surveys (video) carried out at 2 cm GSD January through December; and 2016: Nine aerial digital surveys (video) carried out at 2 cm GSD in April, June (two 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 Four Two vs Four Camera Analysis Report	Report commissioned to compare the precision between using two, three or all four camera datasets collected during the site-specific surveys for Hornsea Four, for 7 months selected and agreed with SNCBs (OFF-ORN-1.14). The report concluded that using all four cameras didn't sufficiently increase the precision of the data when compared to the two-camera analysis.	Report provided SNCBs with confidence that the use of two camera analysis was sufficient to inform the baseline characterisation of the Hornsea Four array area (OFF-ORN-1.19).
Hornsea Project Three Offshore Wind Farm (hereafter Hornsea Three) – aerial digital surveys	Aerial digital surveys (video) conducted monthly between April 2016 and November 2017, sampling 10% of the area and considering all recorded bird species. A further four Aerial digital surveys were conducted between January 2019 and March 2019 to make up a full 24 months of baseline data.	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) –aerial digital surveys	Twelve Aerial digital surveys (stills) between June 2012 and February 2013, sampling 10% of the Hornsea 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 – aerial digital surveys	Twelve Aerial digital surveys (stills) between June 2012 and February 2013, sampling 4% of the former Hornsea 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 Project 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.

Title, year and reference	Summary	Relevance to 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 Hornsea Zone.

5.7 Baseline Environment

5.7.1 Existing Baseline – Intertidal Ornithology

5.7.1.1 The existing baseline for the 'Hornsea Four Offshore and Intertidal Ornithology Study Area' provided as a desktop study for the receptors within the cable landfall and ECC areas (OFF-ORN-1.18) are provided in detail within **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report** and summarised in **Table 5.8**.

Table 5.8: Summary of existing baseline of intertidal avifauna for the Hornsea Four cable landfall and ECC derived from the desktop study.

Source	Summary
BTO (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 5.9**, 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 2007-2011 (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 recorded on migration or during the non-breeding (wintering period) are referred. Of those species recorded in peak numbers within the Yorkshire Bird Report 2012, 2013, 2015 and 2016 (Yorkshire Naturalists' Union, 2015, 2018, 2019 & 2020) common scoter, red-throated diver and sanderling were above the 1% of the national populations for the given season, though not on a regular basis, the common threshold for consideration within impact assessments. 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 A & B OWF surveys (Forewind 2013)	The peak counts of ten wintering waterbird species recorded in 2011/2012 are as follows: two oystercatcher, two ringed plover, two turnstone, one knot, eight sanderling, one bar-tailed godwit, 11 redshank, 15 black-headed gull, 593 common gull, 17 great black-backed gull.

Table 5.9: 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-backed gull	nc	nc	Nc	11-20	30	1,200
Herring gull	nc	nc	Nc	201-400	1,527	1,300
Great black-backed gull	nc	nc	Nc	3-30	147	760

Table note: nc = no count recorded

5.7.1.2 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 Ornithology

5.7.2.1 The existing baseline within Hornsea Four Offshore and Intertidal Ornithology Study Area for the receptors within the array area and a 4 km buffer is based on the most recent site-specific surveys (24 aerial digital surveys between April 2016 and March 2018) and is provided in detail within **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report** and summarised below.

5.7.2.2 A total of 24 bird species were recorded during the 24-month survey programme (**Table 5.10**). The findings of the 24-month survey programme identified the following key species (those recorded in the greatest abundance / density within the Hornsea Four array area and 4 km buffer): fulmar (*Fulmarus glacialis*), gannet, kittiwake, great black-backed gull (*Larus marinus)*, guillemot, razorbill (*Alca torda*) and puffin (*Fratercula arctica*).

5.7.2.3 Fulmars were recorded in all 24 aerial digital surveys within the Hornsea Four array area and 4 km buffer. Peak abundance within the array area occurred during the migration-free breeding bio-season (April to August) with an estimated mean peak abundance of 226 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 23 of the 24 aerial digital surveys and were loosely distributed throughout the Hornsea Four array area and 4 km buffer. Gannet peak abundance in the array area occurs during the post-breeding migration bio-season (September to November) with an estimated mean peak abundance of 593 birds and mean peak density of 1.261 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 541 birds and mean peak density of 1.295 birds/km². Lowest densities were observed in the return migration bio-season. The density increased from the migration-free breeding bio-season to the post-breeding migration bio-season with the highest densities in the southeast of the Hornsea Four array area bordering the 4 km buffer for both seasons.

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 array area during the post-breeding migration bio-season (August – December) with an estimated mean peak of 2,944 birds and mean peak density of 6.260 birds/km². Kittiwakes were loosely distributed throughout the Hornsea Four array area and 4 km buffer. Densities were lowest in the return migration bio-season, but increased slightly 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 Great black-backed gull were the most abundant large gull species. Great back-blacked gulls were recorded in 15 of the 24 aerial digital 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 post-breeding migration bio-season (August – November), with an estimated mean peak abundance of 209 birds and a mean peak density of 0.445 birds/km².

5.7.2.7 The most abundant species recorded in each of the 24 months of aerial digital surveys was guillemot. Abundance in the array area was highest during the post-breeding migration bio-season (July – October) with an estimated mean peak abundance of 21,519 birds and density of 45.760 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 25,157 birds and density of 60.154 birds/km². Guillemots were distributed throughout the Hornsea Four array area and 4 km buffer. Densities were lowest in the migration-free breeding and return migration bio-seasons, and 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 of the 24 aerial digital surveys within the Hornsea Four array area and 4 km buffer. Abundance peaked within the array area during the post-breeding migration bio-season (August – October) with an estimated mean peak abundance of 2,367 birds and a mean peak density of 5.033 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 2,695 birds and a mean peak density of 6.444 birds/km². Razorbills were loosely distributed throughout the Hornsea Four array area and 4 km buffer.

5.7.2.9 Puffins were recorded in 15 of the 24 monthly aerial digital surveys within the Hornsea Four array area and 4 km buffer. Puffins were loosely distributed in low densities. Abundance was highest in the array area during the post-breeding migration bio-season (July – August) with an estimated mean peak abundance of 222 birds and a mean peak density of 0.471 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 204 birds and a mean peak density of 0.488 birds/km².

5.7.2.10 Further species recorded in either very low abundance / densities and / or on only a very small number of occasions included; red-throated diver (*Gavia stellata*), Manx shearwater (*Puffinus puffinus*), lapwing (*Vanellus vanellus*), curlew (*Numenius arquata*), Arctic skua (*Stercorarius parasiticus*), great skua (*Stercorarius skua*), little gull (*Hydrocoloeus minutus*), black-headed gull (*Chroicocephalus ridibundus*), common gull (*Larus canus*), lesser black-backed gull (*Larus fuscus*), herring gull (*Larus argentatus*), Sandwich tern (*Thalasseus sandvicensis*), 'commic' tern (species group of common and Arctic tern), little auk (*Alle alle*), feral pigeon (*Columba livia domestica*) and starling (*Sturnus vulgaris*) (see **Table 5.10** below).

5.7.2.11 The desktop review of published sources of information on offshore avifauna (see **Table 5.10** 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).

5.7.2.12 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 5.10: Bird species recorded in site-specific aerial digital video surveys of the Hornsea Four study area (2016-2018); 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	'Commic' tern	Little auk	Starling
	Herring gull			
	Great black-backed gull			
	Lesser black-backed gull			

Table Note: 'Commic' tern represents tern sightings of unidentified Arctic tern and common tern.

5.7.2.13 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 are provided in **Volume A5, 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. For seven species (fulmar, gannet, kittiwake, great black-backed gull, guillemot, razorbill and puffin), the MRSea statistical package was used to model their spatial density distributions instead of design-based abundance estimates. A methodology for the MRSea analysis is provided in **Volume A5, Annex 5.6: Offshore Ornithology MRSea Report**. Other information collected during the surveys such as species spatial distribution, flight height, flight direction and age classification are also contained within the **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report**.

5.7.2.14 The species recorded during the aerial digital video surveys are those that have been assessed to consider the risk to the populations resulting from the 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, and biological characteristics that make them susceptible to impacts (such as, for example, species with flight distributions that have a high proportion within the rotor swept zone).

5.7.2.15 The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 require that "an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge" is included within the ES (EIA Regulations, Schedule 4, Paragraph 3). From the point of assessment, over the course of the development and operational lifetime of Hornsea Four (operational lifetime anticipated to be 35 years), long-term trends mean that the condition of the baseline environment is expected to evolve. **Section 5.7.5** provides a qualitative description of the evolution of the baseline environment, on the assumption that Hornsea Four is not constructed, using available information and scientific knowledge of offshore and intertidal ornithology.

5.7.2.16 In the event that Hornsea Four does not come forward, an assessment of the future baseline conditions has been carried out and is described within **Section 5.7.5**. A projection of the likely evolution of the baseline for species relevant to Hornsea Four is best assessed from the latest population trends. These are published by JNCC for seabirds, as part of the Seabird Monitoring Programme (SMP) (JNCC 2020), and by the BTO for waterbirds, as part of the WeBS Alerts (BTO 2020), as annual updates on population trends. A summary of these are presented in **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Technical Report**.

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 5.11** below.

Table 5.11: Summary of nature conservation value of species considered at risk of impacts.

Species	Conservation Status
Red-throated diver	BoCC4 Green listed (Eaton et al. 2015), Birds Directive Migratory Species, Birds Directive Annex 1
Fulmar	BoCC4 Amber listed, Birds Directive Migratory Species
Gannet	BoCC4 Amber listed, Birds Directive Migratory Species
Arctic skua	BoCC4 Red listed, Birds Directive Migratory Species
Great skua	BoCC4 Amber listed, Birds Directive Migratory Species
Kittiwake	BoCC4 Red listed, Birds Directive Migratory Species
Little gull	BoCC4 Green listed, Birds Directive Migratory Species
Lesser black-backed gull	BoCC4 Amber listed, Birds Directive Migratory Species
Herring gull	BoCC4 Red listed, Birds Directive Migratory Species
Great black-backed gull	BoCC4 Amber listed, Birds Directive Migratory Species
Common tern	BoCC4 Amber listed, Birds Directive Migratory Species, Birds Directive Annex 1
Arctic tern	BoCC4 Amber listed, Birds Directive Migratory Species, Birds Directive Annex 1
Guillemot	BoCC4 Amber listed, Birds Directive Migratory Species
Razorbill	BoCC4 Amber listed, Birds Directive Migratory Species
Puffin	BoCC4 Red listed, Birds Directive Migratory Species

5.7.3.2 There are a number of SPAs that the birds in **Table 5.11** may be associated with and these are detailed within **B2.2: Report to Inform Appropriate Assessment**. Those sites with offshore and intertidal ornithology features identified that may have potential connectivity with the Hornsea Four study area will form the basis of RIAA. However, for the purpose of this ES, the same list of SPA sites was 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 seasons (bio-seasons) that may be applicable to different seabird species. Separate bio-seasons are recognised in this ES 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 BDMPS bio-seasons are based on those in Furness (2015), hereafter referred to as BDMPS bio-seasons or bio-seasons (**Table 5.12**). The bio-seasons are defined within this ES as: return migration, migration-free breeding, post-breeding migration, migration-free winter bio-seasons and extended non-breeding bio-seasons. These five bio-seasons can be applied to different periods within the annual cycle for most seabird species, though not all five 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: when birds are either migrating to wintering areas or dispersing from colonies;
- Migration-free winter: when non-breeding birds are over-wintering in an area; and
- Non-breeding: extended bio-season from modal departure from the colony at the end of breeding to modal return to the colony the following year.

5.7.4.2 Following guidance from Natural England's Scoping response, Section 42 responses and dialogue through the EP Process, the non-breeding season reference populations were taken from Furness (2015), which are provided in **Table 5.12** below, where applicable (OFF-ORN-2.1).

Table 5.12: UK North Sea (and English Channel) BDMPS bio-season definitions and population estimates (Furness 2015).

Species	Return Migration (all individuals)	Migration-free Breeding (all individuals)	Post-breeding Migration (all individuals)	Migration-free Winter (all individuals)	Non-breeding (all individuals)
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)	September to December
Gannet	December to March (248,385)	April to August	September to November (456,298)	November to March	-
Arctic skua	April to May (1,227)	June to July	August to October (6,427)	November to March	August to April
Great skua	March to April (8,485)	May to July	August to October (19,556)	November to February (143)	September to April
Kittiwake	January to April (627,816)	May to July	August to December (829,937)		-
Little gull	-	May to July	August to October (30,500*)	-	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)	September to March
Herring gull	January to April	May to July	August to November	December	September to February (466,511)

Species	Return Migration (all individuals)	Migration-free Breeding (all individuals)	Post-breeding Migration (all individuals)	Migration-free Winter (all individuals)	Non-breeding (all individuals)
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***)	October to March	August to April
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 June	August to October (591,874)	November to December (218,622)	August to March
Puffin	March to April	May to June	July to August	September to February	August to March (231,957)

Table Note: *Population estimates based research by APEM (2020) presented in **Appendix C** of **Volume A5, Annex 5.5: Offshore Ornithology Migratory Birds Report** and consulted on through the Evidence Plan Process (OFF-ORN-1.17) as not provided in Furness (2015).

**'Commic' tern includes both common terns and Arctic terns because the species are difficult to distinguish between.

*** Combined common and Arctic tern UK North Sea and English Channel BDMPS population.

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 5.13**. 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. Demographic data from Horswill and Robinson (2015) were used to calculate the expected stable proportions in each age class for each species. Each age class survival rate was then multiplied by its stable age proportion and the total for all ages summed to give the weighted average survival rate converted to an average mortality rate.

Table 5.13: 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	4-5	5-6	Adult		
Red-throated diver	Demographic rate	0.600	0.620	-	-	-	-	0.840	0.571	0.235
	Population age ratio	0.179	0.145	-	-	-	-	0.676	-	
Gannet	Demographic rate	0.424	0.829	0.891	0.895	0.895	-	0.919	0.700	0.187
	Population age ratio	0.191	0.081	0.067	0.060	0.054	-	0.547	-	
Kittiwake	Demographic rate	0.790	0.854	0.854	0.854			0.854	0.690	0.156
	Population age ratio	0.153	0.121	0.103	0.088			0.535	-	
Great black-backed gull*	Demographic rate	0.798	0.816	0.816	0.816	0.816		0.885	0.890	0.160
	Population age ratio	0.177	0.141	0.115	0.094	0.076		0.397	-	
Common tern	Demographic rate	0.441	0.441	0.850	-		-	0.883	0.764	0.268
	Population age ratio	0.235	0.104	0.046	-		-	0.615	-	
Guillemot	Demographic rate	0.560	0.792	0.917	0.917	0.939	0.939	0.939	0.672	0.138
	Population age ratio	0.160	0.090	0.071	0.065	0.061	0.057	0.496	-	
Razorbill	Demographic rate	0.630	0.630	0.630	0.895	0.895	-	0.895	0.570	0.193
	Population age ratio	0.163	0.103	0.065	0.041	0.037	-	0.591	-	
Puffin	Demographic rate	0.709	0.709	0.709	0.760	0.805	-	0.906	0.617	0.175
	Population age ratio	0.158	0.112	0.079	0.056	0.043	-	0.552	-	

Table Note: *Great black-backed gull mortality rate was calculated using herring gull juvenile survival rate (0.798) for juveniles and the calculated survival rate taken from the herring gull juvenile and adult for great black-backed gull sub-adults. Great black-backed gull productivity was taken from the latest SMP report (JNCC 2020) providing an average UK productivity between 1991 to 2018 of 0.890.

5.7.4.4 The regional breeding population of each species was based on the number of birds recorded at the closest breeding colonies, including those at the FFC SPA, which are provided in **Table 5.14** (JNCC 2019; Aitken et al. 2017) in addition to other colonies in the UK North Sea that are within foraging range of the Hornsea Four array area. The foraging area used to determine the regional breeding population is based on species-specific mean max plus one Standard Deviation (1 SD) foraging ranges from Woodward et al. (2019).

5.7.4.5 The array area is within the mean-max foraging range for breeding fulmars, gannets, kittiwakes, guillemots, razorbills and puffins coming from the FFC SPA and other colonies along the east coast, according to the values in Woodward et al. (2019). However, the regional breeding and wider BDMPS populations for fulmar are excluded from **Table 5.14** as this species is deemed to be at very low risk from offshore wind farms, including Hornsea Four, and as such was not screened in for any potential impacts for this ES (**Section 5.11.2**).

5.7.4.6 Additional species such as herring gull, lesser black-backed gull and great black-backed gull were recorded in small numbers during the breeding season that may be foraging beyond their mean-max ranges to reach the Hornsea Four array area on occasion. However, herring gull and lesser black-backed gull were also recorded in such low abundances and densities within the array area and 4 km buffer in all bio-seasons that they do not form part of the detailed impact assessments in **Section 5.11.2**, so data with respect to their regional breeding and wider BDMPS populations are not included in **Table 5.14**.

5.7.4.7 Great black-backed gulls were recorded within the array area throughout the site-specific surveys of Hornsea Four (see **Volume A5, Annex 5.1 Offshore and Intertidal Ornithology Baseline Characterisation Report**). 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**.

5.7.4.8 Evidence from tagging studies suggests that the foraging areas used by 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. Therefore, the regional breeding population is based upon the individuals from the FFC SPA only.

5.7.4.9 In addition to the breeding birds from the FFC SPA and other east coast colonies, it is estimated that additional juvenile, immature and non-breeding birds may be present within the region during the non-migratory breeding season. This is evidenced, for instance, from counts of immature gannets at FFC SPA in 2017 where 1,169 non-breeding birds were present in 'clubs' which are likely to form future extensions to the colony (Aitken et al. 2017). As a proportion of juvenile, immature and non-breeding birds are considered to remain within their wintering areas (whether connected to regional breeding colonies or not), 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 5.14**. 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 5.14** below.

Table 5.14: Regional breeding season populations (Calculated from the number of individuals at the FFC SPA and other contributary colonies and the wider juveniles, immatures and non-breeding birds).

Species	Regional breeding population (breeding adults)	Return migration BDMPS for the UK North Sea and Channel	Proportion of juvenile, immature and non-breeding individuals (%)	Juvenile, immature and non-breeding individuals	Total regional baseline population during non-migratory breeding bio-season
Gannet	26,784	248,385	45	112,518	139,302
Kittiwake	147,968	627,816	47	291,934	439,902
Great black-backed gull	Not applicable	91,399*	60	55,114	55,114
Guillemot	121,754	1,617,306*	50	815,122	936,876
Razorbill	40,506	591,874	41	242,076	282,582
Puffin	156,809	231,957*	45	103,917	260,726

Table Note: * Non-breeding BDMPS used instead.

5.7.4.10 In addition to the regional breeding season populations (**Table 5.14**) and the non-breeding UK North Sea and English Channel BDMPS populations (**Table 5.12**), 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 5.15** below.

Table 5.15: Biogeographic Population Sizes (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
Herring gull	1,098,000
Great black-backed gull	235,000
'Commic' tern	1,108,000 (Arctic tern: 628,000; Common tern: 480,000)

Species	Biogeographic population with connectivity to UK waters (adults and immatures)
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 description above provides an accurate reflection of the current state of the existing environment. The earliest possible date for the start of the offshore construction of Hornsea Four is August 2026, with an expected operational life of 35 years, and therefore there exists the potential for the baseline to evolve between the time of assessment and point of impact. Outside of short-term or seasonal fluctuations, changes to the baseline in relation to offshore and intertidal ornithology usually occur over an extended period of time. Based on current information regarding reasonably foreseeable events over the next six years, the baseline is not anticipated to have fundamentally changed from its current state at the point in time when impacts occur.

5.7.5.2 The baseline environment for operational/decommissioning impacts is expected to evolve on a species by species basis, which is described in the detail in impact assessments when population level impacts are considered (mostly at the cumulative level in **Section 5.12**) over the lifetime of the Hornsea Four project of 35 years, with the additional consideration that any changes during the construction phase will have altered the baseline environment to a degree as set out in this chapter. Should Hornsea Four be developed or not, then the likely evolution of the population of birds within the study area is likely to continue to increase during the breeding season, as the majority of species are increasing at the largest and closest colonies along the east coast of England. Outside of the breeding season there may be declines in some species, including kittiwakes and guillemot, regardless of whether Hornsea Four is developed, due to declines at colonies in the northern North Sea. However, gannet continues to increase across the UK and so is likely to continue to increase in abundance into the future regardless of whether Hornsea Four is developed or not.

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.

5.7.6.3 Following consultation with Natural England and the RSPB, it was agreed (OFF-ORN-1.24) that in order to supplement the standard design-based abundance estimates, where possible, abundance estimates should also be generated using a model-based technique, specifically the Marine Renewables Strategic environmental assessment (MRSea) R package (**Volume A5, Annex 5.6: Offshore Ornithology MRSea Report**). MRSea requires sufficient data to correctly fit the models and therefore this technique was only feasible for the more regularly occurring species. These species were fulmar, gannet, kittiwake, great black-backed gull, guillemot, razorbill and puffin. For all other species recorded, design-based abundances were used to characterise the baseline environment.

5.7.6.4 Thus, following the MRSea modelling and integration of these results with standard design based abundances, for birds not run through MRSea, 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 5.4**) (OFF-ORN-1.24).

5.8 Project Basis for Assessment

5.8.1 Impact Register and Impacts Not Considered in Detail in this ES

5.8.1.1 Upon consideration of the baseline environment, the project description outlined in **Volume A1, Chapter 4: Project Description**, the Hornsea Four Commitments detailed within **Volume A4, Annex 5.2: Commitments Register**, and in response to formal consultation on the PEIR, one impact is "not considered in detail" in the ES for Offshore and Intertidal Ornithology. This impact is outlined, together with appropriate justification for this approach, in **Table 5.16** alongside those impacts that were agreed to be scoped out during the Scoping process. Further detail is provided in **Volume A4, Annex 5.1: Impacts Register**.

5.8.1.2 In July 2019, Highways England issued an update to the DMRB significance matrix (see **Volume A1, Chapter 5: Environmental Impact Assessment Methodology**). Impacts resulting in effects on offshore and intertidal ornithology that were formerly assessed within the category medium sensitivity and minor magnitude, as Minor (Not Significant), under the new guidance are now within the significance range of Slight or Moderate and, therefore, require professional judgement. Following a review of the relevant potential impacts, it was considered that the changes do not alter the overall significance of the effects assessed at Scoping and in the PEIR (see **Volume A4, Annex 5.1: Impacts Register**).

Table 5.16: Impacts scoped out of assessment and justification.

Project activity and impact	Significance of effect	Approach to assessment	Justification
Potential for ad-hoc maintenance of export cables through the operational phase may lead to disturbance and displacement of	No significant adverse effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.6.4).

Project activity and impact	Significance of effect	Approach to assessment	Justification
species within the ECC and differing degrees of buffers surrounding it (ORN-O-10).			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 cables 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 significant adverse effect	Scoped Out	Scoped out based on PINS Scoping Opinion (PINS Scoping Opinion, November 2018, ID: 4.6.5). 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.
Decommissioning phase: 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).	No significant adverse effect	Not considered in detail in the ES.	Simple assessment at PEIR with conclusion of no significant adverse effect. Not considered in the ES. A degree of temporary disturbance and displacement is likely to occur throughout the decommissioning phase. 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.

Notes:
Grey – Scoped out – Agreement reach between the Applicant and PINS at Scoping.
Purple - Impact not considered in detail in the ES. No likely significant effect at PEIR.

5.8.1.3 Please note that the term "scoped out" in **Table 5.16** relates to the potential for a significant adverse effect in EIA terms and not "scoped out" of the EIA process *per se*. All impacts "scoped out" for significant adverse effects are assessed for magnitude, sensitivity of the receiving receptor and conclude an EIA significance in the Impacts Register (see **Volume A4, Annex 5.1: Impacts Register**). This approach is aligned with the Hornsea Four Proportionate approach to EIA (see **Volume A1, Chapter 5: EIA Methodology**).

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 DAA, as described in **Section 5.5**. 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 kittiwake, gannet, and guillemot populations, such as the breeding colonies closest to Hornsea Four at the 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 adopted commitments (primary design principles inherent as part of Hornsea Four, installation techniques and engineering designs/modifications) as part of their pre-application phase, to eliminate and/or reduce the potential for significant adeverse effects arising from a number of impacts. These are outlined in **Volume A4, Annex 5.2: Commitments Register**. Further commitments (adoption of best practice guidance), referred to as tertiary commitments are embedded as an inherent aspect of the EIA process. Secondary commitments are incorporated to reduce the potential for significant adverse effects to environmentally acceptable levels following initial assessment i.e. so that residual effects are reduced to environmentally acceptable levels.

5.8.2.4 The commitments adopted by Hornsea Four in relation to Offshore and Intertidal Ornithology, are presented in **Table 5.17** The full list of Commitments can be found in **Volume A4, Annex 5.2: Commitments Register**.

Table 5.17: Relevant offshore and intertidal ornithology commitments.

Commitment ID	Measure Proposed	How the measure will be secured
Co2	Primary: A range of sensitive historical, cultural and ecological conservation areas (including statutory and non-statutory designations) have been directly avoided by the permanent Hornsea Four footprint, at the point of DCO. These include, but are not restricted to: Listed Buildings (585 sites); Scheduled Monuments (30 sites); Registered Parks and Gardens (Thwaite Hall and Risby Hall); Onshore Conservation Areas (19 sites); Onshore Natura 2000 sites (one site); Offshore Natura 2000 sites (three sites); Offshore Marine Conservation Zones (two sites); Sites of Special Scientific Interest (two sites); Local Nature Reserves (none have been identified); Local Wildlife sites (33 sites); Yorkshire Wildlife Trust Reserves (none have been identified); Royal Society for the Protection of Birds (RSPB) Reserves (none have been identified); Heritage Coast; National Trust land; Ancient Woodland (10 sites and known	DCO Works Plan -Onshore (**Volume D1, Annex 4.2: Works Plan – Onshore**); and DCO Works Plan - Offshore (**Volume D1, Annex 4.1: Works Plan – Offshore**)

Commitment ID	Measure Proposed	How the measure will be secured
	tree preservation orders); non-designated built heritage assets (368 sites); and historic landfill (none have been identified). Where possible, unprotected areas of woodland, mature and protected trees (i.e. veteran trees) have and will also be avoided.	
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; and DCO Works Plan - Offshore (**Volume D1, Annex 4.1: Works Plan – Offshore**)
Co87	Primary: Proposed developable area has been selected and refined from the larger Hornsea Four AfL area to avoid areas with the highest concentrations of birds (kittiwake, gannet an 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; and DCO Works Plan - Offshore (**Volume D1, Annex 4.1: Works Plan – Offshore**)
Co88	Tertiary: Construction and operational maintenance vessels (e.g. Crew Transfer Vessels (CTVs)) will avoid high concentrations of rafting red-throated diver.	DCO Schedule 11, Part 2 - Condition (13)(1)(d)(v) and; DCO Schedule 12, Part 2 - Condition (13)(1)(d)(v) (Vessel Management Plan)
Co138	Primary: Lower air draught of wind turbines will be a minimum of 40 m above Mean Sea Level (MSL) or 42.43 m above LAT	DCO Requirement 2(2)(c) (Detailed offshore design parameters) DCO Schedule 11, Part 2 - Condition 1(2)(c) (Design Parameters)
Co181	Tertiary: An Offshore Decommissioning Plan will be developed prior to decommissioning.	DCO Schedule 11, Part 1(6) and; DCO Schedule 12, Part 1(6) (General Provisions)
Co187	Secondary: The installation of the offshore export cables at landfall will be undertaken by Horizontal Directional Drilling or other trenchless methods.	DCO Requirement 17 (Code of Construction Practice) DCO Schedule 12, Part 2 - Condition 13(1)(h) (Cable Specification and Installation Plan)

5.9 Maximum Design Scenario

5.9.1.1 This section describes the MDS parameters on which the offshore and intertidal ornithology assessment has been based. These are the parameters which are judged to give rise to the maximum levels of effect for the assessment undertaken, as set out in **Volume A1, Chapter 4: Project Description**. Should Hornsea Four be constructed to different parameters within the design envelope, then impacts would not be any greater than those set out in this ES using the MDS presented in **Table 5.18**.

Table 5.18: MDS for impacts on offshore and intertidal ornithology.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	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: Co2 Co87 Tertiary: Co88	**Construction Vessels / Helicopters within Array Area:** • Up to eight construction vessels in a given 5 km^2 area with approximately three or four 5 km^2 areas at any one time. • Single phase of offshore construction over approximately 3 years. **WTG Installation:** • -Up to two installation vessels (Jack Up Vessels (JUV) or anchored) (90 return trips); • Up to 12 support vessels (270 return trips); • Up to 24 transport vessels (540 return trips); and • Up to 135 helicopter return trips. **WTG Foundation Installation:** • 6 installation vessels (2 anchored or 4DP2 or 6 x Tugs) (90 return trips if anchored or DP2. 540 return trips if Tugs); • 19 support vessels (900 return trips); • 40 transport/feeder vessels (including tugs) (720 return trips); • 12 dredging vessels (720 return trips); and • 180 helicopter return trips. **OSS and Accommodation Platform Installation:** • 2 installation vessels (36 return trips); • 12 support vessels (162 return trips); • 4 transport/feeder vessels (72 return trips); and • 63 helicopter return trips. **OSS and Accommodation Platform Foundation Installation:** • 2 installation vessels (24 return trips);	The maximum estimated number of development areas within the array area with vessels operating concurrently would cause the greatest disturbance to birds on site.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
		• 12 support vessels (108 return trips); • 4 transport/feeder vessels (48 return trips); and • 42 helicopter return trips. **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); and • 396 helicopter return trips.	
Indirect impacts during the construction phase within the array area through effects on habitats and prey species (ORN-C-2).	None	See MDS for Fish and Shellfish Ecology assessment (**Volume A2, Chapter 3: Fish and Shellfish Ecology**) and for the Benthic and Intertidal Ecology assessment (**Volume A2, Chapter 2: Benthic and Intertidal Ecology**).	Indirect effects on birds could occur through changes to any of the species and habitats considered within the Fish and Shellfish Ecology or Benthic and Intertidal Ecology assessments. The maximum indirect impact on birds would result from the maximum direct impact on fish, shellfish and benthic species and habitats. The maximum design scenario is therefore as per justifications in **Volume A2, Chapter 3: Fish and Shellfish Ecology** and **Volume A2, Chapter 2: Benthic and Intertidal Ecology**.
Construction activities associated with export cable laying may lead to disturbance and displacement of species within the ECC and	Primary: Co2 Co86 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.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
different degrees of buffers surrounding it (ORN-C-3).		• Single phase of offshore construction over approximately 3 years.	
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).	Primary: Co2 Co86 Co187	**Horizontal Directional Drilling (HDD) Installation:** • Eight offshore HDD exits pits; • Minimum 6 m entry pit and 5m exit pit depth; • Small 4x4 vehicles related to emergency response on the beach; and • Small 4x4 on beach to monitor the drill head using handheld equipment. **Cable Laying:** • Maximum duration of cable laying via HDD is 24 months within a 32 month period.	The assumption is that the process would be undertaken by HDD methods, so no open trenching, cable laying and burial of the export cable would be required. Therefore, MDS activities to be assessed are limited, though they are to take place over a maximum of 24 months within a 32 month period (allowing for up to six months of weather-related downtime).
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).	Primary: Co2 Co87 Co138 Tertiary: Co88	**Array Area:** • WTG deployment across the full array area (468 km^2). **WTGs:** • Up to 180 WTGs; • Minimum height of lowest blade tip above MSL: 40 m; and • Maximum rotor blade radius: 152.5 m. **Operation and Maintenance:** • 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; • A total of 3,525 total trips per year completed by helicopter and / or vessels; and	Displacement would be assumed from the entire array area that contains WTGs 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.

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
		• Vessels include: CTVs, service operation vessels, supply vessels, cable and remedial protection vessels, and JUVs.	
Seabirds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure (ORN-O-6).	Primary: Co2 Co87 Co138	**Array Area:** • WTG deployment across the full array area (468 km^2) area. **WTGs:** • Up to 180 WTGs; • Minimum height of lowest blade tip above MSL:40 m; and • Maximum rotor blade radius: 152.5 m.	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 (ORN-O-7).	Primary: Co2 Co87 Co138	**Array Area:** • WTG deployment across the full array area (4680 km2) area. **WTGs:** • Up to 180 WTGs; • Minimum height of lowest blade tip above MSL: 40 m; and • Maximum rotor blade radius: 152.5 m.	This represents the maximum number of the largest WTGs, which represents the greatest total swept area to be considered for collision risk.
Indirect impacts within the array area during the operational phase through effects on habitats and prey species (ORN-O-8).	None	See MDS for Fish and Shellfish Ecology assessment (**Volume A2, Chapter 3: Fish and Shellfish Ecology**) and for the Benthic and Intertidal Ecology assessment (**Volume A2, Chapter 2: Benthic and Intertidal Ecology**).	Indirect effects on birds could occur through changes to any of the species and habitats considered within the Fish and Shellfish Ecology or Benthic and Intertidal Ecology assessments. The maximum indirect impact on birds would result from the maximum direct impact on fish, shellfish and benthic species and habitats. The maximum design scenario is therefore as per justifications in **Volume A2, Chapter 3: Fish and Shellfish Ecology**

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
			and **Volume A2, Chapter 2: Benthic and Intertidal Ecology**.
The presence of WTGs could create a barrier to the migratory or regular foraging movements of seabirds(ORN-O-9).	Primary: Co87	**Array Area:** • WTG deployment across the full array area (468 km^2) area; and • Up to 25.6 km north-south extent between the northernmost point of the array area and the southernmost point. **WTGs:** • Up to 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 (ORN-O-14).	Primary: Co87	**WTGs:** • Up to 180 WTGs; • Minimum height of lowest blade tip above MSL: 40 m; • Maximum rotor blade radius: 152.5 m; • Total array area of 468 km^2; and • Minimum 810 m spacing. **OSS and Accommodation Platforms:** • Up to six offshore transformer substations in the array area; • Up to three offshore High Voltage Direct Current (HVDC) converter substations in the array area; • Up to one offshore accommodation platform in the array area; and • Up to three HVAC booster stations (in the HVAC booster station search area). Lighting outward and not directional on all structures, maximised intensity and range to provide best visibility for aviation and shipping purposes.	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. It is important to note that three HVDC converter substations in the array area are mutually exclusive with three HVAC booster stations along the ECC in a single transmission system. As secured by **C1.1 Draft DCO including Draft DML**, a maximum of ten OSS and platforms will be constructed within the Hornsea Four Order Limits, however in order to assess the MDS for both the array and the ECC, the presence of the maximum numbers of OSS and platforms in each area has been considered (ten and three, respectively). As a result, the outcome of the

Impact and Phase	Embedded Mitigation Measures	Maximum Design Scenario	Justification
			assessment is therefore inherently precautionary.
Decommissioning			
Indirect impacts during the decommissioning phase within the offshore ECC and landfall through effects on habitats and prey species (ORN-D-13).	None	See MDS for Fish and Shellfish Ecology assessment (**Volume A2, Chapter 3: Fish and Shellfish Ecology**) and for the Benthic and Intertidal Ecology assessment (**Volume A2, Chapter 2: Benthic and Intertidal Ecology**).	Indirect effects on birds could occur through changes to any of the species and habitats considered within the Fish and Shellfish Ecology or Benthic and Intertidal Ecology assessments. The maximum indirect impact on birds would result from the maximum direct impact on fish, shellfish and benthic species and habitats. The maximum design scenario is therefore as per justifications in **Volume A2, Chapter 3: Fish and Shellfish Ecology** and **Volume A2, Chapter 2: Benthic and Intertidal Ecology**.

5.10 Assessment methodology

5.10.1 Impact assessment criteria

5.10.1.1 The criteria for determining the significance of effects is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the impacts. This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts. The terms used to define sensitivity and magnitude are based on those used in the DMRB methodology, which is described in further detail in **Volume A1, 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 (2018) and the PD 6900:2015 Environmental impact assessment for offshore renewable energy projects - Guide (British Standards Institute 2015).

5.10.1.2 The assessment approach therefore follows the conceptual source-pathway-receptor model. This model identifies any likely environmental impacts on ornithology receptors resulting from the proposed construction, operation and decommissioning of Hornsea Four's offshore and intertidal infrastructure. This process enables an easy to follow assessment route between identified impact sources and potentially sensitive receptors, ensuring a transparent impact assessment. The parameters of this model are defined as follows:

- Source – the origin of a potential impact (noting that one source may have several pathways and receptors), e.g. an activity such as cable installation and a resultant effect such as re-suspension of sediments.
- Pathway – the means by which the effect of the activity could impact a receptor e.g. for the example above, re-suspended sediment could settle and smother the seabed.
- Receptor – the element of the receiving environment that is impacted e.g. for the above example, bird prey species living on or in the seabed are unavailable to foraging birds.

5.10.1.3 The sensitivity of the receptors to sources of effect is defined in **Table 5.19** below, through reference to an example potential impact from disturbance activities.

Table 5.19: 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.

5.10.1.4 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.

5.10.1.5 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. Therefore, example criteria for defining conservation value in this chapter are outlined in **Table 5.20** below. Additional consideration may be provided to the current national conservation status of particular species, where appropriate, according to the Birds of Conservation Concern 4 (BoCC4) (Eaton et al. 2015), from which the status from BoCC4 for the main seabird species assessed within this ES chapter are presented in **Table 5.11**.

Table 5.20: Definition of conservation value levels for ornithological receptors.

Conservation Value	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 during a particular season.
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 during a particular season, 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 attribute to particular SPAs and may be found in regionally or locally important numbers during specific seasons within the offshore and intertidal ornithology study area.

5.10.1.6 The criteria for defining magnitude in this chapter are outlined in **Table 5.21** below. In addition to those levels of magnitude defined in **Table 5.21**, 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 5.21: Definition of levels of potential magnitude of impact for ornithological receptors.

Magnitude	Definition Used in This Chapter
Major	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.
Moderate	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 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.
Minor	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.

5.10.1.7 The 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 5.22**. Where a range of significance of effect is presented in **Table 5.22**, the final assessment for each effect is based upon expert judgement.

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

Table 5.22: Matrix used for the assessment / assignment of the potential significance of effect.

Environmental value (sensitivity)	Magnitude of impact (degree of change): *Negligible*	*Minor*	*Moderate*	*Major*
Low	Neutral or Slight (Not Significant)	Neutral or Slight (Not Significant)	Slight (Not Significant)	Slight (Not Significant) or Moderate (Significant)
Medium	Neutral or Slight (Not Significant)	Slight (Not Significant) or Moderate (Significant)	Moderate or Large (Significant)	Moderate or Large (Significant)
High	Slight (Not Significant)	Slight (Not Significant) or Moderate (Significant)	Moderate or Large (Significant)	Large or Very Large (Significant)
Very High	Slight (Not Significant)	Moderate or Large (Significant)	Large or Very Large (Significant)	Very Large (Significant)

5.10.1.9 Further modifications have been introduced in the interest of proportionate assessment and in accordance with guidance presented in PD 6900:2015 Environmental impact assessment for offshore renewable energy projects - Guide (British Standards Institute (BSI) 2015) such that:

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

5.11 Impact Assessment

5.11.1 Construction

5.11.1.1 The impacts of the offshore construction of Hornsea Four have been assessed on offshore and intertidal ornithology. The environmental impacts arising from the construction of Hornsea Four are listed in **Table 5.18** along with the MDS against which each construction phase impact has been assessed.

5.11.1.2 The construction phase of Hornsea Four includes a range of potential drivers that may cause displacement to sensitive seabirds. These drivers include construction and personnel vessel movements and WTG construction activities as well as the physical presence of constructed WTGs, which may cause a displacement response, though it is acknowledged that these may be both spatially and temporally limited. As the construction phase progresses, more WTGs are erected in the array area and the spatial scale increases, until a point when the entire array is constructed, yet not operational, and may present a similar displacement stimulus as an operational phase.

5.11.1.3 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)

5.11.1.4 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.

5.11.1.5 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 effects 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.

5.11.1.6 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 present within the array area and a 4 km buffer and those that may be more susceptible to displacement than others and therefore which species may be considered for further assessment (**Table 5.23**). 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, with the exception of gannet, are not considered further for the potential impact of displacement from the array area during the construction phase of Hornsea Four.

5.11.1.7 At the request of Natural England, gannet has also been screened in for assessment of potential displacement during the construction phase of Hornsea Four. This is not due to evidence suggesting that this species is at risk from impacts during the construction phase, but in order to provide Natural England with confidence that any potential impacts on gannet during the construction phase are considered in a quantitative manner.

5.11.1.8 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.

5.11.1.9 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 5.23: 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	Low to medium	In (at request of Natural England)
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	In
Razorbill	Medium	In
Puffin	Medium	In

5.11.1.10 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 that construction activities will be spatially and temporally discrete:

- Construction activities being undertaken within only three to four blocks of 5 km^2 at any one time across the entire 468 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 three years); and
- Large parts of the array area not being influenced by construction activities.

5.11.1.11 In recognition of the potential construction disturbance activities being of a lesser extent to that of an operational OWF, then the levels of displacement are also of lesser extent.

5.11.1.12 Few studies have provided definitive empirical displacement rates for the construction phase of OWF developments. Disturbance during the construction phase is primarily centred around where construction vessels and piling activities are occurring with differences also seen for disturbance effects of non-operational versus operational turbines. For example, Krijgsveld et al. (2011) demonstrated higher flight paths of gannets next to operating versus non-operating turbines. Displacement rates for auks during construction have been shown to be either significantly lower or comparable to the operation phase (Royal Haskoning 2013; Vallejo et al. 2017). These studies would suggest that although the level of disturbance from construction activities can be high, it is focussed around a limited area of the development site. Therefore, displacement rates for the entire site reflect reduced displacement within the site away from construction areas including areas where built non-operational turbines are present.

5.11.1.13 As actual rates of displacement during the construction of OWFs is difficult to determine from the available studies, a proposed methodology was agreed with Natural England and the RSPB (OFF-ORN-2.13). The method considers that as the construction phase of Hornsea Four is limited both spatially and temporarily, any potential impacts are unlikely to reach the same level as those estimated during the operational phase of Hornsea Four. Therefore, for the purpose of providing a precautionary approach to assessing the potential impacts on gannets and auks during the construction phase of Hornsea Four, it was agreed that the level to be used would be half that of the operational phase assessments.

5.11.1.14 The level of displacement for gannets and auk species assessed for potential construction displacement are provided below:

- For gannet, consideration is provided to half of the operation and maintenance displacement rates (range of 60-80%), which is 30-40% displacement during the construction phase;
- For auk species (guillemot, razorbill and puffin) consideration is also provided to half of the operation and maintenance displacement rate of 50% displacement (with a range of 30-70%), which is 25% displacement (with a range of 15-35%) during the construction phase; and
- For all four species the level of mortality applied for this assessment is 1% of those displaced, though this is likely to be over precautionary when considering the evidence put forward in **Section 5.11.2**.

Gannet

Potential magnitude of impact

5.11.1.15 The annual estimated mortality rate for gannet as a consequence of displacement from the Hornsea Four array area during the construction phase is between six to eight individuals based on the estimated mortality being 50% less than what is predicted at the operational phase in **Table 5.27**. The potential 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 as presented in **Table 5.13**.

5.11.1.16 When considering the largest UK North Sea and English Channel BDMPS population of 456,298 individuals (Furness 2015) and using the average baseline mortality rate of 0.187 (**Table 5.13**), the natural predicted mortality across all seasons is 85,328. The addition of between six to eight additional mortalities as a consequence of displacement during the Hornsea Four construction phase would increase the baseline mortality rate of between 0.007% to 0.009%. The natural predicted mortality for the biogeographic population of 1,180,000 across all seasons is 220,660. The addition of six to eight mortalities would increase the biogeographic baseline mortality rate by 0.003%.

5.11.1.17 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 (**Table 5.22**) and is therefore not considered further in this assessment.

Guillemot

Potential magnitude of impact

5.11.1.18 The annual estimated mortality rate for guillemot is 64 individuals as a result of Hornsea Four construction activities and vessel movements within the array area and a 2 km buffer, which is further broken down into relevant bio-seasons in **Table 5.24**. The potential 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 as presented in **Table 5.13**.

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

Bio-season (months)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during operational phase.	Estimated number of guillemots subject to mortality (individuals) based on 50% of operational phase.	Increase in baseline mortality (%) during construction phase.
	Population	Baseline mortality			
Breeding (Mar-Jul)	936,876	129,289	43 (*26 – 599*)	21 (*13 – 30*)	0.010 (0.006 – 0.013)
Non-breeding (Aug-Feb)	1,617,306	223,188	85 (*51 – 1,194*)	43 (26 – 60)	0.019 (0.011 – 0.027)
Annual (BDMPS)	**1,617,306**	**223,188**	**128** (*77 – 1,793*)	**64** (38 – 90)	**0.029** (0.017 – 0.040)
Annual (biogeographic)	**4,125,000**	**569,250**	**128** (*77 – 1,793*)	**64** (38 – 90)	**0.011** (0.007 – 0.016)

Table Note: Values in parenthesis include displacement range requested to be presented by Natural England as described in paragraph **5.11.1.14**.

5.11.1.19 During the breeding bio-season, approximately 21 guillemots may be subject to mortality as a consequence of displacement during the construction phase, which would present an increase of 0.010% relative to the current baseline mortality rate at the UK North Sea and English Channel BDMPS scale.

5.11.1.20 This level of potential impact is considered to be of **negligible** magnitude during the 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.

5.11.1.21 During the non-breeding bio-season, approximately 43 guillemots may be subject to mortality as a consequence of displacement during the construction phase, which would present an increase of 0.019% relative to the current baseline mortality rate for the UK North Sea and English Channel BDMPS scale.

5.11.1.22 This level of potential impact is considered to be of **negligible** magnitude during the non-breeding 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.

5.11.1.23 The annual estimated mortality rate for guillemot as a consequence of displacement from the Hornsea Four array area and 2 km buffer during the construction phase is 64 individuals. When considering the largest UK North Sea and English Channel BDMPS population of 1,617,306 individuals (Furness 2015) and using the average baseline mortality rate of 0.138 (**Table 5.13**), the natural predicted mortality across all seasons is 223,188. The addition of 64 additional mortalities as a consequence of displacement during the Hornsea Four construction phase would increase the baseline mortality rate by 0.029%. When considering the wider biogeographic population of 4,125,000 individuals, which has a natural predicted mortality across all seasons of 569,250, then the addition of 64 mortalities would increase the biogeographic baseline mortality rate by 0.011%.

5.11.1.24 The magnitude of this impact is therefore considered to be **negligible** at both the UK North Sea and English Channel scale and the biogeographic scale. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment.

<u>*Razorbill*</u>

Potential magnitude of impact

5.11.1.25 The annual estimated mortality rate for razorbill is 12 individuals as a result of Hornsea Four construction activities and vessel movements within the array area and a 2 km buffer, which is further broken down into relevant bio-seasons in **Table 5.25**. The potential 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 as presented in **Table 5.13**.

Table 5.25: Bio-season construction displacement estimates for razorbill for Hornsea Four.

Bio-season (months)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during operational phase	Estimated number of razorbills subject to mortality (individuals) based on 50% of operational phase	Increase in baseline mortality (%) during construction phase
	Population	Baseline mortality			
Return Migration (Jan-Mar)	591,874	114,232	2 (1 – 26)	1 (1 – 1)	0.001 (0.000 – 0.001)
Migration-free Breeding (Apr-Jul)	282,582	54,538	1 (1 – 19)	1 (0 – 1)	0.001 (0.001 – 0.002)
Post-breeding migration (Aug-Oct)	591,874	114,232	18 (11 – 251)	9 (5 – 13)	0.008 (0.005 – 0.011)
Migration-free Winter (Nov-Dec)	218,622	42,194	2 (1 – 33)	1 (1 – 2)	0.003 (0.002 – 0.004)
Annual (BDMPS)	**591,874**	**114,232**	**24** (14 – 330)	**12** (7 – 16)	**0.010** (0.006 – 0.014)
Annual (Biogeographic)	**1,707,000**	**329,451**	**24** (14 – 330)	**12** (7 – 16)	**0.004** (0.002 – 0.005)

Table Note: Values in parenthesis include displacement range requested to be presented by Natural England as described in paragraph 5.11.1.14.

5.11.1.26 During the return migration bio-season, approximately one razorbill may be subject to mortality as a consequence of displacement during the construction phase, which would present an increase of 0.001% relative to the current baseline mortality rate for the UK North Sea and English Channel BDMPS.

5.11.1.27 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.

5.11.1.28 During the migration-free breeding bio-season, approximately one razorbill may be subject to mortality as a consequence of displacement during the construction phase, which would present an increase of 0.001% relative to the current baseline mortality rate for the UK North Sea and English Channel BDMPS.

5.11.1.29 This level of potential impact is also 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.

5.11.1.30 During the post-breeding migration bio-season, approximately nine razorbills may be subject to mortality as a consequence of displacement during the construction phase, which would present an increase of 0.008% relative to the current baseline mortality rate for the UK North Sea and English Channel BDMPS.

5.11.1.31 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.

5.11.1.32 During the migration-free wintering bio-season, approximately one razorbill may be subject to mortality as a consequence of displacement during the construction phase, which would present an increase of 0.003% relative to the current baseline mortality rate for the UK North Sea and English Channel BDMPS.

5.11.1.33 This level of potential impact is also 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.

5.11.1.34 The annual estimated mortality rate for razorbill as a consequence of displacement from the Hornsea Four array area and a 2 km buffer during the construction phase is 12 individuals. When considering the largest UK North Sea and English Channel BDMPS of 591,874 individuals (Furness 2015) and using the average baseline mortality rate of 0.193 (**Table 5.13**), the natural predicted mortality across all seasons is 114,232. The addition of 12 additional mortalities would increase the baseline mortality rate by 0.010%. When considering the wider biogeographic population of 1,707,000 individuals, which has a natural predicted mortality across all seasons of 329,451, then the addition of 12 mortalities would increase the biogeographic baseline mortality rate by 0.004%.

5.11.1.35 The magnitude of this impact is therefore considered to be **negligible** at both the UK North Sea and English Channel scale and the biogeographic scale. Irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment.

Puffin

Potential magnitude of impact

5.11.1.36 The annual estimated mortality rate for puffin as a consequence of displacement from the Hornsea Four array area and a 2 km buffer during the construction phase is one individual. This is based on the estimated mortality being 50% less than what is predicted in **Table 5.34**. In this instance, as the mortality rate is only of one individual per annum then the potential magnitude of impact is estimated by calculating what this level of impact may have as an increase to the baseline mortality rate of the UK North Sea and English Channel BDMPS population scale. The overall baseline mortality rates are based on age specific demographic rates and age class proportions as presented in **Table 5.13**.

5.11.1.37 The magnitude of this impact, the loss of a single individual from the UK North Sea and English Channel BDMPS population, 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 (**Table 5.22**) and is therefore 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)

5.11.1.38 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.

5.11.1.39 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 A2, Chapter 3: Fish and Shellfish Ecology** and **Volume A2, 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 significance of the effect is therefore **not significant**.

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

5.11.1.40 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 three years (potentially three 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.

5.11.1.41 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 ES 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, in keeping with Co2 and Co86, the ECC does not run directly through the Greater Wash SPA, so would avoid the highest densities of both species (see **Section 5.8.2**). Of the two species, it is also known that common scoter are not regularly recorded in abundances and densities that would warrant assessment as the highest densities of this species are within the Wash and North Norfolk coast (Lawson et al. 2016), so this species is not considered further in this ES. Construction vessels will also avoid areas of rafting red-throated diver when travelling to/from construction sites, further minimising impacts (Co88; see **Section 5.8.2**).

5.11.1.42 Following the screening process, an assessment of displacement has been carried out for Hornsea Four, with detailed methods and results presented in **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis**, 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 (OFF-ORN-2.12).

5.11.1.43 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 EP process (OFF-ORN-2.12).

5.11.1.44 The ECC route was selected so that it does not run directly through the Greater Wash SPA (Co86) and as a result it avoids the areas known to hold the highest densities of this species (derived from an evaluation of the SeaMaST data set: Bradbury et al. 2014). In order to account for them potentially being within the ECC and a 2 km buffer surrounding this area, a separate method for estimating the potential abundance and density of this species was developed and agreed for use with Natural England (OFF-ORN-2.39). The methods and corresponding data for red-throated diver within the ECC and a 2 km buffer are presented in **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis.**

5.11.1.45 As the SeaMaST data does not provide absolute densities of birds, the 'benchmark' approach, as agreed with Natural England (OFF-ORN-2.25), using an alternate data source with known density and abundance estimates from datasets collected from further south in the Southern North Sea was completed. This provided suitable data and was used to produce a scaled density factor, which were applied to the relative densities of the ECC (see **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis** for detailed methodology).

5.11.1.46 Following the agreed methodology, these data estimated that red-throated diver occur in very low densities of between 0.004 and 0.005 birds per km^2. Based on the above densities, it was estimated that between two and three red-throated divers would be present within a 2 km buffer of the cable laying vessel.

Potential magnitude of impact

5.11.1.47 Using the 'benchmark' approach, a maximum of three red-throated divers were estimated within the ECC plus 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**.

5.11.1.48 Irrespective of the sensitivity of the receptor, given a negligible magnitude of impact, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 5.22**) and is therefore 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)

5.11.1.49 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 are not considered further in this ES.

5.11.1.50 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, sanderling. This was agreed with Natural England and RSPB throughout the EP process (**Table 5.4**) (OFF-ORN-2.6).

5.11.1.51 Based on the MDS (**Table 5.18**), 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. However, the method to install the export cable through the intertidal area is through the use of HDD techniques, Co187, which would avoid the majority of the construction activities within or in close proximity to the intertidal area. The only activities likely to occur as a result of HDD are small levels of personnel and occasional vehicle movements, with limited potential to disturb or displace birds in the intertidal area for prolonged periods of time.

Potential magnitude of impact

5.11.1.52 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 vehicles and workforce would not be operating 24 hours a day or continuously through the hours of darkness. With the commitment to the use of HDD techniques (Co187), there would be no machinery in place or operational at the surface that would create any source of noise considered to disturb birds on the intertidal sands. Furthermore, the majority of vehicle and personnel 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.

5.11.1.53 The proposed construction activities would be very limited in nature and are expected to take place only during daylight 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.

5.11.1.54 The potential disturbance and displacement of sanderling through the limited surface level construction activities associated with HDD techniques 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 occasional vehicle and personnel on the beach) which sanderling may be displaced would not result in a significant reduction in the overall area available for them to forage or rest.

5.11.1.55 In accordance with construction activities from other cable landfall operations, vehicles and personnel on the beach within the cable landfall area as well as HDD under the surface would not reach anywhere near 55-dB, which is considered a level whereby birds may react within the Institute of Estuarine & Coastal Studies' (IECS) wader sensitivity toolkit (IECS 2012).

5.11.1.56 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 HDD) is of local spatial extent, of short-term duration, intermittent and reversible. The magnitude of impact is therefore considered to be **negligible**.

5.11.1.57 Irrespective of the sensitivity of the receptor, given a **negligible** magnitude of impact, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment.

5.11.2 Operation and Maintenance

5.11.2.1 The potential impacts of the offshore operation and maintenance of Hornsea Four have been assessed on offshore and intertidal ornithology. The potential environmental impacts arising from the operation and maintenance of Hornsea Four are listed in **Table 5.18** 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 OWF 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 The 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. 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 A5, 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 5.26**. 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 5.26: Screening of seabird species recorded within Hornsea Four array area and 2km buffer for risk of disturbance and displacement.

Receptor	Sensitivity to disturbance & displacement	Avoidance rate based on OWEZ (Krigsveld et al. 2011; Leopold et al. 2011)	Displacement rates based on Robin Rigg (Walls et al. 2013); and 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	28%	<50%	Migration-free breeding	Out
Gannet	Low	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	Very Low	18%	0%	Very low in all bio-seasons	Out
Lesser black-backed gull	Very Low	18%	0%	Very low in all bio-seasons	Out
Guillemot	Medium	68%	50%	Non-breeding	In
Razorbill	Medium	68%	50%	Post-breeding	In
Puffin	Medium	40-68%	n/a	Non-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 A5, 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 EP process (OFF-ORN-2.10) are gannet, guillemot, razorbill and puffin.

5.11.2.9 For each of the four species a review was undertaken of recent displacements rates applied by other assessments of displacement for OWFs. A further review of the displacement values derived from multiple post-consent monitoring reports was undertaken to quantify a suitable evidence-led approach and to provide SNCBs with transparency on how the displacement rates were calculated for this assessment.

Gannet

5.11.2.10 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). 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, the level of displacement considered across all bio-seasons is between 60-80% within the array area and a 2 km buffer, accepted by Natural England as appropriate rates for assessment purposes (OFF-ORN-2.43).

5.11.2.11 A complete range of displacement matrices are presented in **Volume A5 Annex 5.2: Offshore Ornithology Displacement Analysis**, whilst **Table 5.27** 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 and 2 km buffer.

5.11.2.12 A mortality rate of 1% was selected for this assessment, based on expert judgement supported by additional evidence that suggests that gannet have a large mean max (315 km) and maximum (709 km) foraging range (Woodward et al. 2019) 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 and 2 km buffer.

Potential magnitude of impact

5.11.2.13 The annual estimated mortality rate for gannet is between eight and 11 individuals, which is further broken down into relevant bio-seasons in **Table 5.27**. The potential 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 as presented in **Table 5.13**.

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

Bio-season (months)	Seasonal abundance (array area & 2 km buffer)	Regional baseline populations and baseline mortality rates		Estimated number of gannets subject to mortality (individuals per annum)	Increase in baseline mortality (%)
		Population (individuals)	Baseline mortality (per annum)		
Return Migration (Dec-Mar)	235	248,385	46,448	1 – 2	0.004 – 0.004
Migration-free Breeding (Apr-Aug)	791	139,302	26,049	5 – 6	0.018 – 0.024
Post-breeding migration (Sep-Nov)	854	456,298	85,328	5 – 7	0.006 – 0.008
Annual (BDMPS)	**1,881**	**456,298**	**85,328**	**11 – 15**	**0.014 – 0.018**
Annual (biogeographic)	**1,881**	**1,180,000**	**220,660**	**11 – 15**	**0.005 – 0.007**

5.11.2.14 During the return migration bio-season a peak abundance of 235 gannets within the array area and 2 km buffer are estimated to be at risk of displacement. Using displacement rates between 60 – 80% and a mortality rate 1% would result in approximately one to two gannets which may be subject to mortality. The UK North Sea and English Channel BDMPS for the return migration bio-season is defined as 248,385 individuals (Furness 2015) and using the average baseline mortality rate of 0.187 (Table 5.13), the natural predicted mortality in the return migration bio-season is 46,448 per annum. The addition of one to two predicted mortalites would increase the baseline mortality rate by 0.003% to 0.004%.

5.11.2.15 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.

5.11.2.16 During the migration-free breeding bio-season, a peak abundance of 791 gannets within the array area and 2 km buffer are estimated to be at risk of displacement. Using displacement rates between 60 – 80% and a mortality rate of 1% would result in approximately five to six gannets which may be subject to mortality. As calculated in Section 5.7.4, during the migration-free breeding bio-season, the total regional baseline population of breeding adults and immature gannets is predicted to be 139,302 individuals. When the average baseline mortality rate of 0.187 (Table 5.13) is applied, the natural predicted mortality in the migration-free breeding bio-season is 26,049 per annum. The addition of five to six predicted mortalities would increase the baseline mortality rate by 0.018% to 0.024%.

5.11.2.17 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.

5.11.2.18 During the post-breeding migration bio-season, a peak abundance of 854 gannets within the array area and 2 km buffer are estimated to be at risk of displacement. Using displacement rates between 60 – 80% and a mortality rate 1% would result in approximately five to seven gannets which may be subject to mortality. The UK North Sea and English Channel BDMPS for the post-breeding migration bio-season is defined as 456,298 individuals (Furness 2015) and using the average baseline mortality rate of 0.187 (**Table 5.13**), the natural predicted mortality in the return migration bio-season is 85,328 per annum. The addition of between five to seven predicted mortalities would increase the baseline mortality rate by 0.006% to 0.008%.

5.11.2.19 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.

5.11.2.20 For all seasons combined, the maximum number of gannets predicted to be subject to mortality due to displacement from the Hornsea Four array area and 2 km buffer is between 11 and 15. Using the largest UK North Sea and English Channel BDMPS of 456,298 individuals (Furness 2015) and using the average baseline mortality rate of 0.187 (**Table 5.13**), the natural predicted mortality across all seasons is 85,328 per annum . The addition of between 11 to 15 predicted mortalities would increase the baseline mortality rate by 0.013% to 0.018%. When considering displacement impacts at the wider biogeographic population scale, then of the 1,180,000 population the natural annual mortality rate would be 220,660 individuals per annum. The addition of between 12 to 15 predicted mortalities would increase the biogeographic baseline mortality rate by 0.005% to 0.007%. Further consideration of this level of predicted magnitude is provided in **Table 5.42** PVA results.

5.11.2.21 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 (**Table 5.22**) and is therefore not considered further in this assessment.

Auk species

5.11.2.22 Auk species (guillemot, razorbill and puffin) 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). Studies on auk displacement in response to OWFs have previously been summarised by Dierschke et al. (2016). This review summarises evidence of auk displacement obtained from studies of thirteen different European OWF sites that compared changes in seabird abundance between baseline and post-construction. The review concluded that the mean outcome across all OWFs for auks was 'weak displacement' but highly variable. Since the publication of this review, there have been a number of additional OWF sites which have reported displacement effects on auks (APEM 2017; Webb et al. 2017; Vanermen et al. 2019; Peschko et al. 2020; MacArthur Green 2021). Furthermore, previously published datasets from three OWF sites have recently been re-analysed utilising a novel modelling approach, which has resulted in different displacement effects being concluded for some (R-INLA; Zuur 2018; Leopold et al. 2018).

5.11.2.23 A comprehensive review has been undertaken by APEM (2021) of all post-construction monitoring studies undertaken to date within the North Sea and UK Western Waters as summarised in **Table 5.28**. The aim of the review was to provide the latest reported displacement rates from OWF sites and to better understand what explanatory factors might be influencing the varying degree of displacement reported at different operational OWFs. The review's objective was to provde a more empirical approach (rather than the previous speculative displacement rate range) for auk assessments for this report and to better understand the likely consequence of displacement in terms of consequential mortality. The key findings from this review are summarised in the section below. Auk displacement effects vary considerably within different study sites showing attraction, no significant effect or a displacement effect. The studies included: one OWF with positive displacement effects, eight OWFs with no significant effects or weak displacement effects, three with inferred displacement effects (but not statistically tested) and eight with negative displacement effects. The displacement effects from those studies which provided a defined displacement rate ranged from +112% to -75%.

5.11.2.24 Examination of the analysis methods used for these studies, together with the quality of the datasets gathered, suggests that not all predicted displacement effects are equally robust. Some studies have not utilised the most appropriate statistical modelling methods for the data collected, indeed many sites with predicted high displacement rates have low or very low auk abundance. These studies have high numbers of zero counts, making displacement rate prediction highly problematic given natural spatial and temporal variation in auk abundance and distribution. As such, the displacement effects reported in these studies are most likely unreliable. For example, the independent re-analysis of the data for Prinses Amalia and Egmond aan Zee OWFs, which previously reported significant displacement effects, was not able to detect a significant effect using R-INLA analysis (Zuur 2018). Furthermore, Zuur (2018) considered that previously reported displacement effects at Alpha Ventus, Blighbank, Thorntonbank and Horns Rev OWFs, may be misleading since the high-level of zero-inflation in their datasets precluded their re-analysis using R-INLA. These OWFs constitute the majority of the reported displacement rates for auks of up to 75%, so when considering the findings of Zuur (2018), they should be considered with caution and not presented as strong evidence in support of high displacement effects. It has previously been suggested that high displacement rates are associated with those OWF sites which are small in size and/or with a high-density WTG layout. However, other OWF sites such as Robin Rigg and North Hoyle of similarly small sizes with similar densities of WTGs have shown little or no avoidance effects (Vallejo et al. 2017; and PMSS 2007). Indeed, Prinses Amalia OWF is a relatively high WTG density site and after a re-analysis of these data it was predicted to have had no displacement effect, which would suggest that WTG density may not be a predominant factor influencing displacement rates in auks. Indeed, the data presented in **Table 5.28** suggest that there is no clear correlation of displacement effects with current WTG density layouts at OWF.

Table 5.28: Published evidence of auk (guillemot and razorbill) displacement.

Offshore wind farm	Predicted displacement rate	No. years pre-construction data	No. years operational data	Period included in analysis	Array density (turbines/km^2)	Operational array mean peak density (n/km^2)[12]
Beatrice	NSE	1	1	May-Jul	1.56	100/6.0
Thanet	NSE	1	3	Oct-Mar	2.86	11.6/2.6
Westermost Rough	NSE	N/A[5]	N/A[5]	July	1.00	(10.5)
North Hoyle	(+)/<25%[3]	<1[winter]	3	All Months	3.11	8.9/4.8
Robin Rigg	NSE[1]	2[4]	3	All Months	3.16	5.1/4.1
Lincs	NSE	3	3	All Months	2.14	(5.0)
Prinses Amalia	NSE[2]	1.5[6]	3	Sept-Mar	4.30	4.1/1.9
Egmond aan Zee	NSE[2]	1.5[6]	4	Sept-Mar	1.30	4.1/1.9
Helgoland Cluster & Butendiek	63%/44%[11]	14	3	All Months	2.65 1.36 2.01 2.56	n/a
Thornton Bank Phase I, II, II	60%	2-10[10]	6	All Months[9]	2.71	3.0/1.0
Bligh Bank (Belwind)	75%	2-10[10]	4.5	All Months[9]	3.24	2.0/2.5
BARD 1	(-)	2	1	All Months	1.36	2.5/-
Alpha Ventus	75%	N/A[7]	3	All Months	3.05	(<2)[8]
Kentish Flats	NSE	3	2	All Months[9]	3.02	(<1)[8]
Gunfleet Sands	(-)	1	1	Oct-Mar	3.04	<1/-
Horns Rev 1	(-)	N/A[7]	1	Jan-Apr	3.87	(<1)
Horns Rev 2	(-)	2	1	Oct-Apr	2.74	(<1)

[1]weak displacement effect predicted after re-analysis; [2]displacement effects shown to be statistically non-significant after re-analysis; [3]a positive displacement effect was predicted however a weak (<25%) negative displacement rate was also compatible with the data; [4]surveys not conducted in consecutive years (2001/2 and 2004) and a minimum of six years prior to operation; [5]gradient analysis conducted with data from three surveys conducted in July during second year of operation; [6]pre-construction surveys cover two winter seasons; [7]inside/outside wind farm analysis was conducted; [8]density not provided but estimated at less than two from count data; [9]displacement effects are representative of the winter season only due to low/zero counts during other periods; [10]monthly surveys covering two to 10 years for different months; [11]non-breeding and breeding displacement effects, respectively. [12]mean peak density shown at species level for Guillemot and Razorbill or shown in brackets when given at auk group level. Sources: Beatrice: MacArthur Green 2021; Thanet: Percival 2013; Westermost Rough: APEM 2017; North Hoyle: PMSS 2007; Robin Rigg: Vallejo et al. 2017& Zuur 2018; Lincs: Webb et al. 2017;

Prinses Amalia: Leopold et al. 2013 & Zuur 2018; Egmond aan Zee: Leopold et al. 2013 & Zuur 2018; Helgoland Cluster & Butendiek: Peschko et al. 2020; Thornton Bank: Vanermen et al. 2019; Bligh Bank: Vanermen et al. 2019; BARD 1: Braasch et al. 2015: Alpha Ventus: Welcker and Nehls 2016; Kentish Flats: Gill et al. 2008; Gunfleet Sands: Percival 2010; Horns Rev 1: Petersen and Fox 2007; Horns Rev 2: Petersen et al 2014.

5.11.2.25 These data would suggest that OWF sites that have moderate to high auk abundance (e.g. densities of ≥5/km^2), tend to have reported displacement effects that are non-significant or weak as demonstrated from the analysis of data from Beatrice, Robin Rigg, Westernmost Rough, North Hoyle, Lincs and Thanet OWFs. The higher and variable displacement rates demonstrated by some OWF sites seem to be related to low abundance and more likely to be artefacts of the analysis method being incapable of incorporating low abundances and/or high zero inflation within the dataset. Therefore, displacement effects appear to be related to the importance of the respective area for auks with regard to breeding, migrating and moulting. For example, in an area of high auk density competition for food between birds is greater, and individual birds may become more tolerant of any real or perceived disturbance from an OWF. In locations of low auk density, birds select habitat with sufficient prey, but as competition for food between birds is reduced, they can also select areas where real or perceived disturbance is low. This may in part explain the highly variable displacement effects reported between OWF sites, especially in North Sea waters between the UK and mainland Europe. The data show no evidence that displacement effects are predominantly correlated to WTG density or size of the OWF, as suggested in earlier studies.

5.11.2.26 Study design is critical to the statistical power to detect change but is often not adequate for this purpose (Degraer et al. 2012). The power to detect change from survey data alone is related to the frequency of surveys, their temporal extent and spatial coverage (Maclean et al. 2013). The number of years of data that may be needed to be able to demonstrate statistically significant changes (due to 'natural' year-to-year fluctuations in populations), has been suggested to be more than the three-year monitoring studies often employed (Vanermen et al. 2013). Unless declines are substantial (e.g. in excess of 50%) or survey effort is considerable (e.g. > 80 surveys), the likelihood of being able to detect declines is likely to be low (Maclean et al. 2013).

5.11.2.27 The inability to detect changes in abundance should not be taken to mean that no changes are occurring, particularly since **Table 5.28** shows the majority of studies have three or fewer years of monitoring data. Therefore, until further monitoring data is collected and analysed at OWF sites, a precautionary approach would be to assign a displacement rate of up to 50% for auks at sites which currently report no significant displacement effects. The higher displacement rates reported from German and Belgium OWFs with low auk abundance and poor displacement rate accuracy (48-78% reported after explorative INLA analysis for Thorntonbank OWF) would not be suitable sites for predicting auk displacement rates for Hornsea Four. This is on the basis of two important considerations, firstly, some of the reported higher displacement rates from sites of low auk abundance are likely to be artefacts of analysis. Secondly, that the Hornsea Four site displays a moderate auk density similar to sites such as Beatrice, Thanet, Westermost Rough and North Hoyle, and a predominant factor in predicting displacement rate appears to be auk density therefore low auk abundance OWF sites would not be reflective of auk behaviour at Hornsea Four. A displacement rate of 50% for auks would therefore be the most applicable and precautionary for Hornsea Four using this evidence-led approach. This would be on the basis that comparable sites to Hornsea Four should be based primarily on comparable (moderate to high) abundance levels of auks in OWF areas to predict behavioural responses.

5.11.2.28 Therefore, in conclusion there is robust evidence to support an auk displacement rate of up to 50% within the Hornsea Four array area as an upper limit, which is still considered as precautionary as this level of displacement is also applied to the 2 km buffer.

Effects of Displacement on Auk Mortality

5.11.2.29 Current evidence suggests that the response of seabirds to OWFs varies depending on the species and of life stage of the individual birds. Birds that avoid OWFs may do so entirely, including an area considered to be a buffer around an OWF or do so partially. Avoidance of OWFs may be either on a spatial scale or temporally according to levels of competition outside the OWF or prey abundance within the OWF. Habitat loss is ultimately considered to be the consequence of these avoidance behaviours and therefore, a major challenge is understanding how displacement from OWF habitat may impact upon population processes.

5.11.2.30 Displacement effects may act at differing levels, including the individual, colony and population levels and are dependent on key factors:

- The importance of the area to be occupied by the OWF in context to the surrounding area;
- The fraction of the colony/population utilising the area of the OWF;
- The degree (number of birds and distance) of displacement by the OWF; and
- The consequences of habitat loss (in terms of the survival probability and productivity) as a result of the OWF.

5.11.2.31 Mortalities are likely to correlate strongly with the quality of the habitat lost; if key foraging habitat is lost and the remaining habitat is already close to carrying capacity, then the mortality rates of displaced birds may be considerably higher (Busche and Garthe 2016).

5.11.2.32 The appropriateness of using mortality rates as high as 10% in assessments is unclear, given the lack of evidence, though UK SNCBs regularly advise the use of a range of 1–10% mortality based on expert opinion (Natural England 2014) for guillemots and other auk species. In contrast, independent environmental consultants working on behalf of Developers have claimed that 1% or 2% mortality is more appropriate (Norfolk Boreas Limited 2019; SPR 2019; Orsted 2018b), though these were also almost entirely based on expert judgement. The lack of empirical evidence previously considered led to the 1-10% mortality rate range prediction continuing to be used despite it being a 'best guess' to allow for precaution. This was evident following consultation with seabird experts, such as stated by Allen (2013), in the JNCC expert statement on ornithological issues for East Anglia One OWF. At that time there was currently no data (even anecdotal) with which to support the reliable selection of mortality rates stemming from varying levels of displacement. However, since Natural England's interim advise on auk mortality rates was issued and updated in 2017 (SNCBs 2017) there have been two detailed studies with updates to predict the fate or population consequence of displaced seabirds, including auks, from OWFs (Searle et al. 2014 and 2018, and van Kooten et al. 2019), and anecdotal evidence of implied low additional mortality rates from auk colony stability on Helgoland, where OWFs have been operating in the area since 2014 and auk displacement rates of 44-63% have been reported (Peschko et al. 2020).

5.11.2.33 Van Kooten et al. (2019) applied an assessment method to estimate full life cycle, North Sea population effects caused by OWF-induced habitat loss. The study included assessment of two auk species, razorbill and guillemot, for the non-breeding season and included all existing and planned North Sea OWFs as presented in Van der Wal et al. (2018). The analysis consisted of habitat quality maps based on seabird distribution data and determining the cost of habitat loss using an individual based energy-budget model. Together the potential cost of habitat loss in terms of reduced survival rates of bird redistribution, due to a change in the availability and configuration of the foraging area under OWF scenarios, were calculated. Two mortality rates were tested; the first based on the Individual Based Model (IBM), using an energy budget approach to quantify this effect and the outputs from the Habitat Utilization Maps (HUMs); the second based on a precautionary 10% mortality rate. Displacement rates were set at a realistic maximum of 50% based on Dierschke et al. (2016) or an overly precautionary 100% in order to understand complete displacement. The modelling process assumes individual birds have an amount of energy available any particular time and have an intake of energy and incur energetic costs over time. Utilising the values in the habitat maps the model calculates energetic gain or losses of moving to different locations to produce a frequency distribution of survival probabilities.

5.11.2.34 The Van Kooten et al. (2019) study demonstrated that an additional 1% mortality for displaced auks is a more appropriate evidence-based rate that would still be considered precautionary considering the additional monthly mortality rates modelled by the study which translate to an additional non-breeding season mortality rate for displaced auks of 0.1 for a 50% displacement rate and 0.4% for a 100% displacement rate (Van Kooten et al. 2018) and that a 10% mortality rate is overly precautionary.

5.11.2.35 Searle et al. (2014) presented what is still considered to be the most comprehensive assessment of the effects of displacement and barrier effects from OWFs on breeding seabirds. The study developed time and energy models of foraging during the chick-rearing period to estimate the population consequences of displacement from proposed OWF developments for key species of seabirds, including guillemot and razorbill, breeding at local SPAs.

5.11.2.36 The Searle et al. (2014) model simulated foraging decisions of individual seabirds under the assumption that they were acting in accordance with optimal foraging theory. Each individual selected a suitable location for feeding during each foraging trip from the colony based on bird density maps and that the foraging behaviour of individual seabirds was driven by prey availability, travel costs, provisioning requirements for offspring, and behaviour of conspecifics. The impacts of the proposed OWFs were assessed by comparing simulated values of adult and chick survival in models that included the OWFs against the baseline simulations. The scenarios run reflected possible assumptions regarding food availability (good, moderate or poor), the spatial distribution of prey (homogeneous or heterogeneous), and the percentage of birds affected by barrier and displacement effects. The final simulations assumed moderate food availability, a 1 km buffer around each OWF, and that 60% of birds experienced displacement and barrier effect, which may be considered to be the most similar model run to conditions at Hornsea Four. The results did not show evidence of declines in adult survival of more than 0.5% for razorbills or guillemots.

5.11.2.37 The results of the Searle et al. (2014) model simulations consistently yielded estimated OWF effects on adult survival that corresponded to declines of less than 0.5% for guillemot and razorbill. For guillemot and razorbill estimated additional mortality from individual OWFs ranged from 0.04% to 0.3% and 0.01% to 0.11%, respectively, therefore considerably lower than the current minimum applied of 1% mortality. Searle et al., (2018) further developed a tool that uses a simulation model, which extends the simulation model developed by Searle et al. (2014), to predict the time and energy budgets of breeding seabirds and translates these into projections of adult annual survival and productivity (i.e., chick survival/mortality).

5.11.2.38 In summary, Searle et al. (2014) provides evidence that changes in time and energy budgets, in relation to guillemot and razorbill, as a result of displacement from OWFs has the potential to impact on the body condition, and future survival prospects. Such changes may also reduce breeding success if provisioning rate declines result in offspring starvation, or if the extended time required for foraging results in temporary unattendance of eggs or young, which increases the likelihood of mortality from predation or exposure. OWFs located on favoured foraging habitats that force birds to forage at greater densities in sub-optimal habitats were found to have the highest impact. However, studies using simulation models of time and energy budgets for auks during the breeding and non-breeding season conclude that these displacement effects, even at their highest impacts, are unlikely to exceed an additional 0.5% in mortality and that a 1% additional mortality rate based on available evidence, would offer precaution and encompass even scenarios with the highest impacts on demographics from displacement.

5.11.2.39 Considering the results of simulation models by Searle et al. (2014) and van Kooten et al. (2019) on the impacts of displacement on auk adult survival to be consistently less than 0.5%, it would suggest that additional mortality effects at a colony or population level would be negligible or undetectable under current monitoring conditions. However, an additional mortality level of 10% would likely be detectable after several years of monitoring, especially if continued moderate displacement from an OWF is occurring. Although published studies with empirical evidence to support this are lacking, impacts on demographic effects from OWF displacement can be inferred from colony population trends, where displacement effects on auk distributions have been reported. One such colony is that on Helgoland in the German North Sea in which displacement rates for auks have been predicted to be 44% during the breeding season and 63% during the non-breeding season (Peschko et al. 2020). OWFs of the Helgoland cluster have been in operation since 2014 allowing a substantial time for any correlation between operation of the OWFs and changes in colony demographics if significant additional mortality from displacement is occurring. These data provides supporting evidence that overly precautionary rates of mortality over 1% are not apparent, as the latest breeding population status on Helgoland shows a continued increase for both razorbill and guillemot over the latest five-year period, which has remained unchanged compared to long-term data (Gerlach et al. 2019).

5.11.2.40 The studies considered for this assessment (van Kooten et al. 2019; Searle et al. 2014; Peschko et al. 2020; and Gerlach et al. 2019) together provide the most comprehensive review of potential displacement consequences to auks during the breeding and non-breeding season. They all collectively conclude that any displacement effects, even when considering overly precautionary rates to increase potential impacts, are unlikely to exceed a mortality rate 0.5%. Therefore, they support the use of up to a 1% mortality rate based on the best available evidence offers an appropriate level of precaution that encompasses scenarios considering the highest impacts on demographics from displacement.

Guillemot

5.11.2.41 For the purpose of this assessment, an evidence-led displacement and mortality rate of 50% and 1% respectively was applied to each bio-season based on evaluation of the published literature and in line with values used by other OWF displacement assessments. Additional consideration is provided by reference to Natural England's preferred method of assessing potential impacts from displacement using a range of between 30% to 70% displacement and between 1% to 10% mortality rates.

5.11.2.42 However, it should be noted that due to the large expanse of available habitat outside of the array area, the mortality rate due to displacement could be as low as 0% as the increase in density outside of the array area in comparison to the whole of the North Sea would be negligible.

5.11.2.43 A complete range of displacement matrices are presented in **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis**, whilst **Table 5.29** has been populated with data for guillemots during the breeding and non-breeding season within the Hornsea Four array area as well as out to a 2 km buffer.

Potential magnitude of Impact

5.11.2.44 The annual estimated mortality rate as a consequence of displacement during the operation and maintenance phase of Hornsea Four for guillemot is 214 individuals, which is further broken down into relevant bio-seasons in **Table 5.29**. The potential magnitude of impact is estimated by calculating the increase in baseline mortality within each bio-season with respect to the most appropriate regional / BDMPS population scales. The overall baseline mortality rates are based on age specific demographic rates and age class proportions as presented in **Table 5.13**.

Table 5.29: 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		Estimated mortality rate/s (individuals)	Increase in baseline mortality (%)
		Population (individuals)	Baseline mortality (per annum)		
Breeding (Mar-Jul)	8,553	936,876	129,289	43 (26 – 599)	0.019 *(0.011 – 0.268)*
Non-breeding (Aug-Feb)	17,062	1,617,306	223,188	85 (*51 – 1,194*)	0.038 *(0.023 –0.535)*
Annual (BDMPS)	**25,615**	**1,617,306**	**223,188**	**128** (*77 – 1,793*)	**0.057** *(0.034 – 0.803)*
Annual (biogeographic)	**25,615**	**4,125,000**	**569,250**	**128** (*77 – 1,793*)	**0.022** *(0.013 – 0.315)*

Table Note: Values in parenthesis include displacement range requested to be presented by Natural England of 30 – 70 Displacement & 1-10% Mortality (OFF-ORN-2.43).

5.11.2.45 During the breeding bio-season, the mean peak abundance for guillemot is 8,553 individuals within the array area and 2 km buffer. When considering evidence-based displacement and mortality rates of 50% and 1%, respectively, this would result in approximately 43 guillemots predicted to being subject to mortality. As calculated in **Section 5.7.4**, during the breeding bio-season the total guillemot regional baseline population, including breeding adults and immature birds, is predicted to be 936,876 individuals. Using the average baseline mortality rate of 0.138 (**Table 5.13**), the natural predicted mortality of guillemots in the breeding bio-season is 129,289 per annum. The addition of 43 predicted mortalities would increase the baseline mortality rate by 0.019%.

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

5.11.2.47 During the non-breeding bio-season, the weighted mean peak abundance for guillemot is 34,095 individuals within the array area and 2km buffer. When considering evidence-based displacement and mortality rates of 50% and 1%, respectively, this would result in approximately 85 guillemots predicted to being subject to mortality. The UK North Sea and English Channel BDMPS for the non-breeding bio-season is defined as 1,617,306 individuals (Furness 2015) and using the average baseline mortality rate of 0.138 (**Table 5.13**), the natural predicted mortality in the non-breeding bio-season is 223,188 per annum. The addition of 85 predicted mortalities would increase the baseline mortality rate by 0.038%.

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

5.11.2.49 For all seasons combined, the maximum number of guillemots subject to mortality due to displacement from the Hornsea Four array area plus 2 km buffer during the operation and maintenance phase is 128 individuals per annum. Using the largest UK North Sea and English Channel BDMPS population of 1,617,306 individuals (Furness 2015) as a proxy for the total BDMPS population across the year, with an average baseline mortality rate of 0.138 (**Table 5.13**), the natural predicted mortality across all seasons is 223,188 per annum. The addition of 128 predicted mortalities would increase the baseline mortality rate by 0.057% at the BDMPS scale. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality of the biogeographic population of 4,125,000 across all seasons is 569,250 individuals per annum. The addition of 128 predicted mortalities would increase the biogeographic baseline mortality rate by 0.022%.

5.11.2.50 This level of potential impact per annum is considered to be of **negligible** magnitude at the UK North Sea and English Channel BDMPS scale and to be of **negligible** magnitude at the biogeographic scale, as it represents between only a slight to a minor difference to the baseline conditions due to the number of individuals subject to potential mortality as a result of displacement.

5.11.2.51 Natural England consider that displacement and any consequent mortality rates in the assessment of auk species should be made using a range of values. The displacement matrix in **Table 5.31** provides the annual total of guillemots predicted to be at risk of displacement from the Hornsea Four array area plus 2 km buffer (OFF-ORN-4.8) when applying any value of displacement and mortality. When considering Natural England's range of 30% to 70% displacement and 1% to 10% mortality, between 77 and 1,793 additional predicted mortalities may result as a consequence of displacement annually. This range of additional mortality would increase the baseline mortality of the largest UK North Sea and English Channel BDMPS population by between 0.034% and 0.803% when considering 30% displacement with 1% mortality and 70% displacement with 10% mortality, respectively. Even when considering Natural England's upper range of 70% displacement and 10% mortality, the increase in the UK North Sea and English Channel BDMPS baseline mortality rate is still under a 1% increase, it is extremely unlikely that individuals being displaced from the small area within the Hornsea Four array area and a 2 km buffer in relation to the whole UK North Sea and English Channel would result in that level of mortality.

5.11.2.52 Despite the predicted increase in the baseline mortaility rate not exceeding 1% even when considering Natural England's overly precautionary displacement range, a precautionary approach has been taken and further consideration in the form of PVA has been carried out considering a wide range of displacement and mortality rates as requested by Natural England (OFF-ORN-2.50). Further details of the PVA methodology, input parameters and details on how to interpret the PVA results below can be found in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis**. The results of the PVA are summarised in **Table 5.30** below for impacts from displacement for Hornsea Four alone during the O&M Phase.

5.11.2.53 For all PVA results the predicted reduction in the population growth rate is well under 0.2% for the BDMPS or 0.05% for the biogeographic scale, even when considering Natural England's overly precautionary 70% displacement and 10% mortality rate. This level of predicted magnitude would almost certainly be indistinguishable from natural fluctuations in the population's mortality rates on an annual basis.

5.11.2.54 When considering the evidence-led approach to displacement (applying a displacement rate of 50% and a mortality rate of 1%), the magnitude of this impact is considered to be **negligible** during the two bio-seasons and on an annual basis. Therefore, irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment for these two bio-seasons.

Table 5.30: Guillemot PVA results for O&M phase displacement impacts at the BDMPS and biogeographic scale.

Scenario Description	Increase in Mortality	BDMPS results		Biogeographic Results	
		Density independent counterfactual of growth rate (after 35 years)	Reduction in growth rate (%)	Density independent counterfactual of growth rate (after 35 years)	Reduction in growth rate (%)
30% disp, 1% Mort	77	1.000	0.005	1.000	0.002
50% disp, 1% Mort	128	1.000	0.009	1.000	0.004
60% disp, 1% Mort	154	1.000	0.011	1.000	0.004
70% disp, 1% Mort	179	1.000	0.012	1.000	0.005
30% disp, 2% Mort	154	1.000	0.011	1.000	0.004
50% disp, 2% Mort	256	1.000	0.018	1.000	0.007
70% disp, 2% Mort	359	1.000	0.025	1.000	0.010
30% disp, 5% Mort	384	1.000	0.027	1.000	0.010
50% disp, 5% Mort	640	1.000	0.044	1.000	0.018
70% disp, 5% Mort	897	0.999	0.062	1.000	0.024
30% disp, 10% Mort	768	0.999	0.053	1.000	0.021
50% disp, 10% Mort	1,281	0.999	0.089	1.000	0.035
70% disp, 10% Mort	1,793	0.999	0.125	1.000	0.049

Table 5.31: Annual displacement matrix for guillemot within the Hornsea Four array area plus 2 km buffer, values in green represent the range-based values advocated by Natural England and the darker shade of green representing the Applicant's approach value.

Displacement Rate (%)	Mortality Rate (%)														
	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
1	3	5	8	10	13	26	51	77	102	128	154	179	205	231	256
10	26	51	77	102	128	256	512	768	1,025	1,281	1,537	1,793	2,049	2,305	2,561
20	51	102	154	205	256	512	1,025	1,537	2,049	2,561	3,074	3,586	4,098	4,611	5,123
30	77	154	231	307	384	768	1,537	2,305	3,074	3,842	4,611	5,379	6,148	6,916	7,684
40	102	205	307	410	512	1,025	2,049	3,074	4,098	5,123	6,148	7,172	8,197	9,221	10,246
50	128	256	384	512	640	1,281	2,561	3,842	5,123	6,404	7,684	8,965	10,246	11,527	12,807
60	154	307	461	615	768	1,537	3,074	4,611	6,148	7,684	9,221	10,758	12,295	13,832	15,369
70	179	359	538	717	897	1,793	3,586	5,379	7,172	8,965	10,758	12,551	14,344	16,137	17,930
80	205	410	615	820	1,025	2,049	4,098	6,148	8,197	10,246	12,295	14,344	16,394	18,443	20,492
90	231	461	692	922	1,153	2,305	4,611	6,916	9,221	11,527	13,832	16,137	18,443	20,748	23,053
100	256	512	768	1,025	1,281	2,561	5,123	7,684	10,246	12,807	15,369	17,930	20,492	23,053	25,615

Razorbill

5.11.2.55 For the purpose of this assessment, an evidence led displacement and mortality rate of 50% and 1% respectively was applied to each bio-season based on evaluation of the published literature and in line with values used by other OWF displacement assessments. Additional consideration is given to Natural England's preferred method of assessing potential impacts from displacement using a range of between 30% to 70% displacement and between 1% to 10% mortality rates.

5.11.2.56 However, it should be noted that due to the large expanse of available habitat outside of the OWF area, the mortality rate due to displacement could be as low as 0% as the increase in density outside of the OWF area, in comparison to the whole of the North Sea, would be negligible.

5.11.2.57 A complete range of displacement matrices are presented in **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis**, whilst **Table 5.32** 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 2 km buffer.

Potential magnitude of impact

5.11.2.58 The annual estimated mortality rate for razorbill is 24 individuals, which is further broken down into relevant bio-seasons in **Table 5.32**. The potential 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 as presented in **Table 5.13**.

Table 5.32: 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		Estimated mortality rate/s (individuals per annum)	Increase in baseline mortality (%)
		Population (individuals)	Baseline mortality (per annum)		
Return Migration (Jan-Mar)	371	591,874	114,232	2 (*1 – 26*)	0.002 (*0.001 – 0.023*)
Migration-free Breeding (Apr-Jul)	276	282,582	54,538	1 (*1 – 19*)	0.003 (*0.002 – 0.035*)
Post-breeding migration (Aug-Oct)	3,590	591,874	114,232	18 (*11 – 251*)	0.017 (*0.010 – 0.230*)
Migration-free Winter (Nov-Dec)	474	218,622	42,194	2 (*1 – 33*)	0.006 (*0.003 – 0.079*)
Annual (BDMPS)	**4,711**	**591,874**	**114,232**	**24** (*14 – 330*)	**0.021** (*0.012 – 0.289*)
Annual (biogeographic)	**4,711**	**1,707,000**	**329,451**	**24** (*14 – 330*)	**0.007** (*0.004 – 0.100*)

Table Note: Values in parenthesis include displacement range requested to be presented by Natural England of 30 – 70 Displacement & 1-10% Mortality (OFF-ORN-2.43).

5.11.2.59 During the return migration bio-season, the mean peak abundance for razorbill is 371 individuals within the array area and 2 km buffer. When considering evidence-based displacement and mortality rates of 50% and 1%, respectively, this would result in approximately two razorbills being subject to mortality. The UK North Sea and English Channel BDMPS for the return migration bio-season is defined as 591,874 (Furness 2015) and using the average baseline mortality rate of 0.193 (**Table 5.13**), the natural predicted mortality in the return migration bio-season is 114,232 per annum. The addition of two predicted mortalities would increase the baseline mortality rate by 0.002%.

5.11.2.60 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.

5.11.2.61 During the migration-free breeding bio-season, the mean peak abundance for razorbill is 276 individuals within the array area and 2 km buffer. When considering evidence-based displacement and mortality rates of 50% and 1%, respectively, this would result in approximately one razorbill being subject to mortality. As calculated in **Section 5.7.4**, during the migration-free breeding bio-season, the total razorbill regional baseline population, including breeding adults and immature birds, is predicted to be 282,582 individuals. Using the average baseline mortality rate of 0.193 (**Table 5.13**), the natural predicted mortality of razorbills in the migration-free breeding bio-season is 54,538 per annum. The addition of one predicted mortality would increase the baseline mortality rate by 0.003%.

5.11.2.62 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.

5.11.2.63 During the post-breeding migration bio-season, the mean peak abundance for razorbill is 3,590 individuals within the array area and 2 km buffer. When considering the evidence-based displacement and mortality rate of 50% and 1% respectively, this would result in approximately 18 razorbills predicted to be subject to mortality. The UK North Sea and English Channel BDMPS for the post-breeding migration bio-seasons is defined as 591,874 (Furness 2015) and using the average baseline mortality rate of 0.193 (**Table 5.13**), the natural predicted mortality in the post-breeding migration bio-season is 114,232 per annum. The addition of 18 predicted mortalities would increase the baseline mortality rate by 0.016%.

5.11.2.64 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.

5.11.2.65 During the migration-free winter bio-season, the mean peak abundance for razorbills is 474 individuals within the array area and 2 km. Using the evidence-based displacement and mortality rate of 50% and 1% would result in approximately two razorbills predicted to be subject to mortality. The UK North Sea and English Channel BDMPS for the winter bio-season is defined as 218,622 (Furness 2015) and using the average baseline mortality rate of 0.193 (**Table 5.13**), the natural predicted mortality in the migration-free winter bio-season is 42,194 per annum. The addition of two mortalities would increase the baseline mortality rate by 0.006%.

5.11.2.66 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.

5.11.2.67 For all seasons combined, the maximum number of razorbills predicted to be subject to mortality due to displacement from the Hornsea Four array area plus 2 km buffer is 24 individuals per annum. Using the largest UK North Sea and English Channel BDMPS population of 591,874 individuals (Furness 2015), as a proxy for the total BDMPS population across the year, with an average baseline mortality rate of 0.193 (**Table 5.13**), the natural predicted mortality across all seasons is 114,232 per annum. The addition of 24 predicted mortalities would increase the baseline mortality rate by 0.021% at the BDMPS scale. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality of the biogeographic population of 1,707,000 across all seasons is 329,451 per annum. The addition of 24 predicted mortalities would increase the biogeographic baseline mortality rate by 0.007%.

5.11.2.68 This level of potential impact per annum is considered to be of **negligible** magnitude at the UK North Sea and English Channel BDMPS scale and **negligible** magnitude at the biogeographic scale, as it represents between only a slight to a minor difference to the baseline conditions due to the number of individuals subject to potential mortality as a result of displacement.

5.11.2.69 Natural England consider displacement and any consequent mortality rates in the assessment of auk species should be made using a range of values. The displacement matrix in **Table 5.33** provides the annual total of razorbills predicted to be at risk of displacement from the Hornsea Four array area and a 2 km buffer (OFF-ORN-4.8) when applying any value of displacement and mortality. When considering Natural England's range of 30% to 70% displacement and 1% to 10% mortality, between 14 and 330 predicted mortalities may result as a consequence of displacement annually. This range of predicted additional mortality would increase the baseline mortality of the largest UK North Sea and English Channel BDMPS population by between 0.012% and 0.289% when considering 30% displacement with 1% mortality and 70% displacement with 10% mortality, respectively.

5.11.2.70 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 (**Table 5.22**) and is therefore not considered further in this assessment.

Table 5.33: Annual displacement matrix for razorbill within the Hornsea Four array area plus 2 km buffer, values in green represent the range-based values advocated by Natural England and the darker shade of green representing the Applicant's approach value.

Displacement Rate (%)	Mortality Rate (%)														
	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
1	0	1	1	2	2	5	9	14	19	24	28	33	38	42	47
10	5	9	14	19	24	47	94	141	188	236	283	330	377	424	471
20	9	19	28	38	47	94	188	283	377	471	565	660	754	848	942
30	14	28	42	57	71	141	283	424	565	707	848	989	1,131	1,272	1,413
40	19	38	57	75	94	188	377	565	754	942	1,131	1,319	1,508	1,696	1,884
50	24	47	71	94	118	236	471	707	942	1,178	1,413	1,649	1,884	2,120	2,356
60	28	57	85	113	141	283	565	848	1,131	1,413	1,696	1,979	2,261	2,544	2,827
70	33	66	99	132	165	330	660	989	1,319	1,649	1,979	2,308	2,638	2,968	3,298
80	38	75	113	151	188	377	754	1,131	1,508	1,884	2,261	2,638	3,015	3,392	3,769
90	42	85	127	170	212	424	848	1,272	1,696	2,120	2,544	2,968	3,392	3,816	4,240
100	47	94	141	188	236	471	942	1,413	1,884	2,356	2,827	3,298	3,769	4,240	4,711

Puffin

5.11.2.71 For the purpose of this assessment, an evidence-led displacement and mortality rate of 50% and 1% respectively was applied to each bio-season based on evaluation of the published literature and in line with values used by other OWF displacement assessments. Additional consideration is provided to Natural England's preferred method of assessing potential impacts from displacement using a range of between 30% to 70% displacement and between 1% to 10% mortality rates.

5.11.2.72 However, it should be noted that due to the vast expanse of available habitat outside of the OWF area, the mortality rate due to displacement could be as low as 0% as the increase in density outside of the OWF area, in comparison to the whole of the North Sea, would be negligible.

5.11.2.73 A complete range of displacement matrices are presented in **Volume A5, Annex 5.2: Offshore Ornithology Displacement Analysis**, whilst **Table 5.34** has been populated with data for puffins during the breeding and non-breeding bio-seasons within the Hornsea Four array area and a 2 km buffer.

Potential magnitude of impact

5.11.2.74 The annual estimated mortality rate for puffin is three individuals, which is further broken down into relevant bio-seasons in **Table 5.34**. The potential 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 as presented in **Table 5.13**.

Table 5.34: 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		Estimated mortality rate/s (individuals per annum)	Increase in baseline mortality (%)
		Population (individuals)	Baseline mortality (per annum)		
Breeding season (Apr-Jul)	153	260,726	45,627	1 (*0 – 11*)	0.002 (*0.001 – 0.024*)
Non-breeding season (Aug-Mar)	353	231,957	40,592	2 (*1 – 25*)	0.004 (*0.003 – 0.061*)
Annual (BDMPS)	**506**	**260,726**	**45,627**	**3** (*2 – 35*)	**0.006** (*0.003 – 0.078*)
Annual (biogeographic)	**506**	**11,840,000**	**2,072,000**	**3** (*2 – 35*)	**0.000** (*0.000 – 0.002*)

Table Note: Values in parenthesis include displacement range requested to be presented by Natural England of 30 – 70 Displacement & 1-10% Mortality (OFF-ORN-2.43).

5.11.2.75 During the breeding bio-season, the mean peak abundance for puffin is 153 individuals within the array area and a 2 km. When considering evidence-based displacement and mortality rates of 50% and 1%, respectively, this would result in approximately one puffin predicted to be subject to mortality. As calculated in **Section 5.7.4**, during the breeding bio-season, the total puffin regional baseline population of breeding adults and immature birds is predicted to be 260,726 puffins. Using the average baseline mortality rate of 0.175 (**Table 5.13**), the natural predicted mortality in the breeding bio-season is 45,627 per annum. The addition of one predicted mortality would increase the baseline mortality rate by 0.002%.

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

5.11.2.77 During the non-breeding bio-season, the mean peak abundance for puffin is 353 individuals within the array area and a 2 km buffer. When considering evidence-based displacement and mortality rates of 50% and 1%, respectively, this would result in approximately two puffins predicted to be subject to mortality. The UK North Sea and English Channel BDMPS for the non-breeding bio-season is defined as 231,957 individuals (Furness 2015) and using the average baseline mortality rate of 0.175 (**Table 5.13**), the natural predicted mortality in the non-breeding bio-season is 40,592 per annum. The addition of two predicted mortalities would increase the baseline mortality rate by 0.004%.

5.11.2.78 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.

5.11.2.79 For all seasons combined, the maximum number of puffins predicted to be subject to mortality due to displacement from the Hornsea Four array area and a 2 km buffer is three individuals per annum. Using the largest UK North Sea and English Channel BDMPS population of 260,726 individuals (Furness 2015), as a proxy for the total BDMPS population across the year, with an average baseline mortality rate of 0.175 (**Table 5.13**), the natural predicted mortality across all seasons is 45,627 per annum. The addition of three predicted mortalities would increase the baseline mortality rate by 0.006% at the BDMPS scale. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality of the biogeographic population of 11,840,000 across all seasons is 2,072,000 individuals per annum. The addition of three predicted mortalities would increase the biogeographic baseline mortality rate by 0.000%.

5.11.2.80 This level of potential impact per annum is considered to be **negligible** at the UK North Sea and English Channel BDMPS scale and **no change** at the biogeographic scale, as it represents between only a slight to a minor difference to the baseline conditions due to the number of individuals subject to potential mortality as a result of displacement.

5.11.2.81 Natural England consider displacement and any consequent mortality rates in the assessment of auk species should be made using a range of values. The displacement matrix in **Table 5.35** provides the annual total of puffins predicted to be at risk of displacement from the Hornsea Four array area plus 2 km buffer (OFF-ORN-4.8) when applying any value of displacement and mortality. When considering Natural England's range of 30% to 70% displacement and 1% to 10% mortality, between two and 35 predicted mortalities may result as a consequence of displacement annually. This range of additional mortality would increase the baseline mortality of the largest UK North

Sea and English Channel BDMPS population by between 0.003 and 0.078% when considering 30% displacement with 1% mortality and 70% displacement with 10% mortality, respectively.

5.11.2.82 The magnitude of this impact is considered to be of **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 (**Table 5.22**) and is therefore not considered further in this assessment.

Table 5.35: Annual displacement matrix for puffin within the Hornsea Four array area plus 2 km buffer, values in green represent the range-based values advocated by Natural England and the darker shade of green representing the Applicant's approach value.

Displacement Rate (%)	Mortality Rate (%)														
	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	1	1	2	2	3	3	4	4	5	5
10	1	1	2	2	3	5	10	15	20	25	30	35	41	46	51
20	1	2	3	4	5	10	20	30	41	51	61	71	81	91	101
30	2	3	5	6	8	15	30	46	61	76	91	106	122	137	152
40	2	4	6	8	10	20	41	61	81	101	122	142	162	182	203
50	3	5	8	10	13	25	51	76	101	127	152	177	203	228	253
60	3	6	9	12	15	30	61	91	122	152	182	213	243	273	304
70	4	7	11	14	18	35	71	106	142	177	213	248	284	319	354
80	4	8	12	16	20	41	81	122	162	203	243	284	324	365	405
90	5	9	14	18	23	46	91	137	182	228	273	319	365	410	456
100	5	10	15	20	25	51	101	152	203	253	304	354	405	456	506

Seabirds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure (ORN-O-6)

5.11.2.83 There is potential risk to birds from OWFs through collision with WTGs and associated infrastructure described in the MDS (**Table 5.18**) resulting in injury or fatality (OFF-ORN-6). 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.

5.11.2.84 CRM has been carried out for Hornsea Four, with detailed methods and results presented in **Volume A5, 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 5.36**. This screening process assessed the species for which the risk of collision is considered as very low, such as for fulmar that fly very close to the sea surface so are unlikely to interact with WTGs, and as such, these species were screened out of the collision risk assessment. Species were also screened out if their densities in flight within the array area were very low or low, as this also provides evidence of very low risk of collision. The only exception to the latter screening was for seabird species considered to be of medium to high risk of collision, such as gull species, two species of which were screened in despite their density in flight being very low (herring gull and lesser black-backed gull). Following this screening process, the five species agreed, in principle, as the species of focus for CRM through the evidence plan process (OFF-ORN-2.11) were; gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull. Although not recorded in abundances / densities initially considered high enough for CRM, little gull, 'commic' tern, great skua and Arctic skua were screened in at the request of Natural England and addressed in migratory CRM assessments in **paragraph 5.11.2.142** *et seq.* (OFF-ORN-2.41).

Table 5.36: 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 (Number of 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
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

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 (Number of birds/km^2 from 24 months surveys data)	Screening Result (In or Out)
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*
Great skua	Medium	<0.01 birds/km^2 Very low (seasonally restricted)	In*
Arctic skua	Medium	<0.01 birds/km^2 Very low (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: *Species not recorded in abundances / densities initially considered high enough for CRM but screened in at the request of Natural England and addressed in migratory CRM assessments in **Section 5.11.2**.

5.11.2.85 CRM was undertaken using the sCRM, developed by Marine Scotland (McGregor 2018), run deterministically for each seabird species, to determine the risk of collision when in flight, in agreement with Natural England and the RSPB (**Table 5.4**) (OFF-ORN-2.26). The development and testing of the sCRM was funded by MSS and provides the most up-to-date version of the CRM originally created by Band (2012) and addresses the uncertainty in developments and other key input parameters as progressed initially by Masden (2015).

5.11.2.86 The sCRM is run through an online interface referred to as the 'Shiny app', 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).

5.11.2.87 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 A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.

5.11.2.88 Hornsea Four has taken significant measures to reduce the potential impacts from collision to seabirds through:

- Co138, as described in **Table 5.16**, 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 Hornsea Four Order Limits, 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 for the PEIR and further refined for the DCO Application with a revised developable area selected that avoids the areas of highest densities for these two species deemed most at risk from collision. The evolution of the Hornsea Four array area from Scoping to DCO Application is presented in **Figure 5.3**.

5.11.2.89 There were a number of areas of uncertainty with respect to the parameters that are input into the sCRM ahead of this final assessment, due to this modelling approach not having previously been subject to use within a DCO Application for an OWF. Through the EP process, APEM conducted rigorous testing of the newly updated Donovan (2018) sCRM alongside Natural England and the RSPB, with guidance from the development team responsible for maintaining the sCRM via the online platform used to access the model. Natural England requested that the sCRM should be run deterministically to provide comparable results to the Band (2012) CRM carried out in other OWF assessments. The results of these tests provided evidence that the Donovan (2018) sCRM could be run deterministically to reach results that were comparable to those from Band (2012) CRM outputs to within under 0.01% in most instances. Following further consultation on these results, it was agreed with the EP Technical Panel (OFF-ORN-2.38) that the use of the Donovan (2018) sCRM is suitable to determine collision risk to seabirds deterministically for Hornsea Four and other OWF assessments.

5.11.2.90 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 A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling)**.

5.11.2.91 In order to provide a range of values to capture variability for each species, the key input parameters were reviewed in order to provide 'mean', 'minimum' and 'maximum' estimates of collision rates for each species. Full details of the parameters used to calculate each estimate are given in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**. Although the assessment is based on an evidence-led approach the input parameters used adhere to the recommendations made by Natural England (OFF-ORN-2.32 to 2.37) except for the use of Johnston et al. (2014) 95% CI flight height values for calculating the minimum and maximum estimates whereby the evidence-led approach uses the maximum likelihood values.

5.11.2.92 Within this assessment, the Shiny app outputs / results for three different Band Options are presented (BO1, BO2 and BO3), which are described below. However, it is acknowledged that as Natural England and the RSPB are not in agreement with the use of BO1, then the results from BO2 and BO3 form the basis of assessing the risk to seabirds from collision for Hornsea Four.

Band Option 1 (BO1)

5.11.2.93 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 PCH) is determined from the observations of bird flight heights made from the boat-based site-specific surveys (HiDef BioConsult 2018a). This Option has been considered for all five seabird species.

Band Option 2 (BO2)

5.11.2.94 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 Strategic Ornithological Support Services (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.

Band Option 3 (BO3)

5.11.2.95 The Extended Band model accounts for the skewed vertical distribution of bird flight heights between the lowest and the highest levels of the rotors. Most seabird species are observed flying more frequently at the lower level of the rotor swept height, which presents lower risk of collision (i.e. closer to the sea surface) than at heights equivalent to the rotor hub height where collision risk is greater or at the upper levels. By understanding the variation of bird flight through the rotor swept area the Extended Band model considers and applies different probabilities of being struck by the moving rotor blades through the rotor swept area vertically. The Extended Band model, using Band Option 3, relies on the data spreadsheet that accompanies Johnston et al., (2014), which is the result of a statistical analysis of a large number of offshore surveys across multiple study sites. These data are fed into the model in order to allow for the flight distribution to be calculated based upon the OWF parameters of the proposed project. This Band Option has been considered for all three large gull species as per Statutory Body advice (JNCC et al. 2014).

Precautionary nature of CRM

5.11.2.96 It must be noted that a number of elements of additional precaution were included in the input parameters applied in the sCRM for this assessment, including considering a range of nocturnal activity factors and lower avoidance rates than that currently predicted from the latest scientific evidence. The nature of such precaution is evidenced

[1] Final_Report_SOSS02_FlightHeights2014.xls

through the findings of the Bird Collision Avoidance Study funded by ORJIP (Offshore Renewables Joint Industry Programme), which undertook a study to understand seabird behaviour at sea around OWFs. The ORJIP project studied birds around Thanet OWF for a two year period (between 2014 and 2016) recording over 12,000 bird movements throughout the day and night. The findings of this study (Skov et al. 2018) presented updated values for both nocturnal activity and avoidance behaviour from an empirical data source, which it recommended for future incorporation in CRM. It also reported that only six birds (all gull species) collided with WTGs from over 12,000 birds recorded during the two year period, providing evidence of the precautionary nature of collision risk modelling for all species of seabirds.

5.11.2.97 A further review of the data from the ORJIP project was undertaken by Bowgen and Cook (2018), which analysed all the data collected across the two year period to understand more about seabird behaviour and provide evidence to support updates to the previous avoidance rates from Cook et al. (2014). The findings from this study were that for gannet and kittiwake higher avoidance rates were more appropriate of 99.5% and 99.0%, respectively. It concluded that even when applying these higher rates of avoidance, they considered that precaution remained within the estimated number of collision mortality rates.

5.11.2.98 Another recent study on gannets by APEM Ltd during the migratory period (APEM 2014) found that overall avoidance of WTGs was certainly higher than the SNCBs recommended use of 98.9%. This study found that all gannets avoided the WTGs within the study area, which provided evidence that gannets may actually have an avoidance rate as high as 100% during migratory periods at least. However, the concluding recommendation from APEM's research suggested that if it was not appropriate to use a 100% avoidance rate, then a rate of 99.5% for the autumn migration would still offer suitable precaution in collision estimates. This indicates that when estimating gannet collision mortality rates, the use of an avoidance rate of 98.9% is understood to overestimate the risk to this species, as noted by Cook et al. (2014), who acknowledged that precaution remained within the avoidance rates put forward for gannets and gull species.

5.11.2.99 Despite the above supporting evidence, the use of such higher avoidance rates and lower nocturnal activity rates were not included within the CRM for Hornsea Four alone or cumulatively. The final range of nocturnal activity rates were agreed with Natural England through the EP process (OFF-ORN-2.34), making use of the more precautionary range-based approach. The use of more precautionary avoidance rates are also applied in this assessment, based on the joint SNCBs advisory note (JNCC et al. 2014) on Cook et al. (2014), which suggests the use of 98.9% for gannet and kittiwake when using Band Option 2 and 99.5% or 98.9% for large gull species when using either Band Option 2 or 3. The full details of the approach to CRM for Hornsea Four is provided in **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.

5.11.2.100 Therefore, it is considered that the CRM input parameters advocated by the Applicant's evidence-led approach and used in the assessment of collision risk to seabirds for Hornsea Four, the outputs of which are presented in **Table 5.37**, and those from other projects at the cumulative level incorporate a high degree of precaution.

Table 5.37: 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	BO3	BO1	BO2	BO3	BO1	BO2	BO3
Jan	0.91 (0.00 – 3.68)	0.50 (0.00 – 2.01)	0.16 (0.07 – 0.37)	0.91 (0.40 – 2.11)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.90 (0.06 – 2.79)	0.69 (0.04 – 2.14)	0.41 (0.03 – 1.26)
Feb	0.31 (0.05– 0.91)	0.17 (0.03 – 0.50)	0.16 (0.03 – 0.42)	0.91 (0.17 – 2.42)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.17 (0.00 – 0.53)	0.13 (0.00 – 0.41)	0.08 (0.00 – 0.24)
Mar	1.24 (0.50 – 2.81)	0.68 (0.27 – 1.54)	0.18 (0.03 – 0.46)	1.05 (0.19 – 2.68)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.20 (0.00 – 0.70)	0.18 (0.00 – 0.65)	0.09 (0.00 – 0.33)	1.21 (0.00 – 3.85)	0.93 (0.00 – 2.94)	0.55 (0.00 – 1.73)
Apr	3.08 (0.95 – 7.04)	1.69 (0.52 – 3.85)	3.85 (0.65 – 9.45)	22.19 (3.76 – 54.44)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.03 (0.00 – 0.14)	0.02 (0.00 – 0.10)	0.01 (0.00 – 0.06)
May	3.06 (1.30 – 6.07)	1.67 (0.71 – 3.32)	3.08 (1.38 – 5.90)	17.75 (7.96 – 33.99)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.26 (0.00 – 1.05)	0.20 (0.00 – 0.80)	0.12 (0.00 – 0.47)
Jun	4.73 (1.70 – 9.69)	2.59 (0.93 – 5.30)	1.48 (0.75 – 2.64)	8.51 (4.32 – 15.21)	0.53 (0.00 – 1.43)	0.67 (0.00 – 1.81)	0.34 (0.00 – 0.90)	0.93 (0.18 – 2.16)	0.86 (0.17 – 2.00)	0.43 (0.08 – 1.01)	0.19 (0.00 – 0.80)	0.15 (0.00 – 0.61)	0.09 (0.00 – 0.36)
Jul	6.78 (2.85 – 13.35)	3.71 (1.56 – 7.30)	0.61 (0.33 – 1.08)	3.54 (1.88 – 6.23)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.15 (0.00 – 0.80)	0.12 (0.00 – 0.61)	0.07 (0.00 – 0.36)
Aug	6.79 (3.92 – 12.06)	3.72 (2.14 – 6.60)	4.68 (1.20 – 10.63)	26.98 (6.92 – 61.24)	0.13 (0.00 – 0.42)	0.16 (0.00 – 0.53)	0.08 (0.00 – 0.26)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.03 (0.00 – 0.21)	0.02 (0.00 – 0.16)	0.01 (0.00 – 0.09)
Sep	2.87 (1.40 – 5.84)	1.57 (0.77 – 3.20)	1.38 (0.22 – 3.51)	7.97 (1.26 – 20.20)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.20 (0.00 – 0.65)	0.18 (0.00 – 0.60)	0.09 (0.00 – 0.30)	2.82 (0.00 – 17.83)	2.16 (0.00 – 13.64)	1.28 (0.00 – 8.03)

Species	Gannet		Kittiwake		Lesser black-backed gull			Herring gull			Great black-backed gull		
Month / Band Option	BO1	BO2	BO1	BO2	BO1	BO2	BO3	BO1	BO2	BO3	BO1	BO2	BO3
Oct	2.23 (1.36 – 4.38)	1.22 (0.74 – 2.40)	0.08 (0.01 – 0.22)	0.46 (0.06 – 1.25)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	1.90 (0.00 – 8.12)	1.45 (0.00 – 6.21)	0.86 (0.00 – 3.66)
Nov	3.93 (1.87 – 9.62)	2.15 (1.02 – 5.26)	0.13 (0.01 – 0.38)	0.72 (0.03 – 2.18)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	1.07 (0.20 – 2.99)	0.82 (0.15 – 2.28)	0.48 (0.09 – 1.34)
Dec	0.91 (0.15 – 3.04)	0.50 (0.08 – 1.67)	0.4 (0.05 – 1.20)	2.30 (0.26 – 6.92)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.00 (0.00 – 0.00)	0.39 (0.00 – 1.50)	0.36 (0.00 – 1.38)	0.18 (0.00 – 0.70)	0.66 (0.00 – 2.43)	0.50 (0.00 – 1.86)	0.30 (0.00 – 1.09)
Annual	**36.83** (16.04– 78.50)	**20.15** (8.77 – 42.94)	**16.19** (4.72 – 36.25)	**93.27** (27.20 – 208.86)	**0.66** (0.00 – 1.85)	**0.83** (0.00 – 2.34)	**0.42** (0.00 – 1.16)	**1.71** (0.18 – 5.01)	**1.58** (0.17 – 4.63)	**0.79** (0.08 – 2.33)	**9.39** (0.25 – 41.53)	**7.19** (0.19 – 31.76)	**4.25** (0.12 – 18.70)

Table Note: Values in parenthesis are the minimum and maximum collision estimates, as described in **paragraph 5.11.2.91**.

5.11.2.101 Following the consultation through the EP process, Natural England agreed with the majority of CRM input parameters put forward by the Applicant as appropriate for running the CRM. However, there remained some minor differences in the approach to consider which input parameters may determine the mean values. Despite the minor differences in opinion, the mean CRM values for collision risk mortality following the Applicant's evidence-led approach and the Applicant's understanding of Natural England's preferred approach were mostly minimal in nature.

5.11.2.102 The basis for this assessment follows the workings from the Applicant's evidence-led approach, but a second iteration of the sCRM has been provided, in Appendix A of **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**, which incorporates input parameters understood to represent Natural England's current approach for use in CRM carried out by OWF developers. The sCRM was run for each species with these input parameters understood to be preferred by Natural England, which differ only marginally to those selected by the Applicant (OFF-ORN-2.32 to 2.37), in order to provide their more precautionary range of outputs.

5.11.2.103 For the purpose of identifying and assessing the potential magnitude of impact from collision risk to the five seabirds in this ES, the standard bio-seasons from Furness (2015) have been used.

<u>Gannet</u>

sCRM prediction outputs

5.11.2.104 The monthly estimated mortality rates are presented in **Table 5.37**, which vary from a minimum of under one individual in four of the twelve months to a maximum of approximately four individuals in July and August. On an annual basis, the estimated mortality rate for collision risk from Hornsea Four is 20 individuals using the mean sCRM output from BO2 (**Table 5.37**), which is further broken down into relevant bio-seasons in **Table 5.38**. The potential 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 as presented in **Table 5.13**.

Table 5.38: Bio-season collision risk estimates for gannet for Hornsea Four.

Bio-season (months)	Seasonal sCRM totals (per annum)		Regional baseline populations and baseline mortality rates		Increase in baseline mortality (%)	
	BO1	BO2	Population (individuals)	Baseline mortality (per annum)	BO1	BO2
Return Migration (Dec-Mar)	3.37 (0.70 – 10.44)	1.84 (0.38 – 5.71)	248,385	46,448	0.007 (0.002 - 0.022)	0.004 (0.001 - 0.012)
Migration-free Breeding (Apr-Aug)	24.43 (10.71 – 48.21)	13.37 (5.86 – 26.37)	139,302	26,049	0.094 (0.041 - 0.185)	0.051 (0.022 - 0.101)

Bio-season (months)	Seasonal sCRM totals (per annum)		Regional baseline populations and baseline mortality rates		Increase in baseline mortality (%)	
	BO1	BO2	Population (individuals)	Baseline mortality (per annum)	BO1	BO2
Post-breeding migration (Sep-Nov)	9.03 (4.63 – 19.84)	4.94 (2.53 – 10.86)	456,298	85,328	0.011 (0.005 - 0.023)	0.006 (0.003 - 0.013)
Annual (BDMPS)	**36.83** (16.04 – 78.50)	**20.15** (8.77 – 42.94)	**456,298**	**85,328**	**0.043** (0.019 - 0.092)	**0.024** (0.010 - 0.050)
Annual (biogeographic)	**36.83** (16.04– 78.50)	**20.15** (8.77 – 42.94)	**1,180,000**	**220,660**	**0.000** (0.000 - 0.000)	**0.009** (0.004 - 0.019)

Table Note: Values in parenthesis are the minimum and maximum collision estimates, as described in paragraph 5.11.2.91.

Potential magnitude of impact

5.11.2.105 During the return migration bio-season, using the mean sCRM estimate from BO2 two gannets may be subject to mortality. The UK North Sea and English Channel BDMPS for the return migration bio-season is defined as 248,385 (Furness 2015) and using the average baseline mortality rate of 0.187 (Table 5.13), The natural predicted mortality in the return migration bio-season is 46,448 per annum. The addition of two predicted mortalities would increase the baseline mortality rate by 0.004%.

5.11.2.106 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.

5.11.2.107 During the migration-free breeding bio-season, using the mean sCRM estimate from BO2 13 gannets may be subject to mortality. As calculated in Section 5.7.4, during the migration-free breeding bio-season, the total regional baseline population of breeding adults and immature birds is predicted to be 139,302 gannets. When the average baseline mortality rate of 0.187 (Table 5.13) is applied, the natural predicted mortality in the migration-free breeding bio-season is 26,049 per annum. The addition of 13 predicted mortalities would increase the baseline mortality rate by 0.051%.

5.11.2.108 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.

5.11.2.109 During the post-breeding migration bio-season, using the mean sCRM estimate from BO2 five gannets may be subject to mortality.The UK North Sea and English Channel BDMPS for the post-breeding migration bio-season is defined as 456,298 (Furness 2015) and using the average baseline mortality rate of 0.187 (Table 5.13), the natural predicted mortality in the post-breeding migration bio-season is 85,328 per annum. The addition of five prediced mortalities would increase the baseline mortality rate by 0.006%.

5.11.2.110 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.

5.11.2.111 The annual total number of gannets subject to mortality due to collision is estimated to be 20 individuals using the sCRM estimate from BO2. Using the largest BDMPS population of 456,298, as a proxy for the annual BDMPS population, with an average baseline mortality rate of 0.187 (**Table 5.13**), the natural predicted mortality is 85,328 per annum. The addition of 20 predicted mortalities would increase the baseline mortality rate by 0.024%. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality for the biogeographic population of 1,180,000 across all seasons is 220,660 per annum. The addition of 20 predicted mortalities would increase the biogeographic baseline mortality rate by 0.009%.

5.11.2.112 Despite the predicted increase in the baseline mortaility rate not exceeding 0.1%, a precautionary approach has been taken and further consideration in the form of PVA. Further details of the PVA methodology, input parameters and details on how to interpret the PVA results below can be found in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis**. The results of the PVA are summarised in **Table 5.42** below during the O&M Phase.

5.11.2.113 For all PVA results the predicted reduction in the population growth rate is well under 0.01% when considering the BDMPS or 0.01% when considering the biogeographic scale. This level of predicted magnitude would almost certainly be indistinguishable from natural fluctuations in the population's mortality rate on an annual basis.

5.11.2.114 Therefore, the magnitude of this impact annually from collision risk at the BDMPS and bio-geographic scales are 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 (**Table 5.22**) and is not considered further in this assessment.

<u>*Kittiwake*</u>

CRM prediction outputs

5.11.2.115 The monthly estimated mortality rates are presented in **Table 5.37**, which vary from under one individual in four of the twelve months to a maximum of 27 individuals in August. On an annual basis the estimated mortality rate for collision risk from Hornsea Four is 93 individuals, using the mean sCRM output from Band Option 2 (**Table 5.37**), which is further broken down into relevant bio-seasons in **Table 5.39**. The potential 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 as presented in **Table 5.13**.

Table 5.39: Bio-season collision risk estimates for kittiwake for Hornsea Four.

Bio-season (months)	Seasonal sCRM totals (per annum)		Regional baseline populations and baseline mortality rates		Increase in baseline mortality (%)	
	BO1	BO2	Population (individuals)	Baseline mortality (per annum)	BO1	BO2
Return Migration (Jan-Apr)	4.35 (0.78 – 10.70)	25.05 (4.51 – 61.65)	627,816	97,939	0.004 (0.001 - 0.011)	0.026 (0.005 - 0.063)
Migration-free Breeding (May-Jul)	5.17 (2.46 – 9.62)	29.79 (14.16 – 55.42)	439,902	68,625	0.008 (0.004 - 0.014)	0.043 (0.021 - 0.081)
Post-breeding migration (Aug-Dec)	6.67 (1.48 – 15.93)	38.43 (8.53 – 91.79)	829,937	129,470	0.005 (0.001 - 0.012)	0.030 (0.007 - 0.071)
Annual (BDMPS)	**16.19** (4.27 - 36.25)	**93.27** (27.20 – 208.86)	**829,937**	**129,470**	**0.013** (0.004 - 0.028)	**0.072** (0.021 - 0.161)
Annual (biogeographic)	**16.19** (4.27 – 36.25)	**93.27** (27.20 – 208.86)	**5,100,000**	**795,600**	**0.002** (0.001 - 0.005)	**0.012** (0.003 - 0.026)

Table Note: Values in parenthesis are the minimum and maximum collision estimates, as described in **paragraph 5.11.2.91**.

Potential magnitude of impact

5.11.2.116 During the return migration bio-season using the mean sCRM estimate from BO2, 25 kittiwakes may be subject to mortality. The UK North Sea BDMPS for the return migration bio-season is defined as 627,816 (Furness 2015) and using the average baseline mortality rate of 0.156 (**Table 5.13**), the natural predicted mortality in the return migration bio-season is 97,939 per annum. The addition of 25 predicted mortalities would increase the baseline mortality rate by 0.026%.

5.11.2.117 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.

5.11.2.118 During the migration-free breeding bio-season using the mean sCRM estimate from BO2, 30 kittiwakes may be subject to mortality. As calculated in **Section 5.7.4** during the migration-free breeding bio-season, the total regional baseline population of breeding adults and immature birds is predicted to be 439,902 kittiwakes. When the average baseline mortality rate of 0.156 (**Table 5.13**) is applied, the natural predicted mortality in the migration-free breeding bio-season is 68,625 per annum. The addition of 30 predicted mortalities would increase the baseline mortality rate by 0.043%.

5.11.2.119 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.

5.11.2.120 During the post-breeding migration bio-season using the mean sCRM estimate from BO2, 38 kittiwakes may be subject to mortality. The UK North Sea BDMPS for the post-breeding migration bio-season is defined as 829,937 (Furness 2015) and using the average baseline mortality rate of 0.156 (**Table 5.13**), the natural predicted mortality in the return migration bio-season is 129,470 per annum. The addition of 38 mortalities would increase the baseline mortality rate by 0.030%.

5.11.2.121 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.

5.11.2.122 The annual total of kittiwakes subject to mortality due to collision is estimated to be 93 individuals using the mean sCRM estimate from BO2. Using the largest UK North Sea BDMPS population of 829,937, as a proxy for the annual BDMPS population, with an average baseline mortality rate of 0.156 (**Table 5.13**), the natural predicted mortality across all seasons is 129,470 per annum. The addition of 93 predicted mortalities would increase the baseline mortality rate by 0.072% at the BDMPS scale. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality for the biogeographic population of 5,100,000 across all seasons is 795,600 per annum. The addition of 93 predicted mortalities would increase the biogeographic baseline mortality rate by 0.012%.

5.11.2.123 Despite the predicted increase in the baseline mortaility rate not exceeding 0.1%, a precautionary approach has been taken and further consideration in the form of PVA. Further details of the PVA methodology, input parameters and details on how to interpret the PVA results below can be found in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis**. The results of the PVA are summarised in **Table 5.40** below for impacts from collision alone during the O&M Phase.

5.11.2.124 For all PVA results the predicted reduction in the population growth rate is well under 0.05% when considering the BDMPS or 0.01% when considering the biogeographic scale. This level of predicted magnitude would almost certainly be indistinguishable from natural fluctuations in the population's mortality rate on an annual basis.

5.11.2.125 Therefore, the magnitude of this impact annually from collision risk at the BDMPS and bio-geographic scales are 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 (**Table 5.22**) and is not considered further in this assessment.

Table 5.40: Kittiwake PVA results for O&M phase collision impacts at the BDMPS and biogeographic scale.

Scenario Description	Increase in Mortality	BDMPS results		Biogeographic Results	
		Density independent counterfactual of growth rate (after 35 years)	Reduction in growth rate (%)	Density independent counterfactual of growth rate (after 35 years)	Reduction in growth rate (%)
Evidence-led input parameters, Cook et al. (2014) Avoidance Rates, BO2, Mean density estimates	93	1.000	0.015	1.000	0.002
Evidence-led input parameters, Cook et al. (2014) Avoidance Rates, BO2, Max density estimates	209	1.000	0.032	1.000	0.005
Evidence-led input parameters, Cook et al. (2014) Avoidance Rates, BO2, Min density estimates	27	1.000	0.004	1.000	0.001
Evidence-led input parameters, Bowgen & Cook (2018) BO2 Avoidance Rate, Mean density estimates	85	1.000	0.013	1.000	0.002
Evidence-led input parameters, Bowgen & Cook (2018) BO3 Avoidance Rate, Mean density estimates	24	1.000	0.004	1.000	0.000

Lesser black-backed gull

CRM prediction outputs and potentialmagnitude of impact

5.11.2.126 The monthly estimated mortality rates are presented in **Table 5.37**, which vary from a minimum of zero individuals in ten out of twelve months, to a maximum of less than a single (0.34) individual in June using the mean sCRM estimate from BO3. The predicted level of mortality during any bio-season is under one individual and in total, the annual estimated mortality for lesser black-backed gull is less than a single (0.42) individual. As a consequence, there is a **negligible** impact predicted as a consequence of collision risk from Hornsea Four for this species.

5.11.2.127 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 (**Table 5.22**) and is therefore not considered further in this assessment.

Herring gull

CRM prediction outputs and potentialmagnitude of impact

5.11.2.128 The monthly estimated mortality rates are presented in **Table 5.37**, which vary from a minimum of zero individuals in eight out of twelve months, to a maximum of less than a single (0.43) individual in June using the mean sCRM estimate from BO3. The predicted level of mortality during any bio-season is under one individual and in total, the annual mortality rate for herring gull is less than a single individual (0.79). As a consequence, there is a **negligible** impact predicted as a consequence of collision risk from Hornsea Four for this species.

5.11.2.129 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 (**Table 5.22**) and is therefore not considered further in this assessment.

Great black-backed gull

CRM prediction outputs

5.11.2.130 The monthly estimated mortality rates are presented in **Table 5.37**, which vary from less than a single individual in eleven out of twelve months, to a maximum of one individual in September using the mean sCRM estimate from BO3. On an annual basis, the estimated mortality rate for collision risk from Hornsea Four is approximately four individuals (**Table 5.37**), which is further broken down into relevant bio-seasons in **Table 5.41**. The potential 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 as presented in **Table 5.13**.

Table 5.41: Bio-season collision risk estimates for great black-backed gull for Hornsea Four.

Bio-season (months)	Seasonal sCRM totals (per annum)			Regional baseline populations and baseline mortality rates		Increase in baseline mortality (%)		
	BO1	BO2	BO3	Population (individuals)	Baseline mortality (per annum)	BO1	BO2	BO3
Breeding (Apr-Aug)	0.67 (0.000 – 3.00)	0.51 (0.00 – 2.29)	0.30 (0.00 – 1.35)	55,114	8,818	0.008 (0.000 - 0.034)	0.006 (0.000 - 0.026)	0.003 (0.000 – 0.015)
Non-Breeding (Sep-Mar)	8.72 (0.25 – 38.53)	6.67 (0.19 – 29.47)	3.94 (0.12 – 17.35)	91,399	14,624	0.060 (0.002 - 0.263)	0.046 (0.001 - 0.201)	0.027 (0.001 – 0.119)
Annual (BDMPS)	**9.39** (0.25 – 41.53)	**7.19** (0.19 – 31.76)	**4.25** (0.12 – 18.70)	**91,399**	**14,624**	**0.064** (0.002 - 0.284)	**0.049** (0.001 - 0.217)	**0.029** (0.001 – 0.128)
Annual (biogeographic)	**9.39** (0.25 – 41.53)	**7.19** (0.19 – 31.76)	**4.25** (0.12 – 18.70)	**235,000**	**37,600**	**0.025** (0.001 - 0.110)	**0.019** (0.001 - 0.084)	**0.011** (0.000 – 0.050)

Table Note: Values in parenthesis are the minimum and maximum collision estimates, as described in paragraph 5.11.2.91.

Potential magnitude of impact

5.11.2.131 During the breeding bio-season, using the mean sCRM estimate from BO3 the collision risk estimate for great black-backed gulls is less than a single (0.30) individual. As calculated in **Section 5.7.4** during the breeding bio-season, the total regional baseline population of breeding adults and immature birds is predicted to be 55,114 great black-backed gulls. When the average baseline mortality rate of 0.160 (**Table 5.13**) is applied, the natural predicted mortality in the breeding bio-season is 8,818 per annum. The addition of less than a single predicted mortality would increase the baseline mortality rate by 0.003%.

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

5.11.2.133 During the non-breeding bio-season, using the mean sCRM estimate from BO3, four great black-backed gulls may be subject to mortality. The UK North Sea BDMPS for the non-breeding bio-season is defined as 91,399 (Furness 2015) and using the average baseline mortality rate of 0.160 (**Table 5.13**), the natural predicted mortality in the non-breeding bio-season is 14,624 per annum. The addition of four predicted mortalities would increase the baseline mortality rate by 0.027%.

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

5.11.2.135 The annual total of great black-backed gulls subject to mortality due to collision is estimated at four individuals using the mean sCRM estimate from BO3. Using the largest UK North Sea BDMPS population of 91,399, as a proxy for the annual BDMPS population, with an average baseline mortality rate of 0.160 (**Table 5.13**), the natural predicted mortality across all seasons is 14,624 per annum. The addition of four predicted mortalities would increase the baseline mortality rate by 0.029% at the BDMPS scale. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality for the biogeographic population of 235,000 across all seasons is 37,600 per annum. The addition of four predicted mortalities would increase the baseline mortality rate by 0.011%.

5.11.2.136 Therefore, the magnitude of this impact annually from collision risk at the BDMPS and bio-geographic scales are 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 (**Table 5.22**) and is therefore not considered further in this assessment.

Combined Operational Disturbance and Collision Risk – Gannet

5.11.2.137 Due to gannet being scoped in for both displacement and collision risk assessments during the O&M phase, there's potential for these two impacts to cumulatively adversely affect gannet populations. Previous sections have concluded negligible predicted magnitude of impact from either collision risk or displacement acting alone; however, the combined impact of both collision risk and displacement may be greater than either one acting alone. Further consideration of both impacts acting together is therefore required.

5.11.2.138 As detailed in **Table 5.27** and **Table 5.38** the combined predicted gannet mortality from the O&M phase (displacement and collision risk) equates to between 32 and 35 predicted additional mortalities per annum. Using the largest UK North Sea and English Channel BDMPS of 456,298 individuals (Furness 2015) and using the average baseline mortality rate of 0.187 (**Table 5.13**), the natural predicted mortality across all seasons is 85,328 per annum. The addition of between 31 to 35 predicted mortalities would increase the baseline mortality rate by 0.038% to 0.041%. When considering these combined impacts at the wider biogeographic population scale, then of the 1,180,000 population the natural annual mortality rate would be 220,660 individuals per annum. The addition of between 31 to 35 predicted mortalities would increase the biogeographic baseline mortality rate by 0.015% to 0.016%. It should be noted that the impacts associated with both displacement and collison risk combined assessed in this simplistic additive manner are almost certainly an overestimate, as a bird which has been displaced from the array area can no longer collide with a turbine and vice versa.

5.11.2.139 Despite the predicted increase in the baseline mortaility rate not exceeding 0.1%, a precautionary approach has been taken and further consideration in the form of PVA. Further details of the PVA methodology, input parameters and details on how to interpret the PVA results below can be found in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis**. The results of the PVA are summarised in **Table 5.42** below during the O&M Phase.

5.11.2.140 For all PVA results the predicted reduction in the population growth rate is under 0.01% when considering the BDMPS or 0.01% when considering the biogeographic scale. This level of predicted magnitude would almost certainly be indistinguishable from natural fluctuations in the population's mortality rate on an annual basis.

5.11.2.141 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 (**Table 5.22**) and is therefore not considered further in this assessment.

Table 5.42: Gannet PVA results for O&M phase impacts at the BDMPS and biogeographic scale.

Scenario Description	Increase in Mortality	BDMPS results		Biogeographic Results	
		Density independent counterfactual of growth rate (after 35 years)	Reduction in growth rate (%)	Density independent counterfactual of growth rate (after 35 years)	Reduction in growth rate (%)
Displacement 60%, 1% Mort only	11	1.000	0.002	1.000	0.001
Displacement 80%, 1% Mort only	15	1.000	0.004	1.000	0.001
Evidence-led input parameters, Cook et al. (2014) Avoidance Rates, BO2, Mean density estimates	20	1.000	0.005	1.000	0.002
Evidence-led input parameters, Cook et al. (2014) Avoidance Rates, BO2, Max density estimates	43	1.000	0.011	1.000	0.005
Evidence-led input parameters, Cook et al. (2014) Avoidance Rates, BO2, Min density estimates	9	1.000	0.003	1.000	0.001
Evidence-led input parameters, Cook et al. (2014) Avoidance Rates, Mean density estimates and 60% Disp, 1% Mort combined	31	1.000	0.008	1.000	0.003
Evidence-led input parameters, Cook et al. (2014) Avoidance Rates, Mean density estimates and 60% Disp, 1% Mort combined	35	1.000	0.009	1.000	0.004

Migrant birds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure (ORN-O-7)

5.11.2.142 There is potential risk to birds from OWFs 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 during migration.

5.11.2.143 An assessment of the risk of collision to migratory birds has been carried out for Hornsea Four, with detailed methods and results presented in **Volume A5, Annex 5.5: Offshore Ornithology Migratory Birds Report**. An initial screening exercise was carried out to identify species potentially at risk from collision during migration. A list of 33 species of birds (mostly migratory waterbirds and seabirds) to be considered further was agreed through the EP process (OFF-ORN-2.4.1). APEM's bespoke modelling approach, using Migropath, was then used to estimate the number of individuals expected to pass through the array area each year. Where the number of individuals predicted to pass through the array area exceeded 1% of the UK population, CRM was carried out using the Band (2012) CRM. For three species (dark-bellied brent goose, white-fronted goose and avocet), less than 1% of the UK population was predicted to pass through the array area, and these were screened out of further CRM as the maximum impact would be of **negligible** magnitude.

5.11.2.144 CRM was carried out using Band Option 1 for all species and Band Option 2 for species where species-specific flight height distribution data were available in Johnston et al. (2014). As there is no specific avoidance rate calculated for the species in **Table 5.43** and **Table 5.44** an avoidance rate of 98% was used for evaluation of collision risk as recommended in Cook et al. (2014), except for little gull which is based on the avoidance rate of 99.2% recommended by Cook et al. (2014). The evidence-led results of CRM for the remaining 30 species is shown in **Table 5.43** and **Table 5.44**. Additional results are presented in **Volume A5, Annex 5.5: Offshore Ornithology Migratory Birds Report**.

Table 5.43: Summary of collision risk assessment on migrant waterbirds from Hornsea Four.

Species	UK population	Adult baseline mortality rate (Robinson 2005)	UK population baseline mortality	Avoidance rate	Annual collision rate BO1	Uk population baseline mortality rate percentage increase (%)
Taiga bean gooses	230	0.100	23	98.0%	0.00	0.00
Bewick's swan	4,350	0.822	3,576	98.0%	0.12	0.00
Shelduck	51,000	0.114	5,814	98.0%	0.97	0.02
Gadwall	31,000	0.720	22,320	98.0%	0.10	0.00
Wigeon	450,000	0.470	211,500	98.0%	6.74	0.00
Teal	435,000	0.470	204,450	98.0%	5.99	0.00
Goldeneye	21,000	0.228	4,788	98.0%	0.35	0.01
Hen harrier	273	0.190	52	98.0%	0.01	0.02
Oystercatcher	305,000	0.120	36,600	98.0%	7.68	0.02
Lapwing	635,000	0.295	187,325	98.0%	14.89	0.01
Golden plover	410,000	0.270	110,700	98.0%	7.08	0.01
Grey plover	33,500	0.140	4,690	98.0%	0.71	0.02
Ringed plover	73,000	0.228	16,644	98.0%	0.63	0.00
Whimbrel	3,840	0.110	422	98.0%	0.15	0.04
Curlew	125,000	0.101	12,625	98.0%	4.32	0.03
Bar-tailed godwit	53,500	0.285	15,248	98.0%	1.63	0.01
Black-tailed godwit	41,000	0.060	2,460	98.0%	0.30	0.01
Turnstone	43,000	0.140	6,020	98.0%	0.79	0.01
Knot	265,000	0.159	42,135	98.0%	5.26	0.01
Ruff	920	0.476	438	98.0%	0.02	0.00
Sanderling	20,500	0.170	3,485	98.0%	0.59	0.02

Species	UK population	Adult baseline mortality rate (Robinson 2005)	UK population baseline mortality	Avoidance rate	Annual collision rate BO1	Uk population baseline mortality rate percentage increase (%)
Dunlin	350,000	0.260	91,000	98.0%	6.25	0.01
Redshank	150,000 – 400,000	0.260	39,000 – 104,000	98.0%	4.09	0.01 – 0.00

Table 5.44: Summary of collision risk assessment on migrant seabirds from Hornsea Four.

Species	Largest non-UK North Sea and English Channel migratory population	Adult baseline mortality rate (Horswill & Robinson 2015)	Baseline mortality	Avoidance rate	Annual collision rate BO1	Annual collision rate BO2	Migrant seabird population baseline mortality rate percentage increase (%)
Little gull	30,500	0.2	6,100	99.2%	0.09	0.03	0.00 – 0.00
Sandwich tern	10,090	0.102	1,029	98.0%	0.11	0.02	0.01 – 0.00
Roseate tern	7	0.163	1	98.0%	0.00	N/A	0.00
Common tern	125,969	0.117	14,738	98.0%	4.72	0.20	0.03 – 0.00
Arctic Tern	82,084	0.163	13,380	98.0%	0.67	0.04	0.01 – 0.00
Great skua	2,141	0.118	253	98.0%	0.02	0.00	0.01 – 0.00
Arctic skua	5,216	0.09	469	98.0%	0.03	0.00	0.01 – 0.00

Potential magnitude of impact

5.11.2.145 Following the estimated collision risk to each migratory species being determined (**Table 5.43** and **Table 5.44**) a range from a minimum of zero predicted mortalities per annum (e.g. for Taiga bean goose) to a maximum of 14.89 predicted mortalities per annum (e.g. for lapwing) were estimated for Hornsea Four. However, when considering the level of any impact relative to the basline mortality rate for each of these species, all were between 0.00% and 0.04%. This level of impact on an annual basis for all species is considered to be of **negligible** magnitude at most.Therefore, 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 and hen harrier) passing either north-south or east-west on their annual migrations.

5.11.2.146 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 (**Table 5.22**) 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

5.11.2.147 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.

5.11.2.148 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 A2, Chapter 3: Fish and Shellfish Ecology** and **Volume A2, 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 significance of the effect is therefore **not significant**.

The presence of WTGs could create a barrier to the migratory or regular foraging movements of seabirds (ORN-O-9)

5.11.2.149 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.

5.11.2.150 Whilst birds are breeding they may, theoretically, take the shortest (energetically most efficient) route to and from known areas that provide good foraging resources, though few seabirds are known fly in straight lines between such locations in reality. 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 OWF (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 these offshore wind farms projects once operational.

5.11.2.151 The assessment of Hornsea Four and the potential for its operational WTGs 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 (Woodward et al. 2019). 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 between the Hornsea Four array area and the FFC SPA (65 km at its closest point) being at the outer limits of the known mean max foraging range for razorbill (88.7 km) and guillemot (73.2 km) and further than the mean foraging range of puffin (62.4 km) (Woodward et al. 2019), the presence of WTGs would not be the cause of a barrier effect on a regular basis, as those foraging ranges indicate that breeding auks would predominantly forage in the waters to the west of the Hornsea Four array area. Models based on tracking studies indicate no guillemots or razorbills are likely to forage in the waters to the east of the Hornsea Four array area (Wakefield et al. 2017). Therefore, due to the distance of the Hornsea Four array area from the FFC SPA there would be no discernible barrier effect on auk species and so they are screened out of further assessment.

5.11.2.152 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 Department of Energy and Climate Change (DECC) now the Department for Business, Energy and Industrial Strategy (BEIS) and Orsted. Those studies have examined the foraging flights made by gannet and kittiwake, which suggest that these two species may be more likely to forage in the waters to the east of Hornsea Four, so are selected for a more detailed assessment.

5.11.2.153 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.

<u>Gannet</u>

Potential magnitude of impact

5.11.2.154 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 in Langston et al. 2013). This data set indicates that there are trip end points in the Eastern area of the Hornsea Zone, suggesting that should gannets wish to reach the eastern end of the Hornsea Zone, there is the potential for a barrier effect from Hornsea Four.

5.11.2.155 Gannets are known to avoid entering operational OWFs (e.g. Krijgsveld et al. 2011; APEM 2014), further indicating the potential for a barrier effect. Given the avoidance of operational OWFs, 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 of 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.

5.11.2.156 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 (**Table 5.22**) and is therefore not considered further in this assessment.

Kittiwake

Potential magnitude of impact

5.11.2.157 Kitiwakes from the FFC SPA were tracked in the breeding season between 2010 and 2015 by RSPB and partners as part of a large-scale seabird tracking studies across the UK. Utilisation Distribution Band Models were generated based on these tracking studies and presented in Wakefield et al. (2017), the results of which indicated that kittiwakes from the FFC SPA colony's core foraging areas were located to the west and south of the Hornsea Four array area. Further modelling of the tracking data was undertaken by Cleasby et al. (2018), through maximum curvature and Getis-Ord analysis of hotspots. The results of these analyses provided further evidence that the significant foraging areas for kittiwakes were located to the west and south of the Hornsea Four array area, with no significant foraging areas found to the east of the array area.

5.11.2.158 Kittiwakes from the FFC SPA were also tracked in the breeding season of 2017 and the results reported in Wischnewski et al. (2018). The analyses presented in that 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 a comparative alternative (Figure 10b in Wischnewski et al. 2018).

5.11.2.159 These data set indicate 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 OWFs (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. Tracking studies of kittiwake foraging from Wakefield et al. (2017) and Cleasby et al. (2018) also providing evidence of kittiwakes preferring areas to the North and south of Hornsea Four, thus avoiding areas to the east. 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.

5.11.2.160 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.

5.11.2.161 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 (**Table 5.22**) and is therefore not considered further in this assessment.

The impact of attraction to or repulsion from lit structures by migrating birds in particular (ORN-O-14)

5.11.2.162 There is the potential for some species of birds to be attracted to or repelled from artificially illuminated structures in the offshore environment, such as oil and gas platforms, during the hours of darkness or poor weather conditions which result in restricted visibility. Such structures may provide opportunities for extended feeding periods, shelter and resting places or navigation aids for some migrating birds. They may also act as a deterrent to other species causing a change in their direction of flight during migration causing minor potential increased energy expenditure or be considered a cause of displacement from array areas during those limited periods when birds may have undertaken nocturnal foraging. Therefore, there is evidence that both the potential attractant and deterrent effects of light may cause changes to bird movement and alter habitat selection (reviewed in Drewitt and Langston 2008). However, as WTGs are not as extensively lit or intensively lit, compared to oil and gas platforms for example, from which the majority of offshore evidence on lighting effects is compiled from (reviewed in Ronconi et al. 2015), any benefits relating to increased provision of foraging opportunities during hours of darkness are likely to be minimal from WTGs, so reducing the likelihood of this being pursued by birds.

5.11.2.163 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 on very rare occasions potentially become temporarily trapped within the illuminated area and become exhausted as a result. These potential behavioural effects are predominantly weather dependent, impacting navigation when visibility is low during overcast nights with drizzle and fog. At these times lighting is enhanced because the moisture droplets in the air refract the light and greatly increase the illuminated area (Hill et al. 2014).

5.11.2.164 In terms of attraction to artificial illuminated structures, the MDS for Hornsea Four includes 180 WTGs and up to 10 other offshore ancillary structures within the array area. Lighting of WTGs would meet the minimum necessary regulatory requirements, namely as set out in the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) Recommendation O117 on 'The Marking of Offshore Wind Farms' for navigation lighting and by the Civil Aviation Authority in the Air Navigation Orders (CAP 393 and guidance in CAP 764). In keeping with the minimum legal requirements, this would minimise the risks of migrating birds becoming attracted to or disorientated by WTGs at night or in poor weather. The proposed design with respect to lighting, is, therefore, consistent with Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) guidance and NPS EN-3. The design aims to minimise the emission of light whilst still complying with safety protocols and regulations in relation to aviation and shipping navigation. The individual WTGs for Hornsea Four would therefore not be as extensively lit as, for example, oil and gas installations.

Migrating Birds

Potential magnitude of Impact

5.11.2.165 Migrating birds are potentially susceptible to potential impacts as a result of lit structures, 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, while artificial light from structures such as lighthouses, communications towers and oil and gas platforms has been reported to attract nocturnal migrating birds, especially passerines, the evidence for this potential impact on nocturnal migratory birds at WTGs is somewhat less than predicted. For example; a radar study at the Nysted OWF by Desholm and Kahlert (2005) reported that a larger proportion of the birds fly within the array area at night, compared with day-time, but counteract this higher risk of colliding with the WTGs in the dark by remaining at a greater distance from the individual WTGs.

5.11.2.166 A further review of radar studies by Dirksen et al. (2000) concluded that on average, nocturnal migrants fly higher than diurnal migrants, and are therefore assumed to have a lower risk of colliding with WTGs than birds flying during darkness between feeding and roosting areas (Dirksen et al. 2000). The exception was in semi-offshore situations, when the seasonal migration of birds at night may also take place at WTG height. Data from studies conducted at 30 terrestrial wind farms revealed no significant differences between fatality rates of night migrants at turbines with lights as opposed to turbines without lighting at the same wind farm (Kerlinger et al. 2010), whilst Welcker et al. (2017) found nocturnal migrants do not have a higher risk of collision with WTGs than do diurnally active species, but rather appear to circumvent collision more effectively. This would suggest that studies of bird collisions with other anthropogenic structures such as buildings, towers or offshore platforms (Ronconi et al. 2015) that usually find a high risk of collision of nocturnal migrants do not necessarily reflect the situation at wind farms, both in the terrestrial or marine environments.

5.11.2.167 There could be the potential for a significant impact to occur if large numbers of migrants pass through the site in a single event, leading to mass disorientation or collisions. However, there is insufficient evidence from current literature or any existing

UK OWFs to suggest mass collision events occur as a result of aviation and navigation lighting that is typical for UK OWFs. Evidence from Welcker et al. (2017) and Kerlinger et al. (2010) found nocturnal migrants do not have a higher risk of collision with wind energy facilities than do diurnally active species, nor do mortality rates increase at OWFs with lighting compared to those without. Furthermore, studies have shown that nocturnal flight is altered to counteract the risk of WTG collision (Dirksen et al. 2000; Desholm and Kahlert 2005). Therefore, on the basis of the available evidence, the potential magnitude of impact has been assessed to be no greater than **negligible** to migratory birds with respect to lighting.

5.11.2.168 As 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 (**Table 5.22**) and is therefore not considered further in this assessment.

<u>Seabirds</u>

Magnitude of Impact

5.11.2.169 The species that are likely to be present in largest numbers (fulmar, gannet, kittiwake and auk species) are unlikely to be active at night, either returning to colonies overnight or roosting on the sea surface (Wade et al. 2016). A tracking study by Furness et al. (2018) reported that gannet flight and diving activity was minimal during the night. Gulls are likely to have low to moderate levels of nocturnal activity, being visual foragers that are known to be attracted to lit fishing vessels and well-lit oil and gas platforms that attract fish to the surface waters (Burke et al. 2012). However, Kotzerka et al. (2010) reported that kittiwake foraging trips mainly occurred during daylight and birds were mostly inactive during the night and therefore at lower risk. Fulmar is given a relatively high nocturnal activity rate, however very few flights are likely to be at risk height (Wade et al. 2016). As sufficient precaution is provided within the assessments of disturbance and displacement (**Section 5.11.2**) as well as collision risk (**Section 5.11.2**), which includes consideration of diurnal as well as nocturnal activities the potential magnitude of impacts would be no greater than **negligible** to seabirds with respect to lighting.

5.11.2.170 As 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 (**Table 5.22**) and is therefore not considered further in this assessment.

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 **Table 5.18** 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 - 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; and
- indirect effects – birds may be impacted during the decommissioning phase through effects on habitats and prey species within the offshore ECC and cable landfall leading to a reduction in prey availability or reduced foraging success.

5.11.3.3 Direct effects were found to have no potential for a likely significant effect in the PEIR and have not been considered further here (see **Volume A4, Annex 5.1: Impacts Register**).

Indirect impacts during the decommissioning phase within the offshore ECC and landfall through effects on habitats and prey species (ORN-D-13)

Magnitude of impact

5.11.3.4 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, which could reduce foraging success.

5.11.3.5 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 A2, Chapter 3: Fish and Shellfish Ecology** and **Volume A2, 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. The significance of the effect is therefore **not significant**.

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 plans and projects. 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 plans and projects which may act cumulatively with Hornsea Four. The full list of such developments that have been identified in relation to the offshore environment are set out in **Volume A4, Annex 5.3: Offshore Cumulative Effects** and are presented in a series of maps in **Volume A4, 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 developments, predominantly those projects which are '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 developments. For example, those projects under construction are likely to contribute to cumulative impacts (providing effect pathways exist), whereas those developments 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 ES. An explanation of each tier is included in **Table 5.45**.

Table 5.45: 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 A4, Annex 5.3: Offshore Cumulative Effects** and **Volume A4, 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 were 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; and
- There are 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 the construction or operational periods are not known or projects are located outside of the North Sea and English Channel. Other projects from non-offshore energy projects which were screened out included commercial fisheries as well as shipping and navigation, which due to already being present were evaluated as being part of the offshore and intertidal baseline. A further development, the Endurance Carbon Capture Utilisation and Storage (CCUS) project, is proposed to the north of the Hornsea Four array area. However, no data area currently available on potential impacts to offshore ornithology and as such this project has been screened out from further consideration.

5.12.1.8 The specific projects screened into the CEA for offshore and intertidal ornithology, as well as the tiers (and sub-tiers) into which they have been allocated are presented in **Table 5.46** 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 A4, Annex 5.3: Offshore Cumulative Effects** and **Volume A4, Annex 5.4: Location of Offshore Cumulative Schemes**.

Table 5.46 - Projects screened into the offshore and intertidal ornithology cumulative assessment (from Volume A4, Annex 5.3: Offshore Cumulative Effects).

Tier	Project/Plan	Details/ relevant dates	Distance to Hornsea Four Array (km)	Distance to Hornsea Four ECC (km)	Distance to Hornsea Four HVAC Booster Area (km)	Reason for Project Inclusion in Hornsea Four CEA
1a	Beatrice	Operational	503.16	490.44	498.32	Potential temporal operation with Hornsea Four
1a	Blyth Demonstration Site (Phase 1)	Operational	178.10	140.73	156.54	Potential temporal overlap of operation with Hornsea Four
1a	Dudgeon	Operational	74.89	74.81	102.70	Potential temporal overlap of operation with Hornsea Four
1a	East Anglia One	Operational	201.96	202.40	237.68	Potential temporal overlap of operation with Hornsea Four
1a	European Offshore Wind Development Centre	Operational	381.71	369.94	377.06	Potential temporal overlap of operation with Hornsea Four
1a	Forthwind Demonstration Project (Methil)	Operational	333.87	296.39	314.28	Potential temporal overlap of construction and operation with Hornsea Four
1a	Galloper	Operational	226.12	226.27	252.03	Potential temporal overlap of operation with Hornsea Four
1a	Greater Gabbard	Operational	223.86	223.97	248.38	Potential temporal overlap of operation with Hornsea Four
1a	Gunfleet Sands	Operational	248.78	248.49	262.38	Potential temporal overlap of operation with Hornsea Four
1a	Hornsea Project One	Operational	16.84	26.56	83.33	Potential temporal overlap of operation with Hornsea Four
1a	Humber Gateway	Operational	66.37	41.65	42.69	Potential temporal overlap of operation with Hornsea Four
1a	Hywind Scotland (Hywind 2)	Operational	381.06	379.01	383.20	Potential temporal overlap of operation with Hornsea Four
1a	Kentish Flats	Operational	279.95	279.35	291.09	Potential temporal overlap of operation with Hornsea Four
1a	Kentish Flats Extension	Operational	280.73	280.01	291.13	Potential temporal overlap of operation with Hornsea Four
1a	Kincardine	Operational	353.00	342.00	350.00	Potential temporal overlap of operation with Hornsea Four
1a	Lincs	Operational	96.62	84.15	90.07	Potential temporal overlap of operation with Hornsea Four

Tier	Project/Plan	Details/ relevant dates	Distance to Hornsea Four Array (km)	Distance to Hornsea Four ECC (km)	Distance to Hornsea Four HVAC Booster Area (km)	Reason for Project Inclusion in Hornsea Four CEA
1a	Lynn	Operational	107.20	95.46	101.12	Potential temporal overlap of operation with Hornsea Four
1a	Inner Dowsing	Operational	101.69	88.57	93.77	Potential temporal overlap of operation with Hornsea Four
1a	London Array	Operational	254.65	254.58	271.90	Potential temporal overlap of operation with Hornsea Four
1a	Methil (Samsung) Demo	Operational	335.34	297.94	315.76	Potential temporal overlap of operation with Hornsea Four
1a	Race Bank	Operational	78.83	72.90	83.60	Potential temporal overlap of operation with Hornsea Four
1a	Rampion	Operational	379.41	368.92	375.09	Potential temporal overlap of operation with Hornsea Four
1a	Scroby Sands	Operational	150.93	151.09	179.50	Potential temporal overlap of operation with Hornsea Four
1a	Sheringham Shoal	Operational	91.54	90.25	107.45	Potential temporal overlap of operation with Hornsea Four
1a	Teesside	Operational	140.61	86.99	109.28	Potential temporal overlap of operation with Hornsea Four
1a	Thanet	Operational	281.91	281.86	299.64	Potential temporal overlap of operation with Hornsea Four
1a	Westermost Rough	Operational	62.94	22.07	26.38	Potential temporal overlap of operation with Hornsea Four
1b	Hornsea Project Two	Under Construction	3.46	10.61	67.23	Potential temporal overlap of operation with Hornsea Four
1b	Moray East	Under Construction	489.27	479.28	486.11	Potential temporal overlap of operation with Hornsea Four
1b	Neart na Gaoithe	Under construction	296.10	272.19	285.06	Potential temporal overlap of operation with Hornsea Four
1b	Seagreen (formerly Seagreen A and Seagreen B)	Under construction	314.53	296.10	305.51	Potential temporal overlap of operation with Hornsea Four
1b	Triton Knoll	Under construction	56.99	50.20	61.89	Potential temporal overlap of operation with Hornsea Four
1c	Dogger Bank A	Consented– construction expected 2022-2023	65.86	83.83	108.33	Potential temporal overlap of construction and operation with Hornsea Four
1c	Dogger Bank B	Consented– construction expected 2022-2024	76.14	94.43	112.01	Potential temporal overlap of construction and operation with Hornsea Four

Tier	Project/Plan	Details/ relevant dates	Distance to Hornsea Four Array (km)	Distance to Hornsea Four ECC (km)	Distance to Hornsea Four HVAC Booster Area (km)	Reason for Project Inclusion in Hornsea Four CEA
1c	Dogger Bank C (formerly Dogger Bank Teesside A)	Consented - construction expected 2023-2026	120.86	136.85	171.02	Potential temporal overlap of construction and operation with Hornsea Four
1c	East Anglia Three	Consented - construction expected 2023-2026	168.48	169.31	212.86	Potential temporal overlap of operation with Hornsea Four
1c	Hornsea Three	Consented – construction expected 2024-2030	46.47	60.28	116.91	Potential temporal overlap of construction and operation with Hornsea Four
1c	Inch Cape	Consented	311.84	292.35	303.64	Potential temporal overlap of construction and operation with Hornsea Four
1c	Moray West	Consented – construction expected 2022-2025	492.64	479.44	487.49	Potential temporal overlap of operation with Hornsea Four
1c	Sofia (formerly Dogger Bank Teesside B)	Under construction	97.75	114.01	144.05	Potential temporal overlap of operation with Hornsea Four
1d	East Anglia One North	Application under examination	186.20	186.20	220.74	Potential temporal overlap of construction and operation with Hornsea Four
1d	East Anglia Two	Application under examination	194.20	194.48	225.13	Potential temporal overlap of construction and operation with Hornsea Four
1d	Norfolk Boreas	Application under examination	134.88	138.68	188.41	Potential temporal overlap of construction and operation with Hornsea Four
1d	Norfolk Vanguard	Application under examination	134.40	135.41	176.99	Potential temporal overlap of construction and operation with Hornsea Four
2	Sheringham Shoal Extension Project	PEIR submitted 06/2021	83.60	82.32	100.68	Potential temporal overlap of construction and operation with Hornsea Four

Tier	Project/Plan	Details/ relevant dates	Distance to Hornsea Four Array (km)	Distance to Hornsea Four ECC (km)	Distance to Hornsea Four HVAC Booster Area (km)	Reason for Project Inclusion in Hornsea Four CEA
2	Dudgeon Extension Project	PEIR submitted 06/2021	69.49	69.48	92.80	Potential temporal overlap of construction and operation with Hornsea Four
2	Rampion 2	In planning	379.41	368.92	375.09	Potential temporal overlap of construction and operation with Hornsea Four
3b	Five Estuaries (Galloper Extension)*	In planning	228.57	228.80	256.43	Potential temporal overlap of construction and operation with Hornsea Four
3b	North Falls (Greater Gabbard Extension)*	In planning	223.86	223.97	248.38	Potential temporal overlap of construction and operation with Hornsea Four
3c	Round 4 – Bidding Area 1	Pre-planning	41.40	57.78	95.38	Potential temporal overlap of construction with Hornsea Four
3c	Round 4 – Bidding Area 2	Pre-planning	41.62	59.87	77.71	Potential temporal overlap of construction with Hornsea Four

Table note: * Distances based on operational windfarm as exact location of extension projects has not yet been confirmed.

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 and with very little temporal overlap with the construction phases of other projects;
- Indirect impacts during any phase of Hornsea Four, as they will be spatially limited and all were predicted as negligible at a project level;
- Barrier effects on seabirds due to the potential impacts and effects predicted for Hornsea Four being negligible 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 gannet and auk species (guillemot, razorbill and puffin) during the operational and maintenance phase of Hornsea Four cumulatively 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 cumulatively with other planned, in-construction and operational offshore wind farms within the UK North Sea and English Channel (where appropriate).

- Despite Hornsea Four's contribution to any cumulative collision risk totals for herring gull and lesser black-backed gull being *de minimis*, at the request of Natural England, a high level overview of such a non-material contribution is provided for these two species.

5.12.1.12 The cumulative MDS described in **Table 5.47** 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 5.18**), 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 5.47: 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) and gannet	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, herring gull, lesser black-backed gull 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 application documentation and it is noted that the project parameters quoted within these 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 outcome of their revised assessments were incorporated wherever possible. The assessment presented here is therefore considered to be conservative, with the level of realised impact expected to be reduced compared to that 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 5.46**). 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 5.47**.

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 gannet and auk 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 5.26**.

5.12.2.5 Following the screening process an assessment of cumulative displacement was been carried out for four seabird species of interest identified as potentially at risk and of interest for this CEA. The four species are gannet, guillemot, razorbill and puffin.

Gannet

5.12.2.6 As determined in **Section 5.11.2**, gannets 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; Krijgsveld et al. 2011; Royal HaskoningDHV 2013; APEM 2014). For the purpose of this assessment the level of displacement considered across all bio seasons is between 60-80%, accepted by Natural England as appropriate rates for assessment (OFF-ORN-2.43).

5.12.2.7 A mortality rate of 1% was selected for this assessment based on expert judgement supported by additional evidence that suggests that gannet have a large mean max (315 km) and maximum (709 km) foraging range (Woodward et al. 2019) 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.

5.12.2.8 For other projects, the data on seasonal population estimates have been collated where available. The subsequent bio-season and annual abundance estimates for gannet associated with each of the projects identified in **Table 5.46** are presented in **Table 5.48**. As it is difficult to split these project's data collated between the array area and 2 km buffer a standardised approach has been taken for estimating displacement at the cumulative level. This approach considers gannet displacement within the array area plus 2 km buffers for all projects, despite the Applicant's preferred approach considering that gannet displacement should only be assessed from within the array area only.

Table 5.48: Cumulative bio-season and total abundance estimates for gannet from all Tier 1 & 2 projects.

Project	Migration-free breeding	Post-breeding migration	Return migration	Annual total	Tier
Beatrice	151	0	0	151	1a
Blyth Demonstration Site	-	-	-	-	1a
Dudgeon	53	25	11	89	1a
East Anglia One	161	3,638	76	3,875	1a
European Offshore Wind Development Centre (EOWDC)	35	5	0	40	1a
Galloper	360	907	276	1,543	1a
Greater Gabbard	252	69	105	426	1a
Gunfleet Sands	0	12	9	21	1a
Hornsea Project One	671	694	250	1,615	1a
Humber Gateway	-	-	-	-	1a
Hywind 2 Demonstration	10	0	4	14	1a
Kentish Flats	-	-	-	-	1a
Kentish Flats Extension	0	13	0	13	1a
Kincardine	120	0	0	120	1a
Lincs	-	-	-	-	1a
London Array	-	-	-	-	1a
Lynn and Inner Dowsing	-	-	-	-	1a
Methil	23	0	0	23	1a
Race Bank	92	32	29	153	1a
Rampion	0	590	0	590	1a

Project	Migration-free breeding	Post-breeding migration	Return migration	Annual total	Tier
Scroby Sands	-	-	-	-	1a
Sheringham Shoal	47	31	2	80	1a
Teesside	1	0	0	1	1a
Thanet	-	-	-	-	1a
Westermost Rough	-	-	-	-	1a
East Anglia One	161	3,638	76	3,875	1b
Hornsea Project Two	457	1,140	124	1,721	1b
Moray East	564	292	27	883	1b
Neart na Gaoithe	1,987	552	281	2,820	1b
Triton Knoll	211	15	24	250	1b
Seagreen Alpha	1,716	296	138	2,150	1b
Seagreen Bravo	1,240	368	194	1,802	1b
Dogger Bank A	518	916	176	1,610	1c
Dogger Bank B	637	1,132	218	1,987	1c
Dogger Bank C	968	379	226	1,573	1c
East Anglia Three	412	1,269	524	2,205	1c
Hornsea Three	1,333	984	524	2,841	1c
Inch Cape	2,398	703	212	3,313	1c
Moray West	2,827	439	144	3,410	1c
Sofia	1,282	508	238	2,028	1c
East Anglia ONE North	149	468	44	661	1d
East Anglia TWO	192	891	192	1,275	1d
Norfolk Boreas	1,229	1,723	526	3,478	1d
Norfolk Vanguard	271	2,453	437	3,161	1d
Hornsea Four	791	854	235	1,880	1d
Dudgeon Extension Project	361	343	47	751	2
Sheringham Shoal Extension Project	40	295	0	335	2
All Projects Totals	**21,559**	**22,036**	**5,293**	**48,888**	

Potential magnitude of impact

5.12.2.9 The potential magnitude of impact is estimated by calculating the increase in baseline mortality when compared against the largest UK North Sea and English Channel BDMPS and biogeographic population. The largest gannet BDMPS for the UK North Sea and English Channel is 456,298 (adults and immatures), whilst the wider bio-geographic population is 1,180,000 individuals (adults and immatures). Using the average mortality rate of 0.187, based on age specific demographic rates and age class proportions described in **Section 5.7.4**, the background mortality for these population scales are 85,328 and 220,660 individuals per annum, respectively.

5.12.2.10 The cumulative total of gannets at risk of displacement from all OWF projects is calculated to be 48,888 annually (**Table 5.48**). When applying a 60 – 80% displacement rate and a 1% mortality rate to the cumulative annual total, 293 to 391 individuals may be lost to the UK North Sea and English Channel and the biogeographic populations.

5.12.2.11 The potential cumulative loss of 293 to 391 gannets would represent an increase of 0.34 – 0.46% relative to the baseline mortality rate at the UK North Sea and English Channel BDMPS scale. At the biogeographic scale this additional mortality would increase baseline mortality by 0.13 – 0.18%.

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

5.12.2.13 Therefore, irrespective of the sensitivity of the receptor, the significance of the impact is **not significant** as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment.

Guillemot

5.12.2.14 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; Bradbury et al. 2014).

5.12.2.15 As each individual OWF assessment considers the peak mean for each bio-season when these values are added together at a cumulative level, a highly unlikely total number of birds is estimated within these array areas and 2 km buffers. The total abundance in **Table 5.49** represents almost 25% of the entire North Sea and English Channel BDMPS population, whilst the area covered by the combined array areas and 2 km buffers of all OWFs within this cumulative displacement assessment would be well under 5% of the area. Therefore, by adding together seasonal mean peaks in this manner the overall assessment for cumulative displacement is considered to be highly precautionary.

5.12.2.16 It is also highly likely that guillemot and other auk species are displaced and / or habituate at different levels from areas within and outside active array areas. 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 standardised 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**) for other projects considered in this CEA, a precautionary displacement rate of 50%, as described in **Section 5.11.2**, has been applied across both the array areas and 2 km buffer for all projects.

5.12.2.17 Due to limitations in the data for other OWFs, 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 5.46 are presented in Table 5.49.

Table 5.49: Cumulative bio-season and total abundance estimates for guillemot from all Tier 1 & 2 projects' array areas and 2 km buffers.

Project	Breeding	Non-breeding	Annual total	Tier
Beatrice	13,610	2,755	16,365	1a
Blyth Demonstration Site	1,220	1,321	2,541	1a
Dudgeon	334	542	876	1a
East Anglia One	274	640	914	1a
EOWDC	547	225	772	1a
Galloper	305	593	898	1a
Greater Gabbard	345	548	893	1a
Gunfleet Sands	0	363	363	1a
Hornsea Project One	9,836	8,097	17,933	1a
Humber Gateway	99	138	237	1a
Hywind 2 Demonstration	249	2,136	2,385	1a
Kentish Flats	0	3	3	1a
Kentish Flats Extension	0	4	4	1a
Lincs, Lynn & Inner Dowsing	582	814	1,396	1a
Kincardine	632	0	632	1a
London Array	192	377	569	1a
Methil	25	0	25	1a
Race Bank	361	708	1,069	1a
Rampion	10,887	15,536	26,423	1a
Scroby Sands	-	-	-	1a
Sheringham Shoal	390	715	1,105	1a
Teesside	267	901	1,168	1a
Thanet	18	124	142	1a
Westermost Rough	347	486	833	1a
Hornsea Project Two	7,735	13,164	20,899	1b
Moray East	9,820	547	10,367	1b
Triton Knoll	425	746	1,171	1b
Dogger Bank A	5,407	6,142	11,549	1c
Dogger Bank B	9,479	10,621	20,100	1c
Dogger Bank C	3,283	2,268	5,551	1c
East Anglia Three	1,744	2,859	4,603	1c
Hornsea Three	13,374	17,772	31,146	1c

Project	Breeding	Non-breeding	Annual total	Tier
Inch Cape	4,371	3,177	7,548	1c
Moray West	24,426	38,174	62,600	1c
Neart na Gaoithe	1,755	3,761	5,516	1c
Seagreen Alpha	13,606	4,688	18,294	1c
Seagreen Bravo	11,118	4,112	15,230	1c
Sofia	5,211	3,701	8,912	1c
East Anglia ONE North	4,183	1,888	6,071	1d
East Anglia TWO	2,077	1,675	3,752	1d
Norfolk Boreas	7,767	13,777	21,544	1d
Norfolk Vanguard	4,320	4,776	9,096	1d
Hornsea Four	8,550	17,062	25,612	1d
Dudgeon Extension Project	8,061	2,977	11,038	2
Sheringham Shoal Extension Project	610	599	1,209	2
All Projects Totals	**187,842**	**191,512**	**379,354**	

Potential magnitude of impact

5.12.2.18 The potential magnitude of impact is estimated by calculating the increase in baseline mortality when compared against the largest UK North Sea and English Channel BDMPS population and then separately against the biogeographic population. The largest guillemot BDMPS for the UK North Sea and English Channel is 1,617,306 (adults and immatures), whilst the wider bio-geographic population is 4,125,000 individuals (adults and immatures). Using the average mortality rate of 0.138, based on age specific demographic rates and age class proportions described in **Section 5.7.4**, the background mortality for these population scales are 223,188 and 569,250 individuals per annum, respectively.

5.12.2.19 The cumulative total of guillemots at risk of displacement from all OWF projects is calculated to be 379,354 (**Table 5.49**). At the request of Natural England, a full cumulative displacement matrix is provided in **Table 5.51** for guillemot, which presents a range of displacement and mortality rates for the total predicted number of individuals within the UK North Sea and English Channel OWFs plus a 2 km buffer (OFF-ORN-4.8). When applying the evidence led 50% displacement rate and a 1% mortality rate to cumulative total, 1,897 individuals may be lost to the UK North Sea and English Channel BDMPS population and the wider biogeographic population.

5.12.2.20 The potential cumulative loss of 1,897 guillemots would represent an increase of 0.85% relative to the baseline mortality rate at the BDMPS scale. At the biogeographic scale this additional mortality would increase baseline mortality by 0.33%.

5.12.2.21 Despite the cumulative mortality of 1,897 guillemots not exceeding an increase in 1% baseline mortality at either the BDMPS or biogeographic population scale, a precautionary approach has been taken via further assessment through PVA modelling as detailed in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability**

Analysis with the results summarised in **Table 5.50**. PVA has been undertaken for a wide range of displacement and mortality rate scenarios in order to better understand the level of risk involved with increasing levels of displacement resulting in mortality.

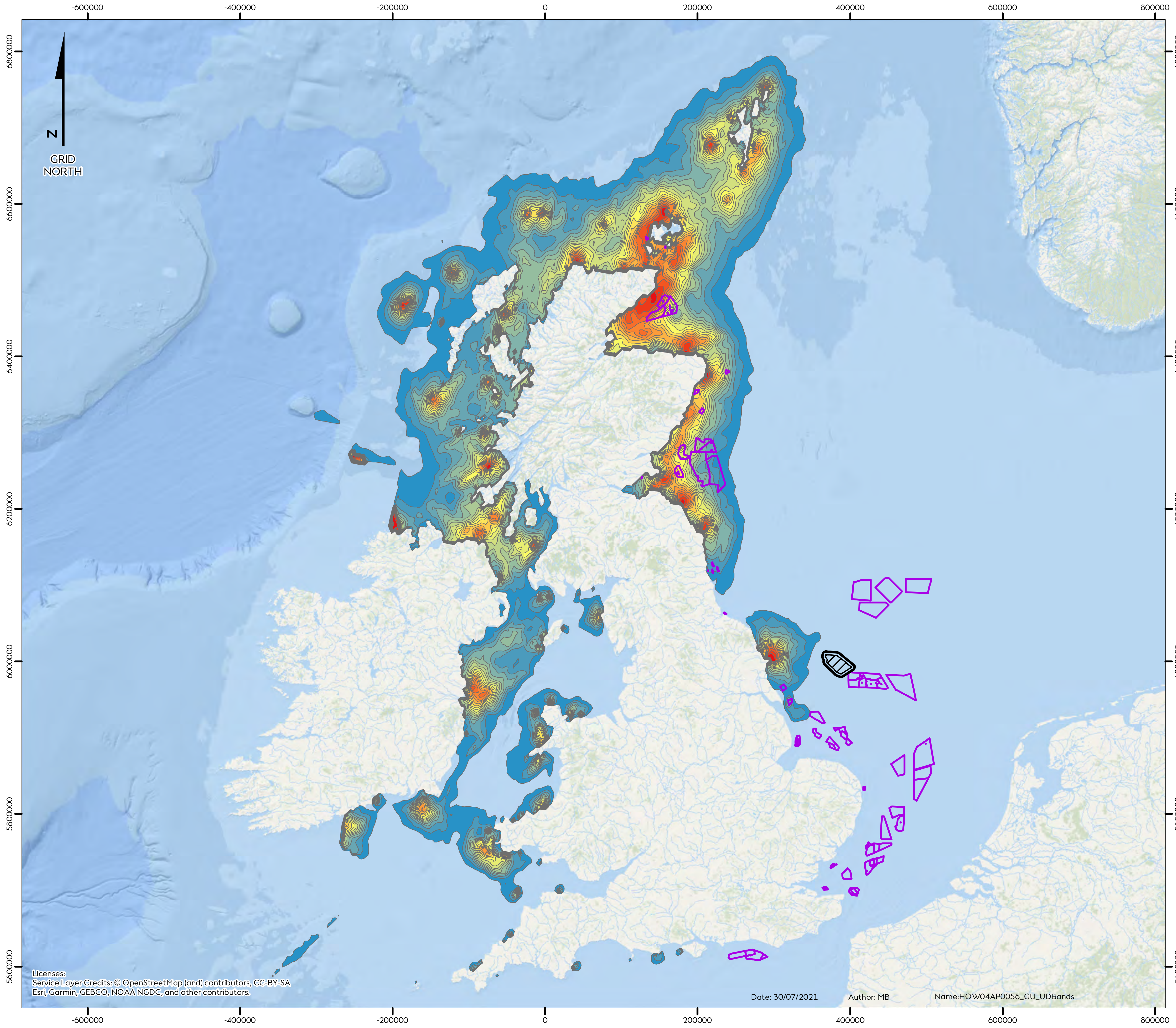
Table 5.50: Guillemot cumulative disturbance and displacement PVA results for the North Sea and English Channel BDMPS and Biogeographic population scales.

Scenario	Increase in mortality (per annum)	North Sea and English Channel BDMPS		Biogeographic	
		Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)	Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)
30% disp, 1% Mort	1138	0.999	0.08%	1.000	0.03%
50% disp, 1% Mort	**1897**	**0.999**	**0.13%**	**0.999**	**0.05%**
70% disp, 1% Mort	2655	0.998	0.18%	0.999	0.07%
30% disp, 2% Mort	2276	0.998	0.16%	0.999	0.06%
50% disp, 2% Mort	3794	0.997	0.26%	0.999	0.10%
70% disp, 2% Mort	5311	0.996	0.37%	0.999	0.14%
30% disp, 5% Mort	5690	0.996	0.40%	0.998	0.16%
50% disp, 5% Mort	9484	0.993	0.66%	0.997	0.26%
70% disp, 5% Mort	13277	0.991	0.92%	0.996	0.36%
30% disp, 10% Mort	11381	0.992	0.79%	0.997	0.31%
50% disp, 10% Mort	18968	0.987	1.32%	0.995	0.52%
70% disp, 10% Mort	26555	0.982	1.85%	0.993	0.72%

Table Note: Value highlighted in bold represents the Applicant's position on suitable displacement and mortality scenario for cumulative assessment based on the evidence in **paragraph 5.11.2.22** *et seq.*

5.12.2.22 As detailed in **Section 5.11.2.22** when considering which of the PVA scenarios is most likely, the evidence suggests that the lower displacement and mortality range is more plausible, especially considering the likely overinflation in guillemot numbers assessed (**paragraph 5.12.2.15**). Furthermore During 2010 to 2015, the RSPB and partners undertook a series of large-scale tracking studies of guillemots across the UK during the breeding season in order to map their UK wide, at-sea distributions. Due to the constraint on foraging range and added stress of breeding it can be considered that impacts during the breeding season are likely to cause the greatest impact on guillemots. These data were subject to analysis by Wakefield et al. (2017) in order to map guillemot distribution and their core foraging ranges, the result of this analysis is presented in **Figure 5.6**. Core foraging range was defined as the area of sea up to the 50% Utilisation Distribution (UD) band (Cleasby et al. 2018). The vast majority of Southern North Sea OWFs (including Hornsea Four array area and 4 km buffer) were not located within any of the UD bands and only a handful of the smaller scale Scottish OWFs were located in areas of sea considered to be guillemot core foraging range, suggesting that the vast majority of the North Sea and English Channel OWFs do not lie within important areas of sea for guillemots and therefore displacement from these areas would not lead to significant reduction in survival.

5.12.2.23 Further analysis of these tracking data was undertaken by Cleasby et al. (2018) using hotspot mapping techniques in order to identify important areas of high seabird density at sea. Maximum curvature and Getis-Ord analyses were used to generate UK-level hotspots as presented in **Figure 5.7**. The results of these analyse again suggest that the vast majority of North Sea and English Channel OWFs lie far outside of areas of sea classified as statistically significant, further evidencing that any disturbance effects from these OWFs is unlikely to provide reductions in guillemot fitness. Therefore, the PVA scenarios which include high mortality rates can be dismissed as unrealistic when considering cumulative assessment of guillemots.



Hornsea Four

Figure 5.6

Guillemot UK Utilisation Distributions in 5% Bands

DCO Array Area
DCO Array Area Plus 4 km Buffer
North Sea Offshore Wind Farms

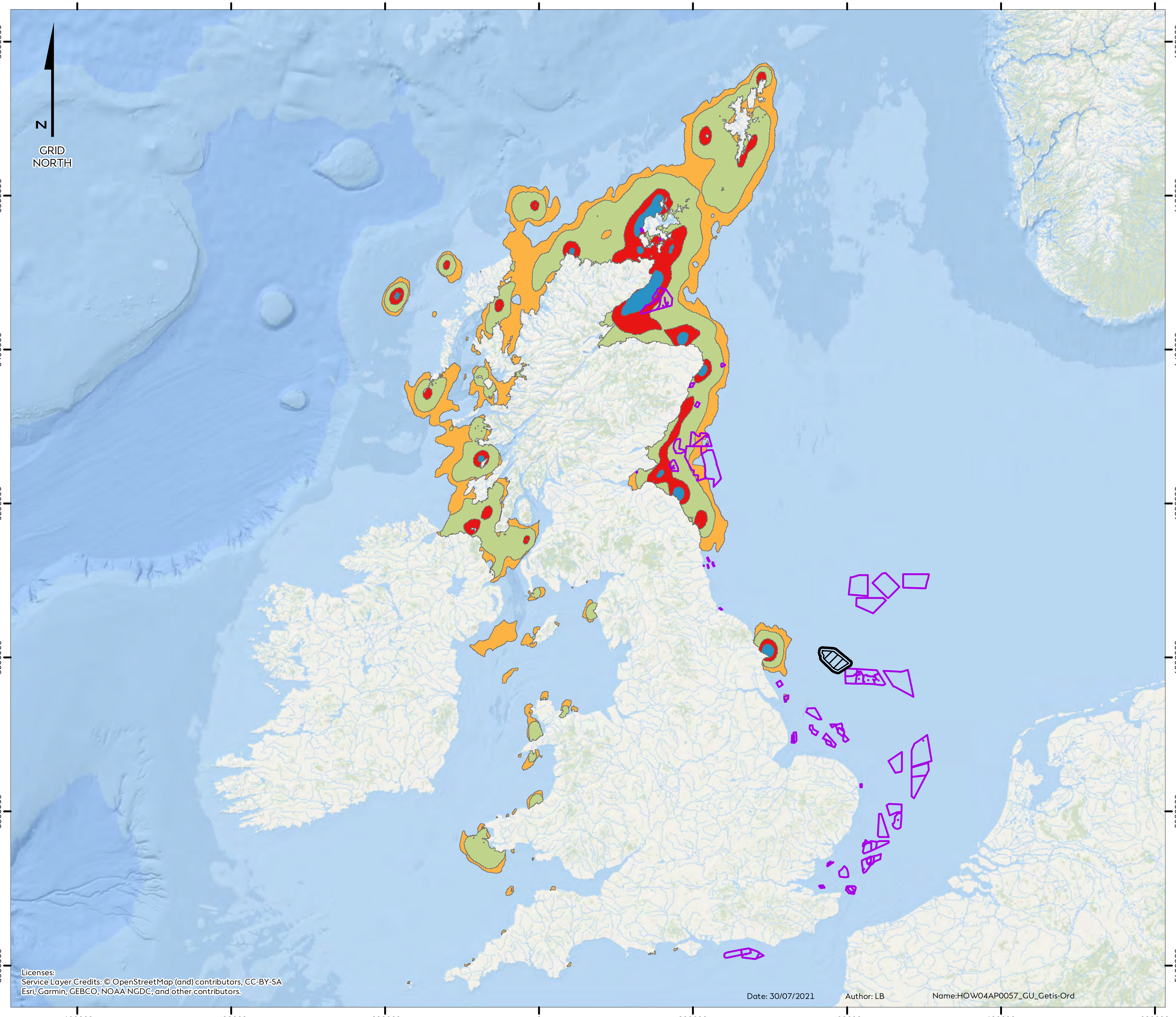
Guillemot UK UD Bands

5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
55%
60%
65%
70%
75%
80%
85%
90%
95%

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:4,800,000
0 75 150 Kilometres
0 30 60 Nautical Miles

REV	REMARK	DATE
	First Issue	30/07/2021

Guillemot UK Utilisation Distributions in 5% Bands
Document no: HOW04AP0056
Checked by: MB
Approved by: SS



Hornsea Four

Figure 5.7

Guillemot Maximum Curviture and Getis-Ord Hotspots

- DCO Array Area
- DCO Array Area Plus 4 km Buffer
- North Sea Offshore Wind Farms
- Maximum Curvature
- Statistically Significant Getis-Ord hotspot - d = 9km
- Top 1% Getis-Ord hotspot - d = 9km
- Top 5% Getis-Ord hotspot - d = 9km

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:4,800,000

0 75 150 Kilometres

0 30 60 Nautical Miles

REV	REMARK	DATE
	First Issue	30/07/2021

Guillemot Maximum Curviture and Getis-Ord Hotspots
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5.12.2.24 At the UK North Sea and English Channel BDMPS population scale, 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. When considering this level of potential impact through the PVA modelling, it is also considered to be of **minor** magnitude on an annual cumulative basis at the UK North Sea and English Channel BDMPS population scale, as it represents well under a 0.5% reduction in growth rate of the UK North Sea and English Channel BDMPS population.

5.12.2.25 At the biogeographic scale this level of potential impact is considered to be of **negligible** magnitude on an annual cumulative basis, as it represents well under a 1% increase to the baseline mortality conditions. When considering this level of potential impact through the PVA modelling, it is also considered to be of **negligible** magnitude on an annual cumulative basis at the biogeographic population scale, as it represents well under a 0.1% reduction in growth rate of the biogeographic population. Therefore, irrespective of the sensitivity of the receptor, the significance of the impact is not significant at the biogeographic scale as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment.

Sensitivity of the receptor

5.12.2.26 As the birds within the UK North Sea and English Channel 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 5.26**). Whilst it may be of medium vulnerability, it is of high conservation value leading to an overall sensitivity of this receptor to offshore wind farms of **high**.

Significance of the effect

5.12.2.27 The magnitude of cumulative displacement 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. However, as the UK North Sea and English Channel BDMPS population is considered to be stable and increasing (Furness 2015; Horswill & Robinson 2015) the resulting reduction in growth rate is not considered to be of any significant consequence to the overall BDMPS population. Therefore, the potential effect from cumulative displacement to guillemot from Hornsea Four and all other UK offshore wind farms in the North Sea and English Channel may be of **slight** adverse significance in total per annum, which is not significant in EIA terms.

Table 5.51: Guillemot cumulative displacement matrix for all North Sea OWF projects (annual), values in green represent the range-based values advocated by Natural England and the darker shade of green representing the Applicant's approach value.

Displacement Rate (%)	Mortality Rate (%)														
	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
1	38	76	114	152	190	379	759	1,138	1,517	1,897	2,276	2,655	3,035	3,414	3,794
10	379	759	1,138	1,517	1,897	3,794	7,587	11,381	15,174	18,968	22,761	26,555	30,348	34,142	37,935
20	759	1,517	2,276	3,035	3,794	7,587	15,174	22,761	30,348	37,935	45,522	53,110	60,697	68,284	75,871
30	1,138	2,276	3,414	4,552	5,690	11,381	22,761	34,142	45,522	56,903	68,284	79,664	91,045	102,426	113,806
40	1,517	3,035	4,552	6,070	7,587	15,174	30,348	45,522	60,697	75,871	91,045	106,219	121,393	136,567	151,742
50	1,897	3,794	5,690	7,587	9,484	18,968	37,935	56,903	75,871	94,839	113,806	132,774	151,742	170,709	189,677
60	2,276	4,552	6,828	9,104	11,381	22,761	45,522	68,284	91,045	113,806	136,567	159,329	182,090	204,851	227,612
70	2,655	5,311	7,966	10,622	13,277	26,555	53,110	79,664	106,219	132,774	159,329	185,883	212,438	238,993	265,548
80	3,035	6,070	9,104	12,139	15,174	30,348	60,697	91,045	121,393	151,742	182,090	212,438	242,787	273,135	303,483
90	3,414	6,828	10,243	13,657	17,071	34,142	68,284	102,426	136,567	170,709	204,851	238,993	273,135	307,277	341,419
100	3,794	7,587	11,381	15,174	18,968	37,935	75,871	113,806	151,742	189,677	227,612	265,548	303,483	341,419	379,354

Razorbill

5.12.2.28 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; Bradbury et al. 2014).

5.12.2.29 As each individual OWF assessment considers the peak mean for each bio-season when these values are added together at a cumulative level, a highly unlikely total number of birds is estimated within these array areas and 2 km buffers. The total abundance in **Table 5.52** represents over 20% of the entire North Sea and English Channel BDMPS population, whilst the area covered by the combined array areas and 2 km buffers of all OWFs within this cumulative displacement assessment would be well under 5% of the area. Therefore, by adding together seasonal mean peaks in this manner, the overall assessment for cumulative displacement is considered to be highly precautionary.

5.12.2.30 It is also highly likely that razorbill and other auk species are displaced and / or habituate at different levels from areas within and outside active array areas. 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 standardised 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**), for other projects considered in this CEA, an evidence-led displacement rate of 50%, as described in **Section 5.11.2**, has been applied across both the array areas and 2 km buffer for all projects.

5.12.2.31 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 5.46** are presented in **Table 5.52**.

Table 5.52: Cumulative bio-season and total abundance estimates for razorbill from all Tier 1 & 2 project array areas and 2 km buffers.

Project	Migration-free breeding	Post-breeding migration	Non-migratory wintering	Return migration	Annual total	Tier
Beatrice	873	833	555	833	3,094	1a
Blyth Demonstration Site	121	91	61	91	364	1a
Dudgeon	256	346	745	346	1,693	1a
East Anglia One	16	26	155	336	533	1a
EOWDC	161	64	7	26	258	1a
Galloper	44	43	106	394	587	1a
Greater Gabbard	0	0	387	84	471	1a
Gunfleet Sands	0	0	30	0	30	1a

Project	Migration-free breeding	Post-breeding migration	Non-migratory wintering	Return migration	Annual total	Tier
Hornsea Project One	1,109	4,812	1,518	1,803	9,242	1a
Humber Gateway	27	20	13	20	80	1a
Hywind 2 Demonstration	30	719	10		759	1a
Kentish Flats	-	-	-	-	-	1a
Kentish Flats Extension	-	-	-	-	-	1a
Kincardine	22	0	0	0	22	1a
Lincs, Lynn & Inner Dowsing	45	34	22	34	134	1a
London Array	14	20	14	20	68	1a
Methil	4	0	0	0	4	1a
Race Bank	28	42	28	42	140	1a
Rampion	630	66	1,244	3,327	5,267	1a
Scroby Sands	-	-	-	-	-	1a
Sheringham Shoal	106	1,343	211	30	1,690	1a
Teesside	16	61	2	20	99	1a
Thanet	3	0	14	21	37	1a
Westermost Rough	91	121	152	91	455	1a
Hornsea Project Two	2,511	4,221	720	1,668	9,119	1b
Moray East	2,423	1,103	30	168	3,724	1b
Triton Knoll	40	254	855	117	1,266	1b
Dogger Bank A	1,250	1,576	1,728	4,149	8,703	1c
Dogger Bank B	1,538	2,097	2,143	5,119	10,897	1c
Dogger Bank C	834	310	959	1,919	4,022	1c
East Anglia Three	1,807	1,122	1,499	1,524	5,952	1c
Hornsea Three	630	2,020	3,649	2,105	8,404	1c
Inch Cape	1,436	2,870	651	-	4,957	1c
Moray West	2,808	3,544	184	3,585	10,121	1c
Neart na Gaoithe	331	5,492	508	-	6,331	1c
Seagreen Alpha	5,876	0	1,103	0	6,979	1c
Seagreen Bravo	3,698	0	1,272	0	4,970	1c
Sofia	1,153	592	1,426	2,953	6,125	1c
East Anglia ONE North	403	85	54	207	749	1d
East Anglia TWO	281	44	136	230	692	1d
Norfolk Boreas	630	263	1,065	345	2,303	1d
Norfolk Vanguard	879	866	839	924	3,508	1d
Hornsea Four	276	3,590	474	371	4,711	1d
Dudgeon Extension Project	824	3,649	576	272	5,321	2

Project	Migration-free breeding	Post-breeding migration	Non-migratory wintering	Return migration	Annual total	Tier
Sheringham Shoal Extension Project	240	646	590	148	1,624	2
All Projects Totals	**33,464**	**42,985**	**25,735**	**33,322**	**135,505**	

Potential magnitude of impact

5.12.2.32 The potential magnitude of impact is estimated by calculating the increase in baseline mortality when compared against the largest UK North Sea and English Channel BDMPS and then separately against the biogeographic population. The largest razorbill BDMPS for the UK North Sea and English Channel is 591,232 (adults and immatures), whilst the wider bio-geographic population is 1,707,000 individuals (adults and immatures). Using the average mortality rate of 0.193, based on age specific demographic rates and age class proportions from **Table 5.13**, The background mortality for these population scales are 114,108 and 329,451 individuals per annum, respectively.

5.12.2.33 The cumulative total of razorbills at risk of displacement from all OWF projects is calculated to be 135,505 (**Table 5.52**). At the request of Natural England, a full cumulative displacement matrix is provided in **Table 5.54** for razorbill, which presents a range of displacement and mortality rates for the total predicted number of individuals within the UK North Sea and English OWFs plus a 2 km buffer (OFF-ORN-4.8). When applying the evidence led 50% displacement rate and a 1% mortality rate to cumulative total, 678 individuals may be lost to the UK North Sea and English Channel BDMPS population and wider biogeographic population.

5.12.2.34 The potential cumulative loss of 678 razorbills would represent an increase of 0.59% relative to the baseline mortality rate at the BDMPS scale. At the biogeographic scale this additional mortality would increase baseline mortality by 0.21%.

5.12.2.35 Despite the cumulative mortality of 678 razorbills not exceeding an increase in 1% baseline mortality at either the BDMPS or biogeographic population scale, a precautionary approach has been taken via further assessment through PVA modelling as detailed in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis** with the results summarised in **Table 5.53**. PVA has been undertaken for a wide range of displacement and mortality rate scenarios in order to better understand the level of risk involved with increasing levels of displacement resulting in mortality.

Table 5.53: Razorbill cumulative disturbance and displacement PVA results for the North Sea and English Channel BDMPS and Biogeographic population scales.

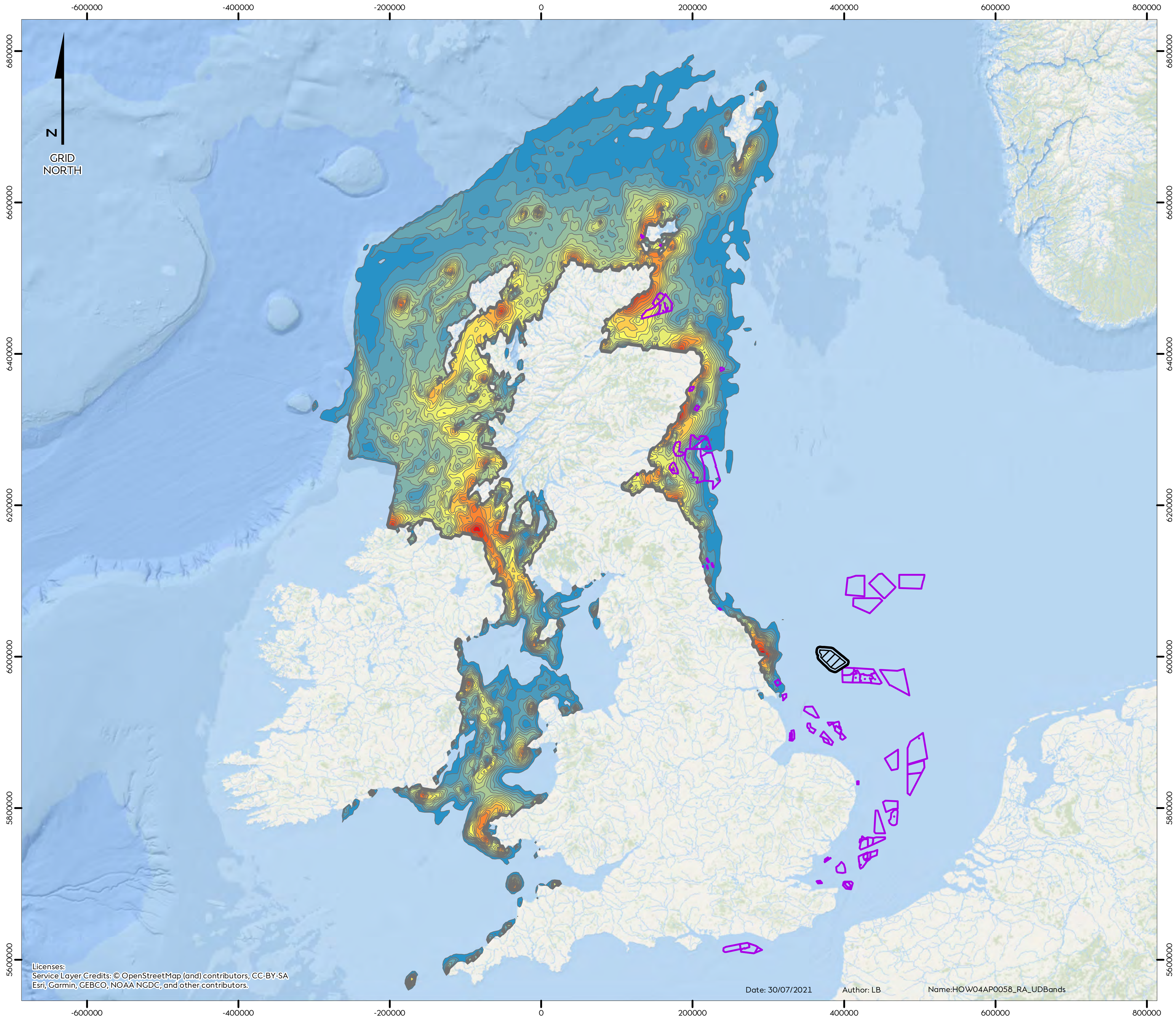
Scenario	Increase in mortality (per annum)	North Sea and English Channel BDMPS		Biogeographic	
		Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)	Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)
30% disp, 1% Mort	407	0.999	0.08%	1.000	0.03%
50% disp, 1% Mort	**678**	**0.999**	**0.14%**	**1.000**	**0.05%**
70% disp, 1% Mort	949	0.998	0.19%	0.999	0.07%
30% disp, 2% Mort	813	0.998	0.16%	0.999	0.06%
50% disp, 2% Mort	1,355	0.997	0.27%	0.999	0.09%
70% disp, 2% Mort	1,897	0.996	0.38%	0.999	0.13%
30% disp, 5% Mort	2,033	0.996	0.41%	0.999	0.14%
50% disp, 5% Mort	3,388	0.993	0.68%	0.998	0.23%
70% disp, 5% Mort	4,743	0.991	0.95%	0.997	0.33%
30% disp, 10% Mort	4,065	0.992	0.81%	0.997	0.28%
50% disp, 10% Mort	6,775	0.986	1.35%	0.995	0.47%
70% disp, 10% Mort	9,485	0.981	1.90%	0.993	0.66%

Table Note: Value highlighted in bold represents the Applicant's position on suitable displacement and mortality scenario for cumulative assessment based on the evidence in **paragraph 5.11.2.22** *et seq*.

5.12.2.36 As detailed in **paragraph 5.11.2.22** *et seq.* when considering which of the PVA scenarios is most likely, the evidence suggests that the lower displacement and mortality range is more plausible, especially considering the likely overinflation in razorbill numbers assessed (**paragraph 5.12.2.15**). Furthermore, during 2010 to 2015, the RSPB and partners undertook a series of large-scale tracking studies of razorbills across the UK during the breeding season in order to map their UK wide, at-sea distributions. Due to the constraint on foraging range and added stress of breeding it can be considered that impacts during the breeding season are likely to cause the greatest impact on razorbills. These data were subject to analysis by Wakefield et al. (2017) in order to map razorbill distribution and their core foraging ranges, the result of this analysis is presented in **Figure 5.8**. Core foraging range was defined as the area of sea up to the 50% UD band

(Cleasby et al. 2018). The vast majority of Southern North Sea OWFs (including Hornsea Four array area and 4 km buffer) were not located within any of the UD bands and only a handful of the smaller scale Scottish OWFs were located in areas of sea considered to be razorbill core foraging range, suggesting that the vast majority of the North Sea and English Channel OWFs do not lie within important areas of sea for razorbill and therefore displacement from these areas would not lead to significant reduction in survival.

5.12.2.37 Further analysis of these tracking data was undertaken by Cleasby et al. (2018) using hotspot mapping techniques in order to identify important areas of high seabird density at sea. Maximum curvature and Getis-Ord analyses were used to generate UK-level hotspots as presented in **Figure 5.9**. The results of these analyse again suggest that the vast majority of North Sea and English Channel OWFs lie far outside of areas of sea classified as statistically significant, further evidencing that any disturbance effects from these OWFs is unlikely to provide significant reductions in razorbill fitness. Therefore, the PVA scenarios which include high mortality rates can be dismissed as unrealistic when considering cumulative assessment of razorbills.



Hornsea Four

Figure 5.8

Razorbill UK Utilisation Distribution in 5% Bands

- DCO Array Area
- DCO Array Area Plus 4 km Buffer
- North Sea Offshore Wind Farms

Razorbill UK UD Bands

- 5%
- 10%
- 15%
- 20%
- 25%
- 30%
- 35%
- 40%
- 45%
- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:4,800,000

0 75 150 Kilometres

0 30 60 Nautical Miles

REV	REMARK	DATE
	First Issue	30/07/2021

Razorbill UK Utilisation Distributions in 5% Bands
Document no: HOW04AP0058
Checked by: MB
Approved by: SS

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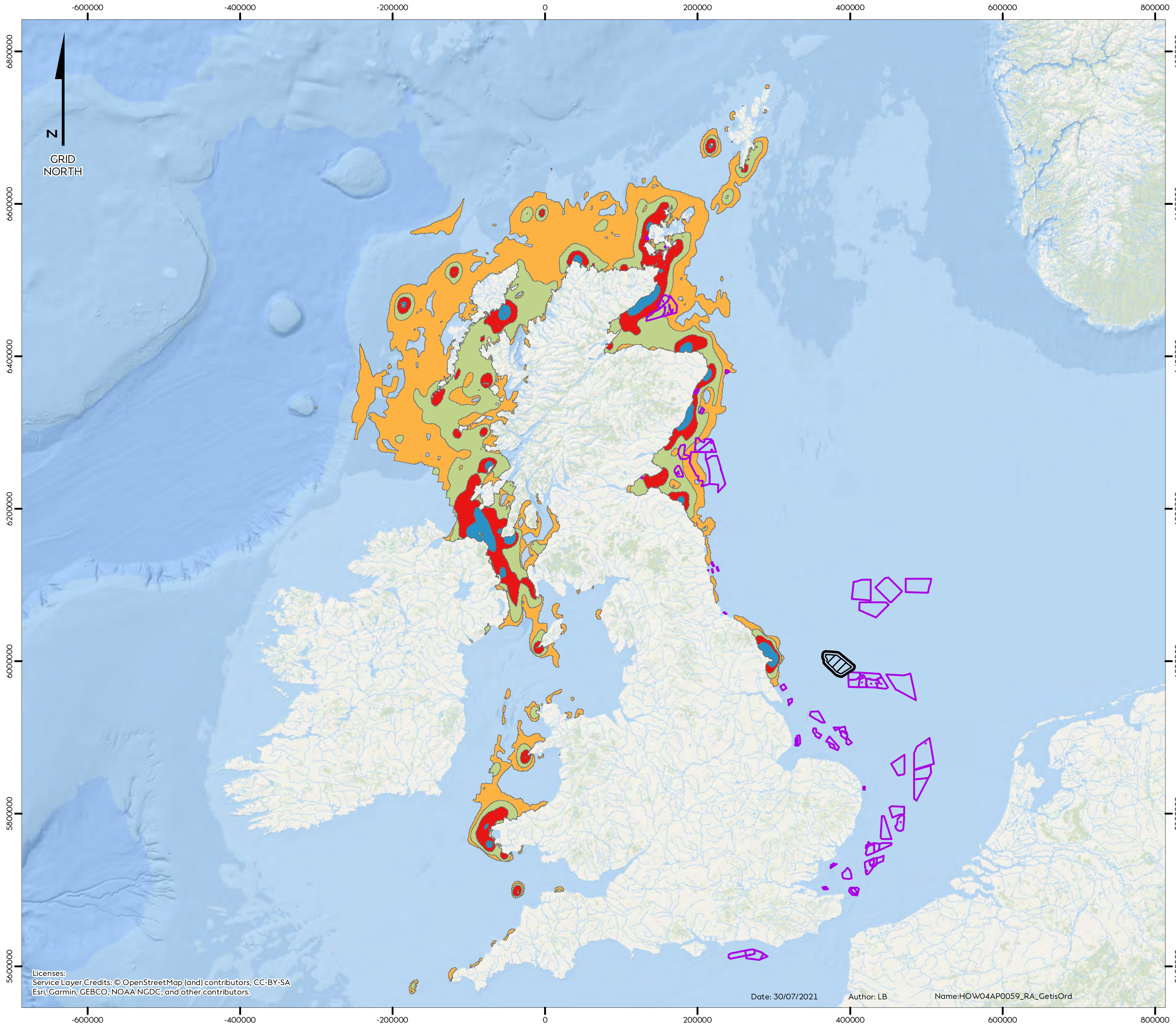

Hornsea Four

Figure 5.9

Razorbill Maximum Curviture and Getis-Ord Hotspots

- DCO Array Area
- DCO Array Area Plus 4 km Buffer
- North Sea Offshore Wind Farms
- Maximum Curvature
- Statistically Significant Getis-Ord hotspot - d = 7km
- Top 1% Getis-Ord hotspot - d = 7km
- Top 5% Getis-Ord hotspot - d = 7km

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:4,800,000
0 75 150 Kilometres
0 30 60 Nautical Miles

REV	REMARK	DATE
	First Issue	30/07/2021

Razorbill Maxmium Curviture and Getis-Ord Hotspots
Document no: HOW04AP0059
Checked by: MB
Approved by: SS

5.12.2.38 At the UK North Sea and English Channel BDMPS population scale 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. When considering this level of potential impact through the PVA modelling, it is also considered to be of **minor** magnitude on an annual cumulative basis, as it represents well under a 0.5% reduction in growth rate of the UK North Sea and English Channel BDMPS population.

5.12.2.39 At the biogeographic scale this level of potential impact is considered to be of **negligible** magnitude on an annual cumulative basis, as it represents well under a 1% increase to the baseline mortality conditions. When considering this level of potential impact through the PVA modelling it is also considered to be of **negligible** magnitude on an annual cumulative basis at the biogeographic population scale, as it represents well under a 0.1% reduction in growth rate of the biogeographic population. Therefore, irrespective of the sensitivity of the receptor, the significance of the impact is not significant at the biogeographic scale as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment.

Sensitivity of the receptor

5.12.2.40 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 5.26**). Whilst it may be of medium vulnerability, it is of high conservation value leading to an overall sensitivity of this receptor to offshore wind farms of **high**.

Significance of the effect

5.12.2.41 The magnitude of cumulative displacement 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**. However, as the BDMPS population is considered to be stable and increasing (Furness 2015; Horswill & Robinson 2015) the resulting reduction in growth rate is not considered to be of any significant consequence to the overall BDMPS population. Therefore, the potential effect from cumulative displacement to razorbill from Hornsea Four and all other UK offshore wind farms in the North Sea and English Channel may be of **slight** adverse significance in total per annum, which is not significant in EIA terms.

Table 5.54: Razorbill cumulative displacement matrix for all North Sea OWF projects, values in green represent the range-based values advocated by Natural England and the darker shade of green representing the Applicant's approach value.

Displacement Rate (%)	Mortality Rate (%)													
	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
1	14	27	41	54	68	136	271	407	542	678	813	949	1,084	1,220	1,355
10	136	271	407	542	678	1,355	2,710	4,065	5,420	6,775	8,130	9,485	10,840	12,195	13,550
20	271	542	813	1,084	1,355	2,710	5,420	8,130	10,840	13,550	16,261	18,971	21,681	24,391	27,101
30	407	813	1,220	1,626	2,033	4,065	8,130	12,195	16,261	20,326	24,391	28,456	32,521	36,586	40,651
40	542	1,084	1,626	2,168	2,710	5,420	10,840	16,261	21,681	27,101	32,521	37,941	43,361	48,782	54,202
50	678	1,355	2,033	2,710	3,388	6,775	13,550	20,326	27,101	33,876	40,651	47,427	54,202	60,977	67,752
60	813	1,626	2,439	3,252	4,065	8,130	16,261	24,391	32,521	40,651	48,782	56,912	65,042	73,172	81,303
70	949	1,897	2,846	3,794	4,743	9,485	18,971	28,456	37,941	47,427	56,912	66,397	75,883	85,368	94,853
80	1,084	2,168	3,252	4,336	5,420	10,840	21,681	32,521	43,361	54,202	65,042	75,883	86,723	97,563	108,404
90	1,220	2,439	3,659	4,878	6,098	12,195	24,391	36,586	48,782	60,977	73,172	85,368	97,563	109,759	121,954
100	1,355	2,710	4,065	5,420	6,775	13,550	27,101	40,651	54,202	67,752	81,303	94,853	108,404	121,954	135,505

Puffin

5.12.2.42 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; Bradbury et al. 2014).

5.12.2.43 As each individual OWF assessment considers the peak mean for each bio-season when these values are added together at a cumulative level, a highly unlikely total number of birds is estimated within these array areas and 2 km buffers. The total abundance in Table 5.55 represents almost 20% of the entire North Sea and English Channel BDMPS population, whilst the area covered by the combined array areas and 2 km buffers of all OWFs within this cumulative displacement assessment would be well under 5% of the area. Therefore, by adding together seasonal mean peaks in this manner the overall assessment for cumulative displacement is considered to be highly precautionary.

5.12.2.44 It is also highly likely that puffin and other auk species are displaced and / or habituate at different levels from areas within and outside active array areas. 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 standardised 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, an evidence-led displacement rate of 50%, as described in Section 5.11.2.1, has been applied across both the array areas and 2 km buffer for all projects.

5.12.2.45 Due to limitations in the data for other OWFs, seasonal population estimates have been collated for two separate bio-seasons covering 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 5.46 are presented in Table 5.55.

Table 5.55: Cumulative bio-season and annual displacement estimates for puffin from all Tier 1 & 2 project array areas and 2 km buffers.

Project	Breeding	Non-breeding	Annual total	Tier
Beatrice	2,858	2,435	5,293	1a
Blyth Demonstration Site	235	123	358	1a
Dudgeon	1	3	4	1a
East Anglia One	16	32	48	1a
EOWDC	42	82	124	1a
Galloper	0	1	1	1a
Greater Gabbard	0	1	1	1a
Gunfleet Sands	-	-	-	1a
Hornsea Project One	1,070	1,257	2,327	1a

Project	Breeding	Non-breeding	Annual total	Tier
Humber Gateway	15	10	25	1a
Hywind 2 Demonstration	119	85	204	1a
Kentish Flats	-	-	-	1a
Kentish Flats Extension	3	6	9	1a
Kincardine	19	0	19	1a
Lincs, Lynn and Inner Dowsing	3	6	9	1a
London Array	0	1	1	1a
Methil	8	0	8	1a
Race Bank	1	10	11	1a
Rampion	7	0	7	1a
Scroby Sands	-	-	-	1a
Sheringham Shoal	4	26	30	1a
Teesside	35	18	53	1a
Thanet	0	0	0	1a
Westermost Rough	61	35	96	1a
Hornsea Project Two	468	2,039	2,507	1b
Moray East	2,795	656	3,451	1b
Triton Knoll	23	71	94	1b
Dogger Bank A	37	295	332	1c
Dogger Bank B	102	743	845	1c
Dogger Bank C	34	273	307	1c
East Anglia Three	181	307	488	1c
Hornsea Three	253	67	320	1c
Inch Cape	2,956	2,688	5,644	1c
Moray West	1,115	3,966	5,081	1c
Neart na Gaoithe	2,562	2,103	4,665	1c
Seagreen Alpha	2,572	1,526	4,098	1c
Seagreen Bravo	3,582	3,863	7,445	1c
Sofia	35	329	364	1c
East Anglia One North	-	-	-	1d
East Anglia Two	15	0	15	1d
Norfolk Boreas	0	23	23	1d
Norfolk Vanguard	67	112	179	1d
Hornsea Four	78	373	451	1d
Dudgeon Extension Project	0	17	17	2
Sheringham Shoal Extension Project	0	11	11	2
All Projects Totals	**21,447**	**23,570**	**45,017**	

Potential magnitude of impact

5.12.2.46 The potential magnitude of impact is estimated by calculating the increase in baseline mortality when compared against the largest UK North Sea and English Channel BDMPS and biogeographic population. The largest puffin BDMPS for the UK North Sea and English Channel is 231,957 (adults and immatures), whilst the wider bio-geographic population is 11,840,000 individuals (adults and immatures). Using the average mortality rate of 0.175, based on age specific demographic rates and age class proportions from **Table 5.13**, The background mortality for these population scales are 40,592 and 2,072,000 individuals per annum, respectively.

5.12.2.47 The cumulative total of puffins at risk of displacement from all OWF projects is calculated to be 45,017 (**Table 5.55**). At the request of Natural England, a full cumulative displacement matrix is provided in **Table 5.57** for puffin, which presents a range of displacement and mortality rates for the total predicted number of individuals within the UK North Sea and English OWFs plus a 2 km buffer (OFF-ORN-4.8). When applying the evidence led 50% displacement rate and a 1% mortality rate to cumulative total, 225 individuals may be lost to the UK North Sea and English Channel BDMPS population and the wider biogeographic population.

5.12.2.48 The potential cumulative loss of 225 puffins would represent an increase of 0.55% relative to the baseline mortality rate at the BDMPS scale. At the biogeographic scale this additional mortality would increase baseline mortality by 0.01%.

5.12.2.49 Despite the cumulative mortality of 225 puffins not exceeding an increase in 1% baseline mortality at either the BDMPS or biogeographic population scale, a precautionary approach has been taken via further assessment through PVA modelling as detailed in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis** with the results summarised in **Table 5.56**. PVA has been undertaken for a wide range of displacement and mortality rate scenarios in order to better understand the level of risk involved with increasing levels of displacement resulting in mortality.

Table 5.56: Puffin cumulative disturbance and displacement PVA results for the North Sea and English Channel BDMPS and Biogeographic population scales.

Scenario	Increase in mortality (per annum)	North Sea and English Channel BDMPS		Biogeographic	
		Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)	Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)
30% disp, 1% Mort	135	0.999	0.07%	1.000	0.00%
50% disp, 1% Mort	**225**	**0.999**	**0.11%**	**1.000**	**0.00%**
70% disp, 1% Mort	315	0.998	0.16%	1.000	0.00%

Scenario	Increase in mortality (per annum)	North Sea and English Channel BDMPS		Biogeographic	
		Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)	Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)
30% disp, 2% Mort	270	0.999	0.14%	1.000	0.00%
50% disp, 2% Mort	450	0.998	0.23%	1.000	0.00%
70% disp, 2% Mort	630	0.997	0.32%	1.000	0.01%
30% disp, 5% Mort	675	0.997	0.34%	1.000	0.01%
50% disp, 5% Mort	1,125	0.994	0.57%	1.000	0.01%
70% disp, 5% Mort	1,576	0.992	0.80%	1.000	0.02%
30% disp, 10% Mort	1,351	0.993	0.69%	1.000	0.01%
50% disp, 10% Mort	2,251	0.989	1.15%	1.000	0.02%
70% disp, 10% Mort	3,151	0.984	1.61%	1.000	0.03%

Table Note: Value highlighted in bold represents the Applicant's position on suitable displacement and mortality scenario for cumulative assessment based on the evidence in paragraph 5.11.2.22 *et seq*.

5.12.2.50 As detailed in paragraph 5.11.2.22 *et seq.* when considering which of the PVA scenarios is most likely, the evidence suggests that the lower displacement and mortality range is more plausible, especially considering the likely overinflation in puffin numbers assessed (paragraph 5.12.2.43). Whilst puffin was not analysed by Wakefield et al. (2017), it is likely that the greatest impacts of displacement on mortality are likely to occur during the breeding season, given constraints on foraging range and the added stress of breeding. Puffins are known to forage over wider areas than either guillemot or razorbill, with a mean-maximum foraging range of 137.1 km (Woodward et al. 2019). Whilst this wider foraging range may indicate a greater degree of overlap with Southern North Sea OWFs, it also demonstrates that puffins are able to access a wider area of foraging habitat during the breeding season than other auk species. Therefore, displacement from Southern North Sea OWFs would not lead to a significant reduction in survival. As such, the PVA scenarios which include high mortality rates can be considered as unrealistic when considering cumulative assessment of puffins.

5.12.2.51 At the UK North Sea and English Channel BDMPS population scale 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. When considering this level of potential impact through the PVA modelling it is also considered to be of **minor** magnitude on an annual cumulative basis at the UK North Sea and English

Channel BDMPS population scale, as it represents well under a 0.5% reduction in growth rate of the UK North Sea and English Channel BDMPS population.

5.12.2.52 At the biogeographic scale this level of potential impact is considered to be of **negligible** magnitude on an annual cumulative basis, as it represents well under a 1% increase to the baseline mortality conditions. When considering this level of potential impact through the PVA modelling it is also considered to be of **negligible** magnitude on an annual cumulative basis at the biogeographic population scale, as it represents well under a 0.1% reduction in growth rate of the biogeographic population. Therefore, irrespective of the sensitivity of the receptor, the significance of the impact is not significant at the biogeographic scale as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment.

Sensitivity of the receptor

5.12.2.53 As the birds within the UK North Sea and English Channel BDMPS and biogeographic populations 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 5.26**). Whilst it may be of low vulnerability, it is of high conservation value leading to an overall sensitivity of this receptor to displacement of **medium**.

Significance of the effect

5.12.2.54 The magnitude of cumulative displacement 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**. However, as the UK North Sea and English Channel BDMPS population is considered to be stable and increasing (Furness 2015; Horswill & Robinson 2015) the resulting reduction in growth rate is not considered to be of any significant consequence to the overall BDMPS population. 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 **slight** adverse significance in total per annum, which is not significant in EIA terms.

Table 5.57: Puffin cumulative displacement matrix for all North Sea OWF projects, values in green represent the range-based values advocated by Natural England and the darker shade of green representing the Applicant's approach value.

Displacement Rate (%)	Mortality Rate (%)														
	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
1	5	9	14	18	23	45	90	135	180	225	270	315	360	405	450
10	45	90	135	180	225	450	900	1,351	1,801	2,251	2,701	3,151	3,601	4,052	4,502
20	90	180	270	360	450	900	1,801	2,701	3,601	4,502	5,402	6,302	7,203	8,103	9,003
30	135	270	405	540	675	1,351	2,701	4,052	5,402	6,753	8,103	9,454	10,804	12,155	13,505
40	180	360	540	720	900	1,801	3,601	5,402	7,203	9,003	10,804	12,605	14,405	16,206	18,007
50	225	450	675	900	1,125	2,251	4,502	6,753	9,003	11,254	13,505	15,756	18,007	20,258	22,508
60	270	540	810	1,080	1,351	2,701	5,402	8,103	10,804	13,505	16,206	18,907	21,608	24,309	27,010
70	315	630	945	1,260	1,576	3,151	6,302	9,454	12,605	15,756	18,907	22,058	25,209	28,361	31,512
80	360	720	1,080	1,441	1,801	3,601	7,203	10,804	14,405	18,007	21,608	25,209	28,811	32,412	36,013
90	405	810	1,215	1,621	2,026	4,052	8,103	12,155	16,206	20,258	24,309	28,361	32,412	36,464	40,515
100	450	900	1,351	1,801	2,251	4,502	9,003	13,505	18,007	22,508	27,010	31,512	36,013	40,515	45,017

Operational Phase CEA – Potential impact from cumulative collision risk

5.12.2.55 There is potential for cumulative collision risk to birds as a result of operational activities associated with Hornsea Four and other projects (**Table 5.46**). 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 5.47**. 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.

5.12.2.56 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. At the request of Natural England, we have also included a high level assessment of the cumulative risk to herring gull and lesser black-backed gull, although the contribution from Hornsea Four is considered to be so low as to be of no consequence to any cumulative totals. 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 **Volume A5, Annex 5.3: Offshore Ornithology Collision Risk Modelling**.

Over precaution in collision risk assessments

5.12.2.57 The following cumulative collision risk assessments presented for all species are most certainly an overestimate due to a number of reasons:

- Collision risk estimates for other OWFs may not be based on as-built designs, but be calculated on the basis of consented designs, which over-inflate risk. This is an important factor to recognise, as multiple consented OWFs have either developed a smaller number of large WTGs to reach their agreed energy outputs or simply not developed out to the maximum number of WTGs included in their consents and be operating at subsequently lower energy outputs. The result is that despite such changes the reduced risk of collision mortality to seabirds is not realised or incorporated into cumulative assessments. Such changes may afford reduction in collision risk mortality rates for individual projects that are likely to be significant when considered cumulatively;
- 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 EP process (OFF-ORN-2.36), whilst other projects applied avoidance rates of between 95% to 99%. When considering an increase of 1% in avoidance rates (for instance from 98% to 99%) 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 eight 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 collision risk for gannets is considerably less during nocturnal periods across the year;
- The Crown Estate's Headroom report (TCE 2015) and updated in 2019 (TCE 2019) 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, 554 and 262 to the cumulative total for gannet, kittiwake and great black-backed gull mortality within the North Sea and English Channel respectively; 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 likely include technological advances which would mean the same generating capacity can be produced by fewer, larger WTGs that have a greater air gap, which is predicted to lead to a new reduction in collisions.

Gannet

5.12.2.58 The subsequent bio-season and annual collision risk estimates for gannet associated with each of the projects identified in **Table 5.46** are presented in **Table 5.58**. The figures within this table are mostly composed of data from the final cumulative tables submitted at Deadline XI for EA1N / EA2 (SPR 2021) which at the time of drafting this assessment represent the most up to date cumulative collision figures available. The following amendments were made to the values published at Deadline XI for EA1N / EA2 (SPR 2021) for assessments included within this report:

- Updated collision risk values for Hornsea Four attributed to the FFC SPA as described within this report (**Table 5.38**);
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time Hornsea Four is predicted to be operational; and
- Inclusion of Hornsea Three Applicant's final values as presented in (Orsted 2021).

Table 5.58: Cumulative bio-season and annual collision mortality estimates for gannet from all Tier 1 projects.

Project	Migration-free breeding	Post-breeding migration	Return migration	Annual total	Tier
Beatrice	37.4	48.8	9.5	95.7	1a
Blyth Demonstration Site	3.5	2.1	2.8	8.4	1a
Dudgeon	22.3	38.9	19.1	80.3	1a
East Anglia One	3.4	131.0	6.3	140.7	1a
EOWDC	4.2	5.1	0.1	9.3	1a
Galloper	18.1	30.9	12.6	61.6	1a
Greater Gabbard	14.0	8.8	4.8	27.5	1a
Gunfleet Sands	-	-	-	-	1a
Hornsea Project One	11.5	32.0	22.5	66.0	1a
Humber Gateway	1.9	1.1	1.5	4.5	1a
Hywind 2 Demonstration	5.6	0.8	0.8	7.2	1a
Kentish Flats	1.4	0.8	1.1	3.3	1a
Kentish Flats Extension	-	-	-	0.0	1a
Kincardine	3.0	0.0	0.0	3.0	1a
Lincs, Lynn & Inner Dowsing	2.3	1.4	1.9	5.6	1a
London Array	2.3	1.4	1.8	5.5	1a
Methil	6.0	0.0	0.0	6.0	1a
Race Bank	33.7	11.7	4.1	49.5	1a
Rampion	36.2	63.5	2.1	101.8	1a
Scroby Sands	-	-	-	-	1a
Sheringham Shoal	14.1	3.5	0.0	17.6	1a
Teesside	4.9	1.7	0.0	6.7	1a
Thanet	1.1	0.0	0.0	1.1	1a
Westermost Rough	0.2	0.1	0.2	0.5	1a
Hornsea Project Two	7.0	14.0	6.0	27.0	1b
Moray East	80.6	35.4	8.9	124.9	1b
Triton Knoll	26.8	64.1	30.1	121.0	1b
Dogger Bank A & B	81.1	83.5	54.4	219.0	1c
Dogger Bank C & Sofia	14.8	10.1	10.8	35.7	1c
East Anglia Three	5.2	28.4	8.2	41.8	1c
Hornsea Three	3.0	2.0	2.0	6.0	1c
Inch Cape	336.9	29.2	5.2	371.3	1c
Moray West	10.0	2.0	1.0	12.0	1c
Neart na Gaoithe	143.0	47.0	23.0	213.0	1c
Seagreen Alpha & Bravo	800.8	49.3	65.8	915.9	1c
East Anglia ONE North	12.4	11.0	1.1	24.5	1d

Project	Migration-free breeding	Post-breeding migration	Return migration	Annual total	Tier
East Anglia TWO	12.5	23.1	4.0	39.6	1d
Norfolk Boreas	14.1	12.7	3.9	30.7	1d
Norfolk Vanguard	8.2	18.6	5.3	32.1	1d
Hornsea Four	13.4	4.9	1.8	20.2	1d
Dudgeon Extension Project	3.6	4.9	0.4	9.0	2
Sheringham Shoal Extension Project	0.3	1.4	0.0	1.8	2
All Projects Totals	**1,800.4**	**825.4**	**323.3**	**2,948.2**	

5.12.2.59 The estimated annual cumulative mortality rates for gannet is 2,948 individuals (**Table 5.58**), although as stated in **paragraph 5.11.2.96** *et seq.* this is almost certainly an overestimation.

Potential magnitude of impact

5.12.2.60 The potential magnitude of impact is estimated by calculating the increase in baseline mortality when compared against the largest UK North Sea and English Channel BDMPS and then separately against the biogeographic population. The largest gannet 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). When considering the average mortality rate of 0.187, based on age specific demographic rates and age class proportions from **Table 5.13**, the background mortality for these two population scales are 85,328 and 220,660 individuals per annum, respectively.

5.12.2.61 The potential cumulative loss of 2,948 gannets would represent an increase of 3.46% relative to the baseline mortality rate at the UK North Sea and English Channel BDMPS scale. At the biogeographic scale this additional mortality would increase baseline mortality by 0.98%.

5.12.2.62 Despite the apparent over precaution in the cumulative total of gannets at risk of mortality, as the increase in the baseline mortality rate for the UK North Sea and English Channel BDMPS exceeds 1% further assessment has been undertaken through PVA analysis as described in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis** and sumarrised in **Table 5.66**. The results of the PVA suggest that when considering an increase of 2,948 additional mortalities, a maximum reduction in the population growth rate of 0.76% may occur at the UK North Sea and English Channel BDMPS scale and 0.30% at the biogeographic scale would occur per annum. Over the last 50 years the UK gannet population has been consistently increasing at a rate of ~2 to 3% per annum as summarised in **Table 5.59**, with the trend in UK abundance for gannet suggesting that the UK population is still predicted to increase in size (JNCC 2021). Although it is not possible to predict exactly how the population of UK gannets will change over the 35 year time span of Hornsea Four, based on the current trend when considering the results of the PVA predicting a reduction in the population growth rate of 0.76% the population would still maintain a positive annual growth rate of over 1% per annum. Furthermore, Natural England recently provided feedback to EA1N / EA2 in relation to reduction in population growth of gannets stating that if the

UK gannet population maintains it's current annual growth over the next 30 years, they believe that a reduction of 0.8% would not result in a significant impact.

Table 5.59: UK gannet compound annual growth rates between 1970 and 2015 from figures presented in JNCC (2021).

	Operation Seafarer (1969 – 1970)	Seabird Colony Register (1984 – 1985)	UK Census (2003 – 2004)	UK Census (2013 – 2015)
UK Population estimate (AON / AOS)	113,006	157,247	218,546	293,161
Compound annual growth rate (%)	2.1	2.1	2.7	N/A

5.12.2.63 For the purpose of this ES assessment, consideration has been given to evidence provided through the recent EA1N / EA2, Hornsea Three, Norfolk Vanguard andThanet Extension PINS examinations. All three of these projects submitted multiple documents providing accounts of the most recent assessment of potential impacts on gannets from cumulative collision risk. Each made reference to the Wildfowl and Wetland Trust (WWT 2012) study on gannets that concluded that (using the density independent model) even when using the lower 95% CI 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).

5.12.2.64 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 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, whilst other projects need considering in future, including Awel y Mor off the north Wales coast and proposed Round 4 and ScotWind projects. The estimated annual total cumulative collision risk for the west coast of Britain OWFs, excluding Awel y Mor, is 32.4 individuals (when using an avoidance rate of 98.9%). This provides evidence that even when considering all British OWFs 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.

5.12.2.65 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.

5.12.2.66 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

5.12.2.67 As the majority of the gannets within the UK North Sea and English Channel 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 5.36**). Whilst it may be of medium vulnerability it is of high conservation value leading to an overall sensitivity of this receptor to collision risk of **high**.

Significance of the effect

5.12.2.68 The magnitude of cumulative collision risk 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**. However, as the UK North Sea and English Channel BDMPS population is considered to be increasing (Furness 2015; Horswill & Robinson 2015) the resulting reduction in growth rate is not considered to be of any significant consequence to the overall BDMPS population. Therefore, the potential effect from cumulative collision risk to gannet from Hornsea Four and all other UK offshore wind farms in the North Sea and English Channel may be of **slight** adverse significance in total per annum, which is not significant in EIA terms.

Kittiwake

5.12.2.69 The predicted level of annual mortality associated with collision risk for Hornsea Four alone is 93 individuals. A cumulative assessment was undertaken at the request of Natural England and the RSPB to quantify the contribution to the overall cumulative impacts from collision to be identified.

5.12.2.70 The subsequent bio-season and annual collision risk estimates for kittiwake associated with each of the projects identified in **Table 5.46** are presented in **Table 5.60**. The figures within this table are mostly composed of data from the final cumulative tables submitted at Deadline XI for EA1N / EA2 (SPR 2021) which at the time of drafting this assessment represent the most up to date cumulative collision figures available. The following amendments were made to the values published at Deadline XI for EA1N / EA2 (SPR 2021) for assessments included within this report:

- Updated collision risk values for Hornsea Four attributed to the FFC SPA as described within this report (**Table 5.39**);
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time Hornsea Four is predicted to be operational; and
- Inclusion of Hornsea Three Applicant's final values as presented in (Orsted 2021).

Table 5.60: Cumulative bio-season and annual collision mortality estimates for kittiwake from all Tier 1 projects.

Project	Migration-free breeding	Post-breeding migration	Return migration	Annual total	Tier
Beatrice	94.7	10.7	39.8	145.2	1a
Blyth Demonstration Site	1.7	2.3	1.4	5.4	1a
Dudgeon	-	-	-	-	1a
East Anglia One	1.8	160.4	46.8	209.0	1a
EOWDC	11.8	5.8	1.1	18.7	1a
Galloper	6.3	27.8	31.8	65.9	1a
Greater Gabbard	1.1	15.0	11.4	27.5	1a
Gunfleet Sands	-	-	-	-	1a
Hornsea Project One	44.0	55.9	20.9	120.8	1a
Humber Gateway	1.9	3.2	1.9	7.0	1a
Hywind 2 Demonstration	16.6	0.9	0.9	18.3	1a
Kentish Flats	0.0	0.9	0.7	1.6	1a
Kentish Flats Extension	0.0	0.0	2.7	2.7	1a
Kincardine	22.0	9.0	1.0	32.0	1a
Lincs, Lynn & Inner Dowsing	0.7	0.7	1.2	2.6	1a
London Array	1.4	2.3	1.8	5.5	1a
Methil	0.4	0.0	0.0	0.4	1a
Race Bank	1.9	23.9	5.6	31.4	1a
Rampion	0.0	0.0	0.0	0.0	1a
Scroby Sands	-	-	-	-	1a
Sheringham Shoal	-	-	-	-	1a
Teesside	38.4	24.0	2.5	64.9	1a
Thanet	0.2	0.5	0.4	1.1	1a
Westermost Rough	0.1	0.2	0.1	0.5	1a
Hornsea Project Two	16.0	9.0	3.0	28.0	1b
Moray East	43.6	2.0	19.3	64.9	1b
Triton Knoll	24.6	139.0	45.4	209.0	1b
Dogger Bank A & B	288.6	135.0	295.4	719.0	1c
Dogger Bank C & Sofia	136.9	90.7	216.9	444.5	1c
East Anglia Three	5.0	56.5	30.8	92.3	1c
Hornsea Three	9.0	6.0	3.0	18.0	1c
Inch Cape	13.1	224.8	63.5	301.4	1c
Moray West	79.0	24.0	7.0	109.0	1c
Neart na Gaoithe	32.9	56.1	4.4	93.4	1c
Seagreen Alpha & Bravo	153.1	313.1	247.6	713.8	1c
East Anglia ONE North	40.4	8.1	3.5	52.0	1d

Project	Migration-free breeding	Post-breeding migration	Return migration	Annual total	Tier
East Anglia TWO	29.5	5.4	7.4	42.3	1d
Norfolk Boreas	13.3	32.2	11.9	57.5	1d
Norfolk Vanguard	21.8	16.4	19.3	57.5	1d
Hornsea Four	29.8	38.4	25.1	93.3	1d
Dudgeon Extension Project	17.2	8.6	2.2	28.0	2
Sheringham Shoal Extension Project	0.9	1.9	0.0	2.8	2
All Projects Totals	**1,254.1**	**1,548.1**	**1,207.4**	**4,008.7**	

5.12.2.71 The estimated annual cumulative mortality rates for kittiwake is 4,009 individuals (**Table 5.60**), although as stated in **paragraph 5.11.2.96** *et seq.*, this is almost certainly an overestimation.

Potential magnitude of impact

5.12.2.72 The potential magnitude of impact is estimated by calculating the increase in baseline mortality when compared against the largest UK North Sea BDMPS and then separately against the biogeographic population. The largest kittiwake BDMPS for the UK North Sea is 829,937 individuals (adults and immatures), whilst the wider bio-geographic population is 5,100,000 individuals (adults and immatures). Considering the average mortality rate of 0.156, based on age specific demographic rates and age class proportions from **Table 5.13**, the background mortality for these population scales are 129,470 and 795,600 individuals per annum, respectively.

5.12.2.73 The potential cumulative loss of 4,009 kittiwakes would represent an increase of 3.10% relative to the baseline mortality rate at the UK North Sea BDMPS and an increase of 0.50% relative to the baseline mortality rate at the wider bio-geographic population scale.

5.12.2.74 Despite the apparent over precaution in the cumulative total of kittiwakes at risk of mortality, as the increase in the baseline mortality rate for the UK North Sea BDMPS exceeds 1% further assessment has been undertaken through PVA analysis as described in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis**. The results of the PVA suggest that when considering an increase of 4,009 additional mortalities, a maximum reduction in the population growth of 0.60% at the BDMPS scale and 0.10% at the biogeographic scale would occur per annum (**Table 5.61**).

Table 5.61: Kittiwake cumulative collision risk PVA results for the UK North Sea BDMPS and Biogeographic population scales.

Population scale	Increase in mortality (per annum)	Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)
UK North Sea BDMPS	4,009	0.994	0.60%
Biogeographic	4,009	0.999	0.10%

5.12.2.75 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 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, whilst to the biogeographic population it would be considered to be of **negligible** adverse magnitude. Therefore, irrespective of the sensitivity of the receptor, the significance of the impact is not significant at the biogeographic scale as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment.

Sensitivity of the receptor

5.12.2.76 As kittiwakes within the wider UK North Sea 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 5.36**). Whilst it may be of medium vulnerability it is of medium conservation value leading to an overall sensitivity of this receptor to collision risk of **medium**.

Significance of the effect

5.12.2.77 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**. However, as the UK North Sea BDMPS population is considered to be stable and within growth (Furness 2015; Horswill & Robinson 2015) the resulting reduction in growth rate is not considered to be of any significant consequence to the overall BDMPS population. Therefore, the potential effect from collision risk to kittiwake from Hornsea Four and all other projects may be of **slight** adverse significance during each bio-season, which is not significant in EIA terms.

Great black-backed gull

5.12.2.78 The subsequent bio-season and annual collision risk estimates for great black-backed gull associated with each of the projects identified in **Table 5.46** are presented in **Table 5.62**. The figures within this table are mostly composed of data from the final agreed cumulative tables submitted at Deadline VIII for Norfolk Boreas (Vattenfall 2020). However, as projects evolve a number of differences to collision risk estimates were identified, including revisions to Hornsea Three, the removal of Thanet Extension due to consent refusal, updated East Anglia One North and East Anglia Two collision risk values from Deadline I submissions (SPR 2020), changes to the values for East Anglia Three from a NMC application (SPR 2020) and the removal of Beatrice Demonstrator as the project will be decommissioned by the time Hornsea Four is predicted to be operational.

Table 5.62: Cumulative bio-season and annual collision mortality estimates for great black-backed gull from all Tier 1 projects.

Project	Breeding	Non-breeding	Annual total	Tier
Beatrice	30.2	120.8	151.0	1a
Blyth Demonstration Site	1.3	5.1	6.3	1a
Dudgeon	0.0	0.0	0.0	1a
East Anglia One	0.0	46.0	46.0	1a
EOWDC	0.6	2.4	3.0	1a
Galloper	4.5	18.0	22.5	1a
Greater Gabbard	15.0	60.0	75.0	1a
Gunfleet Sands	-	-	-	1a
Hornsea Project One	17.2	68.6	85.8	1a
Humber Gateway	1.3	5.1	6.3	1a
Hywind 2 Demonstration	0.3	4.5	4.8	1a
Kentish Flats	0.10	0.2	0.3	1a
Kincardine	0.0	0.0	0.0	1a
Lincs, Lynn & Inner Dowsing	0.0	0.0	0.0	1a
London Array	-	-	-	1a
Methil	0.8	0.8	1.6	1a
Race Bank	0.0	0.0	0.0	1a
Rampion	5.2	20.8	26.0	1a
Scroby Sands	-	-	-	1a
Sheringham Shoal	0.00	0.0	0.0	1a
Teesside	8.7	34.8	43.6	1a
Thanet	0.1	0.4	0.5	1a
Westermost Rough	0.00	0.0	0.1	1a
Hornsea Project Two	3.0	20.0	23.0	1b
Moray East	9.5	25.5	35.0	1b
Triton Knoll	24.4	97.6	122.0	1b
Dogger Bank A & B	5.80	23.3	29.1	1c
Dogger Bank C & Sofia	6.4	25.5	31.9	1c
East Anglia Three	4.1	30.3	34.4	1c
Hornsea Three	4.0	12.0	16.0	1c
Inch Cape	0.0	36.8	36.8	1c
Moray West	4.0	5.0	9.0	1c
Neart na Gaoithe	0.9	3.6	4.5	1c
Seagreen Alpha & Bravo	13.4	53.4	66.8	1c
East Anglia ONE North	3.7	1.2	4.9	1d
East Anglia TWO	3.5	3.4	6.9	1d

Project	Breeding	Non-breeding	Annual total	Tier
Norfolk Boreas	6.9	28.7	35.6	1d
Norfolk Vanguard	4.50	21.5	26.0	1d
Hornsea Four	0.3	4.0	4.3	1d
Dudgeon Extension Project	0.3	1.6	1.9	2
Sheringham Shoal Extension Project	0.0	5.3	5.3	2
All Projects Totals	**174.8**	**765.3**	**940.1**	

5.12.2.79 The estimated annual cumulative mortality rates for great black-backed gull of 940 individuals (**Table 5.62**), although as stated in **paragraph 5.11.2.96** *et seq.*, this is almost certainly an overestimation.

Potential magnitude of impact

5.12.2.80 The potential magnitude of impact is estimated by calculating the increase in baseline mortality when compared against the largest UK North Sea BDMPS and biogeographic population. The BDMPS for the North Sea is 91,399 individuals (adults and immatures), whilst the wider bio-geographic population is 235,000 individuals (adults and immatures). When considering the average mortality rate of 0.160, based on age specific demographic rates and age class proportions from **Table 5.13**, the background mortality for these population scales are 14,624 and 37,600 individuals per annum, respectively.

5.12.2.81 The potential cumulative loss of 940 great black-backed gulls would represent an increase of 6.43% relative to the baseline mortality rate at the UK North Sea BDMPS and 2.50% at the biogeographic 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.

5.12.2.82 Despite the apparent over precaution in the cumulative total of great black-backed gulls at risk of mortality, as the increase in the baseline mortality rate for the UK North Sea BDMPS exceeds 1% further assessment has been undertaken through PVA analysis as described in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis.** The results of the PVA suggest that when considering an increase of 940 additional mortalities, a maximum reduction in the population growth of 1.24% at the BDMPS scale and 0.48% at the biogeographic scale would occur per annum (**Table 5.63**).

Table 5.63: Great black-backed gull cumulative collision risk PVA results for the UK North Sea BDMPS and Biogeographic population scales.

Population scale	Increase in mortality (per annum)	Density in-dependant counterfactual of population growth rate (after 35 years)	Reduction in Growth rate (per annum)
UK North Sea BDMPS	940	0.988	1.24%
Biogeographic	940	0.995	0.48%

5.12.2.83 For the purpose of this ES consideration is given to evidence provided through the recent East Anglia One North, East Anglia Two, Hornsea 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 accounts of the most recent assessment of potential impacts on great black-backed gulls from cumulative collision risk. For the three consented projects (East Anglia Three, Rampion and Hornsea Three) and the East Anglia One North and Two projects that recently closed their PINS examination, conclusions on cumulative assessments included the following:

- Population modelling was undertaken for East Anglia One North and East Anglia Two using density independent counterfactuals of population growth rate (SPR 2021). The cumulative collision total would reduce the population growth rate by 1.18-1.30% when assessed against the BDMPS population and 0.46-0.50% when assessed against the biogeographic population. The maximum 1.30% reduction in growth is not considered likely to be significant to either the BDMPS or biogeographic population when set against baseline breeding population change. Furthermore, collisions are heavily skewed to winter periods when large numbers of birds from Norway and Russia are present (Furness 2015). Therefore, the UK population trend is less relevant than the IUCN classification of least concern, as it reflects UK breeding birds rather than the international, healthy population of this species. As UK breeding birds make up less than one third of the North Sea wintering population (Furness 2015), East Anglia One North and Two argue that the level of predicted cumulative collisions, considering the over-precaution when calculating the estimates, is not sufficient to result in a significant cumulative impact.
- 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 (ExA) (Planning Inspectorate 2014) concluded *'that the addition of Rampion OWF does not tip the balance in terms of exceeding a threshold that would otherwise not 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 940 individuals estimated for Hornsea Four and other projects sits well below both Rampion values. The SoS for Energy and Climate Change (DECC) 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

lost 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. It was noted in the Examining Authority's Report to the SoS of Findings and Conclusions for East Anglia Three (Examination Authority, 2017) that Natural England confirmed in its revised SoCG [REP7-023] that the updated cumulative totals including East Anglia THREE are not materially different from the most recently consented totals for Hornsea Project 2, therefore Natural England has no further concerns.; and

- On the basis of the conclusions agreed during the consenting process for Rampion, East Anglia Three and Hornsea Three, and the arguments made for East Anglia One North and East Anglia Two, then Hornsea Four's contribution of 4.0 individuals per annum to the over precautionary cumulative collision mortality total of 940 would also be deemed to be so small that it would not materially affect the overall cumulative impact magnitude, as it is well below both Rampion (26 individuals), East Anglia Three (36 individuals) and Hornsea Three (16 individuals) offshore wind farms.

5.12.2.84 Therefore, accounting for the evidence supporting wider population scales being stable, the results of the PVA modelling indicating that such cumulative impacts could be absorbed by the wider population, 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

5.12.2.85 As this species is not connected with a significant number of designated sites within the UK North Sea 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 5.36**). Whilst it may be of high vulnerability it is of low conservation value leading to an overall sensitivity of this receptor to collision risk of **medium**.

Significance of the effect

5.12.2.86 The magnitude of cumulative collision risk from operational OWFs 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**. However, as the UK North Sea BDMPS population is considered to be stable and increasing (Furness 2015; Horswill & Robinson 2015) the predicted level of impact is not considered to be of any significant consequence to the overall BDMPS population. 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 would be of **slight** adverse significance in total per annum, which is not significant in EIA terms.

Herring gull

5.12.2.87 The subsequent bio-season and annual total cumulative collision risk estimates for herring gull presented in **Table 5.64** are mostly composed of data from the latest cumulative tables submitted at Deadline XI for EA1N / EA2 (SPR 2021). The differences to collision risk estimates are due to updated values for Hornsea Four, the use of Hornsea Three Applicant's value and the removal of Beatrice Demonstrator as the project will be decommissioned by the time Hornsea Four is predicted to be operational.

Table 5.64: Summary of cumulative bio-season and annual collision mortality estimates for herring gull with / without Hornsea Four.

Herring gull cumulative collision risk	Breeding	Non-breeding	Annual
Seasonal Total (excluding Hornsea Four)	367.8	385.0	752.8
Hornsea Four (BO3)	0.5	0.3	0.8
Seasonal Total (including Hornsea Four)	368.3	385.3	753.5

5.12.2.88 The estimated collision risk to herring gull from Hornsea Four is an annual total of less than a single bird (Table 5.37), which would increase the cumulative annual total by 0.09%.

5.12.2.89 In this instance, it is clear that the collision risk from 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. Therefore, the significance of this effect can therefore be considered **not significant** on the grounds that its contribution is *de minimis*.

Lesser black-backed gull

5.12.2.90 The subsequent bio-season and annual total cumulative collision risk estimates for lesser black-backed gull presented in Table 5.65 are mostly composed of data from the final agreed cumulative tables submitted at Deadline XI for EA1N / EA2 (SPR 2021). The differences to collision risk estimates are due to updated values for Hornsea Four, the use of Hornsea Three Applicant's value and the removal of Beatrice Demonstrator as the project will be decommissioned by the time Hornsea Four is predicted to be operational.

Table 5.65: Summary of cumulative bio-season and annual collision mortality estimates for lesser black-backed gull with / without Hornsea Four.

Lesser black-backed gull cumulative collision risk	Breeding	Non-breeding	Annual
Seasonal Total (excluding Hornsea Four)	162.6	366.8	529.3
Hornsea Four (BO3)	0.3	0.1	0.4
Seasonal Total (including Hornsea Four)	162.9	366.9	529.7

5.12.2.91 The estimated collision risk to lesser black-backed gull from Hornsea Four is an annual total of less than a single bird (Table 5.37), which would increase the cumulative annual total by 0.08%.

5.12.2.92 In this instance, it is clear that the collision risk from 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. Therefore, the significance of this effect can therefore be considered **not significant** on the grounds that its contribution is *de minimis*.

Combined cumulative Operational Disturbance and Collision Risk – Gannet

5.12.2.93 Due to gannet being scoped in for both displacement and collision risk assessments during the O&M phase, there's potential for these two impacts to cumulatively adversely affect gannet populations. Previous sections have concluded negligible to minor predicted magnitude of impact from either collision risk or displacement acting independantly; however, the combined impact of both collision risk and displacement may be greater than either one acting alone. Further consideration of both impacts acting together is therefore required.

5.12.2.94 As detailed in **Table 5.48** and **Table 5.58** the combined cumulative predicted gannet mortality from the O&M phase (displacement and collision risk) equates to between 3,242 and 3,339 predicted additional mortalities per annum. Using the largest UK North Sea and English Channel BDMPS of 456,298 individuals (Furness 2015) and using the average baseline mortality rate of 0.187 (**Table 5.13**), the natural predicted mortality across all seasons is 85,328 per annum. The addition of between 3,242 to 3,339 predicted mortalities would increase the baseline mortality rate by 3.80% to 3.91%. When considering these combined impacts at the wider biogeographic population scale, then of the 1,180,000 population the natural annual mortality rate would be 220,660 individuals per annum. The addition of between 3,242 to 3,339 predicted mortalities would increase the biogeographic baseline mortality rate by 1.47% to 1.51%. It should be noted that the impacts associated with both displacement and collison risk combined assessed in this simplistic additive manner are almost certainly an overestimate, as a bird which has been displaced from the array area can no longer collide with a turbine and vice versa.

5.12.2.95 Despite the apparent overprecation in the assessment as the increase in baseline mortality rate is over 1% further consideration in the form of PVA has been undertaken. Further details of the PVA methodology, input parameters and details on how to interpret the PVA results below can be found in **Volume A5, Annex 5.4: Offshore Ornithology Population Viability Analysis**. The results of the PVA suggest that when considering an increase of between 3,242 to 3,339 additional mortalities, a maximum reduction in the population growth rate of 0.80% to 0.83% may occur at the UK North Sea and English Channel BDMPS scale and 0.31% to 0.32% at the biogeographic scale would occur per annum. Over the last 50 years the UK gannet population has been consistently increasing at a rate of ~2 to 3% per annum as summarised in **Table 5.59**, with the trend in UK abundance for gannet suggesting that the UK population is still predicted to increase in size (JNCC 2021). Although it is not possible to predict exactly how the population of UK gannets will change over the 35 year time span of Hornsea Four, based on the current trend when considering the results of the PVA predicting a reduction in the population growth rate of a maximum 0.83% the population would still maintain a positive annual growth rate of over 1% per annum. Furthermore, Natural

England recently provided feedback to EA1N / EA2 in relation to reduction in population growth of gannets stating that if the UK gannet population maintains on it's current annual growth over the next 30 years, they believe that a reduction of 0.8% would not result in a significant impact.

Table 5.66: Gannet cumulative assessments PVA results for the UK North Sea and English Channel BDMPS and Biogeographic population scales.

Scenario Description	Increase in Mortality (per annum)	BDMPS results		Biogeographic Results	
		Density independent counterfactual of growth rate (after 35 years)	Reduction in growth rate (%)	Density independent counterfactual of growth rate (after 35 years)	Reduction in growth rate (%)
Cumulative displacement 60%, 1% Mort only	293	0.999	0.07%	1.000	0.03%
Cumulative displacement 80%, 1% Mort only	391	0.999	0.10%	1.000	0.04%
Cumulative collision risk only	2,948	0.993	0.73%	0.997	0.28%
Combined cumulative collision and displacement (60%, 1% Mort)	3,242	0.992	0.80%	0.997	0.31%
Combined cumulative collision and displacement (80%, 1% Mort)	3,339	0.992	0.83%	0.997	0.32%

5.12.2.96 For the purpose of this ES assessment, consideration has been given to evidence provided through the recent EA1N / EA2, Hornsea Three, Norfolk Vanguard andThanet Extension PINS examinations. All three of these projects submitted multiple documents providing accounts of the most recent assessment of potential impacts on gannets from cumulative collision risk. Each made reference to the Wildfowl and Wetland Trust (WWT 2012) study on gannets that concluded that (using the density independent model) even when using the lower 95% CI 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).

5.12.2.97 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 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 OWFs 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.

5.12.2.98 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.

5.12.2.99 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

5.12.2.100 As the majority of the gannets within the UK North Sea and English Channel 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 5.36**). Whilst it may be of medium vulnerability it is of high conservation value leading to an overall sensitivity of this receptor to collision risk of **high**.

Significance of the effect

5.12.2.101 The magnitude of cumulative displacement and collision risk 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. However, as the UK North Sea and English Channel BDMPS population is considered to be increasing (Furness 2015; Horswill & Robinson 2015) the resulting reduction in growth rate is not considered to be of any significant consequence to the overall BDMPS population. Therefore, the potential effect from cumulative collision risk to gannet from Hornsea Four and all other UK offshore wind farms in the North Sea and English Channel may be of **slight** adverse significance in total per annum, which is not significant in EIA terms.

Operational Phase CEA – Potential impact to birds on migration from cumulative collision risk

5.12.2.102 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 and other species) 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.

Hornsea Project One

5.12.2.103 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 5.67**.

Hornsea Project Two

5.12.2.104 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 5.67**.

Hornsea Three

5.12.2.105 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 (Orsted 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 5.67**.

Norfolk Vanguard

5.12.2.106 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 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 5.67**.

Table 5.67: Summary of collision risk assessment on migrant seabirds and waterbirds and hen harrier from Hornsea Four and other North Sea 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	Hornsea Four collisions per annum	Total collisions per annum (all projects)	Impact magnitude[2]	Significance of effect
Arctic skua	0	10	0	0	0	10	No Change / Negligible	Negligible or Minor Adverse
Great skua	1	1	0	0	0	2	No Change / Negligible	Negligible
Little gull	10	1	1	0	0	12	No Change / Negligible	Negligible or Minor Adverse
Common tern	0	9	1	0	0	10	No Change / Negligible	Negligible or Minor adverse
Arctic tern	0	50	0	0	0	50	No Change / Negligible	Negligible or Minor adverse
Bewick's swan	0	0	4	0	0	4	Negligible	Negligible
Taiga bean goose	0	0	0	n/a	0	0	No risk	No risk
Dark-bellied brent goose	1	0	23	1	n/a	25	Negligible	Negligible or Minor adverse
Shelduck	4	0	2	n/a	1	7	Negligible	Negligible
Wigeon	20	0	11	13	7	51	Negligible	Negligible or Minor adverse
Gadwall	n/a	n/a	n/a	1	0	1	Negligible	Negligible
Teal	n/a	n/a	n/a	6	6	12	Negligible	Negligible
Pintail	n/a	n/a	n/a	1	n/a	1	Negligible	Negligible
Shoveler	n/a	n/a	n/a	1	n/a	1	Negligible	Negligible
Pochard	n/a	n/a	n/a	2	n/a	2	Negligible	Negligible
Tufted duck	n/a	n/a	n/a	3	n/a	3	Negligible	Negligible
Common scoter	n/a	n/a	n/a	0	n/a	0	Negligible	Negligible
Goldeneye	n/a	n/a	n/a	1	0	1	Negligible	Negligible
Marsh harrier	n/a	n/a	n/a	0	n/a	0	Negligible	Negligible

[2] 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.

Species	Hornsea Project One collisions per annum	Hornsea Project Two collisions per annum	Hornsea Three collisions per annum	Norfolk Vanguard collisions per annum	Hornsea Four collisions per annum	Total collisions per annum (all projects)	Impact magnitude[2]	Significance of effect
Hen harrier	n/a	n/a	n/a	n/a	0	0	No risk	No risk
Oystercatcher	n/a	n/a	n/a	15	8	23	Negligible	Negligible
Avocet	n/a	n/a	n/a	1	n/a	1	Negligible	Negligible
Ringed plover	n/a	n/a	n/a	1	1	2	Negligible	Negligible
Golden plover	16	0	23	21	7	67	Negligible	Negligible or Minor adverse
Grey plover	2	0	2	2	1	7	Negligible	Negligible
Lapwing	48	0	25	22	15	110	Negligible	Negligible or Minor adverse
Knot	12	0	1	12	5	30	Negligible	Negligible or Minor adverse
Sanderling	n/a	n/a	n/a	1	1	2	Negligible	Negligible
Dunlin	10	0	23	27	6	66	Negligible	Negligible or Minor adverse
Bar-tailed godwit	2	0	2	2	2	8	Negligible	Negligible
Curlew	n/a	n/a	n/a	10	4	14	Negligible	Negligible
Redshank	n/a	n/a	n/a	22	4	26	Negligible	Negligible
Turnstone	n/a	n/a	n/a	2	1	3	Negligible	Negligible

Potential magnitude of impact

5.12.2.107 The estimates of collision mortality from Hornsea Four and other projects cumulatively including; Hornsea Project One, Hornsea Project Two, Hornsea Three and Norfolk Vanguard were reviewed and collated.

5.12.2.108 For the majority of species considered in this cumulative assessment the annual collision mortality rate is 10 individuals or less, which would have an impact of **negligible** magnitude at most on the relevant UK populations. For a number of other species considered in this cumulative assessment the annual collision mortality rates are between 11 and 110 individuals, which would have an impact of **negligible** magnitude at most when considering the increase relative to baseline mortality on the relevant UK populations.

5.12.2.109 The magnitude of this impact is considered to be **negligible** at most for all species. Therefore, irrespective of the sensitivity of the receptor, the significance of the impact is not significant as defined in the assessment of significance matrix (**Table 5.22**) and is therefore not considered further in this assessment.

5.13 Transboundary effects

5.13.1.1 Transboundary effects are defined as those effects upon the receiving environment of a European Economic Area (EEA) state, whether occurring from Hornsea Four alone, or cumulatively with other projects in the wider area. A screening of potential transboundary effects was undertaken at Scoping (Annex L of the Scoping Report (Orsted 2018)), which identified that there was the potential for transboundary effects to occur in relation to offshore and intertidal ornithology.

5.13.1.2 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 key bird species present in the Hornsea Four array area, offshore ECC and cable landfall area, based on the results of the desk study and aerial digital survey data presented in **Volume A5, Annex 5.1: Offshore and Intertidal Ornithology Baseline Characterisation Report** include fulmar, gannet, red-throated diver, common scoter, kittiwake, guillemot, razorbill, puffin and large gulls.

5.13.1.3 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).

5.13.1.4 The final Hornsea Four DCO submission (including this ES) includes a summary of consultations conducted with other EU Member States surrounding the North Sea basin. Protected sites in countries beyond the UK were not considered to have connectivity with Hornsea Four significantly enough to be included in this assessment, though the impacts considered throughout this chapter do consider potential effects on the UK North Sea and English Channel and biogeographic scales that includes birds from outside of the UK.

5.13.1.5 To inform this EIA, consideration has been given to the consultation responses 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 the UK and EU Member States, it is not currently clear how this could be undertaken quantitatively.

5.13.1.6 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 OWFs 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 OWFs, such as East Anglia ONE).

5.13.1.7 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 OWF developments within such a wider context would be relatively much smaller with respect to any potential impacts considered at the UK North Sea and English Channel scale. 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 A1 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 **Volume A4, Annex 5.1: Impacts Register**) and the EIA Scoping Report and PEIR, 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 was updated for the PEIR and has been updated into the ES Stage 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 5.68** below. In addition, the table shows where other chapters have been used to inform the offshore and intertidal ornithology inter-relationships assessment.

Table 5.68: 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 A2, Chapter 2: Benthic and Intertidal Ecology** **Volume A2, Chapter 3: Fish and Shellfish Ecology**	**Paragraph 5.11.1.38** *et seq.*
Indirect impacts through effects on habitats and prey during operation		**Paragraph 5.11.2.147** *et seq.*
Indirect impacts through effects on habitats and prey during decommissioning		**Section 5.11.3**

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 5.69** and **Table 5.70** overleaf presents a summary of the significant impacts assessed within this ES chapter, any mitigation and the residual effects.

Table 5.69: Summary of potential impacts assessed for Hornsea Four alone relating to 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).	Gannet Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Guillemot Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Razorbill Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Puffin Not applicable	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	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
Construction activities associated with export cable laying may lead to disturbance and displacement of species within the ECC and different degrees of buffers surrounding it (ORN-C-3).	Red-throated diver Not applicable	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 Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant

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 Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Guillemot Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Razorbill Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Puffin Not applicable	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 (ORN-O-6).	Gannet Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Kittiwake Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Lesser black-backed gull Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Herring gull Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Great black-backed gull Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
Combined impact from operational activities associated with moving turbines and maintenance vessels may lead to disturbance and displacement	Gannet Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
(ORN-O-5) and the risk of collision with WTG rotors and associated infrastructure (ORN-O-6).				
Migrant non-seabirds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure(ORN-O-7).	All species Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
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 Not Significant	None proposed beyond existing Commitments	Not Significant
The presence of WTGs could create a barrier to the migratory or regular foraging movements of seabirds (ORN-O-9).	Gannet Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Kittiwake Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
The impact of attraction to lit structures by migrating birds in particular (ORN-O-14).	All species Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
Decommissioning				
Indirect impacts during the decommissioning phase within the offshore ECC and landfall through effects on habitats and prey species (ORN-D-13).	All species Not applicable	Not applicable Not Significant	None proposed beyond existing Commitments	Not Significant

Table 5.70: Summary of potential impacts assessed for Hornsea Four cumulatively with other projects for offshore and intertidal ornithology.

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 Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Guillemot Not applicable	Minor Slight	None proposed beyond existing Commitments	Not Significant
	Razorbill Not applicable	Minor Slight	None proposed beyond existing Commitments	Not Significant
	Puffin Not applicable	Minor Slight	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 (ORN-O-6).	Gannet Not applicable	Minor Slight	None proposed beyond existing Commitments	Not Significant
	Kittiwake Not applicable	Minor Slight	None proposed beyond existing Commitments	Not Significant
	Lesser black-backed gull Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Herring gull Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant
	Great black-backed gull Not applicable	Minor Slight	None proposed beyond existing Commitments	Not Significant
Combined impact from operational activities associated	Gannet	Minor	None proposed beyond existing Commitments	Not Significant

Impact and Phase	Receptor and value/sensitivity	Magnitude and significance	Mitigation	Residual impact
with moving turbines and maintenance vessels may lead to disturbance and displacement (ORN-O-5) and the risk of collision with WTG rotors and associated infrastructure (ORN-O-6).	Not applicable	Slight		
Migrant non-seabirds flying through the array area during the operational phase are at risk of collision with WTG rotors and associated infrastructure (ORN-O-7).	All species Not applicable	Negligible Not Significant	None proposed beyond existing Commitments	Not Significant

5.16 References

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