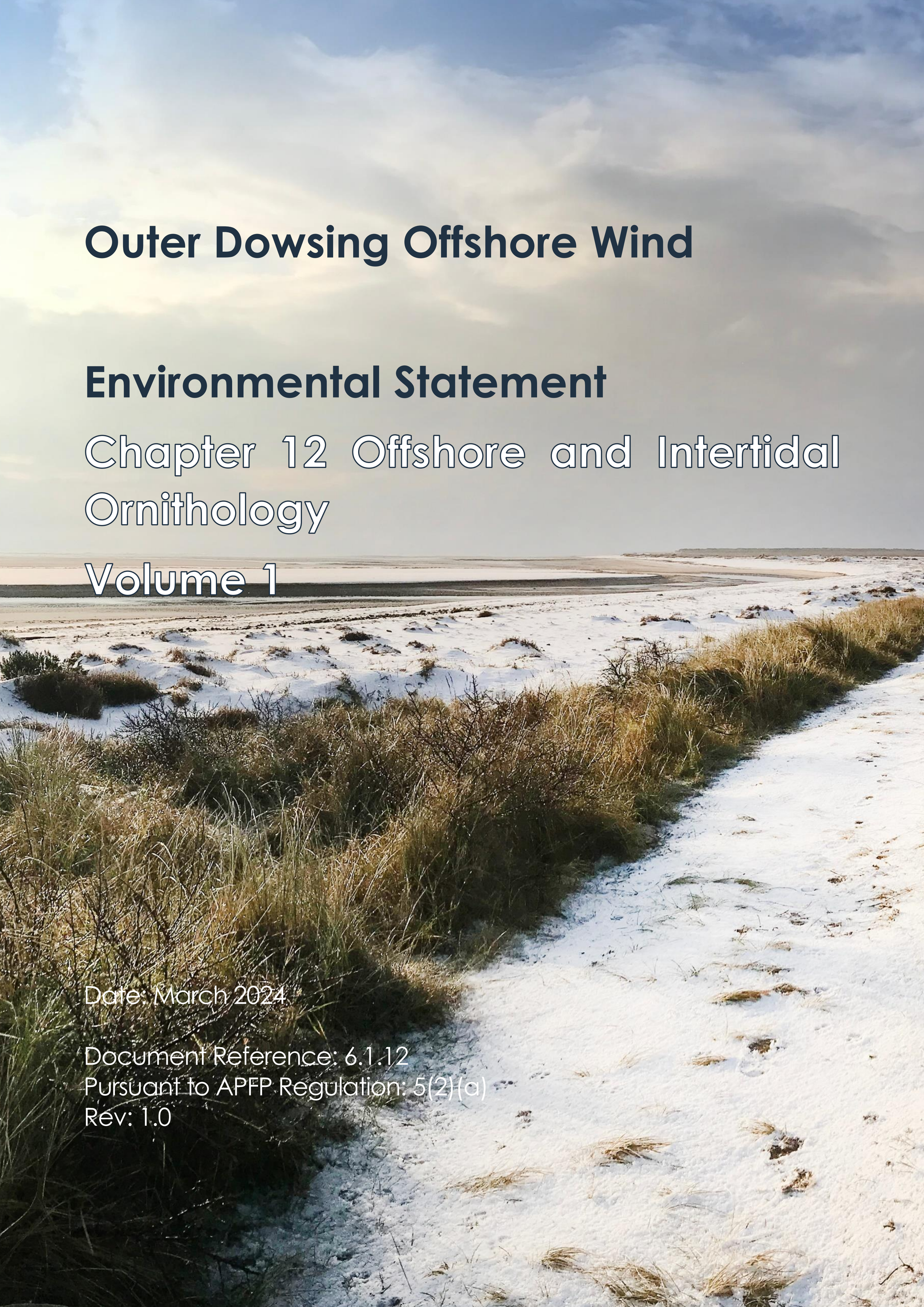

Outer Dowsing Offshore Wind

Environmental Statement

Chapter 12 Offshore and Intertidal Ornithology

Volume 1

Date: March 2024

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Acronyms & Definitions

Abbreviations / Acronyms

Abbreviation / Acronym	Description
AfL	Agreement for lease
ANS	Artificial Nesting Structure
AoS	Area of Search
BDMPS	Biologically Defined Minimum Population Scales
BTO	British Trust for Ornithology
CCUS	Carbon Capture Utilisation and Storage
CFP	Common Fisheries Policy
CGR	Counterfactual of Population Growth
CI	Confidence Interval
CPS	Counterfactual of Population Size
CRM	Collision Risk Modelling
CIEEM	Chartered Institute of Ecology and Environmental Management
DAS	Digital Aerial Survey
DCO	Development Consent Order
DESNZ	Department for Energy Security and Net Zero, formerly Department of Business, Energy and Industrial Strategy (BEIS), which was previously Department of Energy & Climate Change (DECC).
ECC	Export Cable Corridor
EEA	European Economic Area
EIA	Environmental Impact Assessment
EOWDC	European Offshore Wind Development Centre
EPP	Evidence Plan Process
ES	Environmental Statement
ETG	Expert Topic Group
EU	European Union
FFC	Flamborough & Filey Coast
GBBG	Great Black-Backed Gull
GBS	Gravit Based Structure
GES	Good Environmental Status
HDD	Horizontal Directional Drilling
HPAI	Highly Pathogenic Avian Influenza
HRA	Habitats Regulation Assessment
IOF	Important Ornithological Feature
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
JUV	Jack-Up Vessel
LBBG	Lesser Black-Backed Gull
LSE	Likely Significant Effect
MAT	Migration Assessment Tool

Abbreviation / Acronym	Description
MCRM	Migratory Collision Risk Model
MDS	Maximum Design Scenario
MHWS	Marine High-Water Springs
MLWS	Marine Low-Water Springs
MSFD	Marine Strategy Framework Directive
MSL	Mean Sea Level
MSS	Marine Scotland Science
NE	Natural England
NEWS	Non-Estuarine Waterbird Surveys
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
O&M	Operation and Maintenance
ORCP	Offshore Reactive Compensation Platform
ORJIP	Offshore Renewables Joint Industry Programme
OSS	Offshore Substation
OWEZ	Offshore Windpark Egmond aan Zee
OWF	Offshore Windfarm
PCH	Potential Collision Height
PEIR	Preliminary Environmental Information Report
pSPA	Potential Special Protection Area
PVA	Population Viability Analysis
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
RTDs	Red-Throated Diver Species
sCRM	Stochastic Collision Risk Modelling
SD	Standard Deviation
SMP	Seabird Monitoring Programme
SNCB	Statutory Nature Conservation Body
SoS	Secretary of State
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
ST	Sandwich Tern
TCE	The Crown Estate
WEBS	Wetland Bird Survey
WTG	Wind Turbine Generator
WWT	Wildfowl & Wetlands Trust
ZOI	Zone of Influence

Terminology

Term	Definition
AfL array area	The area of the seabed awarded to GT R4 Ltd. Through an Agreement for Lease (AfL) for the development of an offshore windfarm, as part of The Crown Estate's Offshore Wind Leasing Round 4.
Array area	The area offshore within the Order Limits within which the generating stations (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling are positioned.
Barrier effect	Barrier effect is experienced by bird species which intend to forage beyond or migrate past the array but due to avoidance behaviour, have to navigate around the array. Barrier effect is often not discernible from displacement behaviour.
Baseline	The status of the environment at the time of assessment without the development in place.
Cumulative effects	The combined effect of the Project acting cumulatively with the effects of a number of different projects on the same single receptor/resource.
Cumulative impact	Impacts that result from changes caused by other past, present or reasonably foreseeable actions together with the Project.
Project Design Envelope	A description of the range of possible elements that make up the Project's design options under consideration, as set out in detail in the project description. This envelope is used to define the Project for Environmental Impact Assessment (EIA) purposes when the exact engineering parameters are not yet known. This is also often referred to as the "Rochdale Envelope" approach.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP) from the Secretary of State (SoS) for Department for Energy Security and Net Zero (DESNZ).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of an impact with the sensitivity of a receptor, 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 Environmental Impact Assessment (EIA) Regulations, including the publication of an Environmental Statement (ES).
EIA Regulations	The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017
Environmental Statement (ES)	The suite of documents that detail the processes and results of the Environmental Impact Assessment (EIA).

Term	Definition
Habitats Regulations Assessment (HRA)	Habitats Regulations Assessment. 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.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Intertidal	Area where the ocean meets the land between high and low tides.
Landfall	The location at the land-sea interface where the offshore export cable will come ashore.
Maximum Design Scenario	The maximum design parameters of the combined project assets that result in the greatest potential for change in relation to each impact assessed
Mitigation	Mitigation measures, or commitments, are commitments made by the Project to reduce and/or eliminate the potential for significant effects to arise as a result of the Project. Mitigation measures can be embedded (part of the project design) or secondarily added to reduce impacts in the case of potentially significant effects.
National Policy Statement (NPS)	A document setting out national policy against which proposals for Nationally Significant Infrastructure Projects (NSIPs) will be assessed and decided upon
Non-statutory consultee	Organisations that the Applicant may be required to (under Section 42 of the 2008 Act) or may otherwise choose to engage during the pre-application phases (if, for example, there are planning policy reasons to do so) who are not designated in law but are likely to have an interest in a proposed development.
Outer Dowsing Offshore Wind (the Project)	The Project.
Offshore Export Cable Corridor (ECC)	The Offshore Export Cable Corridor (Offshore ECC) is the area within the Order Limits within which the export cable running from the array to landfall will be situated.
Onshore Infrastructure	The combined name for all onshore infrastructure associated with the Project from landfall to grid connection.
Pre-construction and post-construction	The phases of the Project before and after construction takes place.
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses etc.
Rochdale Envelope	Provides flexibility in design options where details of the whole project are not available when the application is submitted, while ensuring the

Term	Definition
	impacts of the final development are fully assessed during the Environmental Impact Assessment (EIA).
Statutory consultee	Organisations that are required to be consulted by the Applicant, the Local Planning Authorities and/or The Inspectorate during the pre-application and/or examination phases, and who also have a statutory responsibility in some form that may be relevant to the Project and the DCO application. This includes those bodies and interests prescribed under Section 42 of the Planning Act 2008.
Study area	Area(s) within which environmental impact may occur – to be defined on a receptor-by-receptor basis by the relevant technical specialist.
The Planning Inspectorate	The agency responsible for operating the planning process for Nationally Significant Infrastructure Projects (NSIPs).
The Project	Outer Dowsing Offshore Wind including proposed onshore and offshore infrastructure.
Transboundary impacts	Transboundary effects arise when impacts from the development within one European Economic Area (EEA) state affects the environment of another EEA state(s).
Vessel cluster	A group of vessels within a confined area performing a joint task
Wind turbine generator (WTG)	All the components of a wind turbine, including the tower, nacelle, and rotor.

12 Intertidal and Offshore Ornithology

12.1 Introduction

0. This chapter of the Environmental Statement (ES) presents the results of the Environmental Impact Assessment (EIA) for the potential impacts of Outer Dowsing Offshore Wind ('the Project') on Intertidal and Offshore Ornithology. Specifically, this chapter considers the potential impact of the Project seaward of Mean High-Water Springs (MHWS) during the construction, operation and maintenance (O&M), and decommissioning phases.
1. GT R4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant', is proposing to develop the Project. The Project array will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (windfarm), export cables to landfall, Offshore Reactive Compensation Platforms (ORCPs), onshore cables, connection to the electricity transmission network, ancillary and associated development and areas for the delivery of up to two Artificial Nesting Structures (ANS) and the creation of a biogenic reef (if these compensation measures are deemed to be required by the Secretary of State) (see Volume 1, Chapter 3: Project Description for full details). All bird names are in English Vernacular and follow the latest IOC order and spelling. Relevant scientific names can be found in Annex 1.
2. This chapter should be read alongside the following chapters presented in Volume 1:
   - Chapter 10 – Fish and Shellfish Ecology (document reference 6.1.10) (in terms of key prey resources available to birds); and
   - Chapter 9 – Benthic Subtidal and Intertidal Ecology (document reference 6.1.9) (in terms of relevant habitat and key prey resources available to birds); and
   - Chapter 22 – Onshore Ornithology (document reference 6.1.22).
3. Additionally, the following appendices have been compiled (presented in Volume 3) to support the information provided within this chapter:
   - Appendix 12.1: Intertidal and Offshore Ornithology Technical Baseline (document reference 6.3.12.1);
   - Appendix 12.2: Collision Risk Modelling Assessment Appendix (document reference 6.3.12.2);
   - Appendix 12.3 : Displacement Assessment Appendix (document reference 6.3.12.3); and
   - Appendix 12.5: Migratory Collision Risk Modelling Appendix (document reference 6.3.12.5).

12.2 Statutory and Policy Context

4. The assessment of impacts on ornithological receptors has considered current legislation, policy and guidance relevant to offshore ornithology. Full details are presented in Volume 1, Chapter 2: Need, Policy and Legislative Context.

5. Relevant National Policy Statements (NPS) are considered of particular importance for the assessment, being principal decision-making documents for Nationally Significant Infrastructure Projects (NSIPs). Documents of relevance to ornithological receptors for the Project are considered to be:
   - Overarching NPS for Energy (EN-1) (Department for Energy Security and Net Zero (DESNZ), 2023a);
   - National Policy Statement for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023b);
   - National Policy Statement for Electricity Networks Infrastructure (EN-5) (DESNZ, 2023c).
6. Specific assessment requirements within these documents which are relevant to this ES chapter are presented in Table 12.1.
7. International and national laws regarding the protection of wildlife and the marine environment also need to be considered, such as the Ramsar Convention on Wetlands of International Importance 1971.
8. The Conservation of Habitats and Species Regulations 2017 (as amended) (known as the 'Habitats Regulations') transfer functions from the European Commission to the appropriate authorities in England and Wales, with all the processes or terms unchanged. The 2017 Habitats Regulations transpose aspects of the Birds Directive and the Habitats Directive into national law, covering all environments out to 12nm.
9. The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) (known as the 'Offshore Marine Regulations') provide similar provisions to the 2017 Habitats Regulations in the offshore environment beyond 12nm throughout the UK.
10. The Conservation of Habitats and Species Regulations 2017 (as amended) transposed aspects of the Birds Directive and the Habitats Directive into national law, covering all environments out to 12nm.
11. The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended) provides similar provisions in the offshore environment beyond 12nm, throughout the UK. These Regulations are together referred to in this chapter as the Habitats Regulations. Following the UK's exit from the European Union (EU), the Habitats Regulations have been amended, mainly to transfer functions from the European Commission to the appropriate authorities in England and Wales, but with most processes and terms otherwise largely unchanged.
12. The Wildlife and Countryside Act 1981 operates in conjunction with the Habitats Regulations and is the principal mechanism for the legislative protection of wildlife in the UK. The Wildlife and Countryside Act 1981 has also been amended following withdrawal from the European Union so that species of wild birds found in or regularly visiting either the UK or the European territory of a Member State will continue to be protected on land and down to MLWS.

Table 12.1: NPS requirements for assessment

Legislation/Policy	Key Provisions	Section where comment addressed
Overarching NPS for Energy (EN-1) (DESNZ, 2023a)	NPS EN-1 Paragraph 5.4.48 states that "the SoS (Secretary of State) 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."	The potential for effects on designated sites is considered in detail in the Report to Inform Appropriate Assessment (RIAA), though consideration to relevant designated sites is given in Section 12.4.
	NPS EN-1 Paragraph 5.4.17 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."	Sections 12.4 – 12.5.
	NPS EN-1 Paragraph 5.4.19 states that the Applicant is required to show how the proposed project has taken advantage of opportunities to conserve and enhance biodiversity conservation interests.	Section 12.5.
	NPS EN-1 Paragraph 5.4.35 states that "Applicants should include appropriate avoidance, mitigation, compensation and enhancement measures as an integral part of the proposed development. In particular, the applicant should demonstrate that: • during construction, they will seek to ensure that activities will be confined to the minimum areas required for the works • the timing of construction has been planned to avoid or limit disturbance during construction and operation best practice will be followed to ensure that risk of disturbance or damage to species or habitats is minimised, including as a consequence of transport access arrangements	Section 12.4, with a more detailed assessment undertaken in the Report to Inform Appropriate Assessment (Document no. 7).

Legislation/Policy	Key Provisions	Section where comment addressed
	• habitats will, where practicable, be restored after construction works have finished • opportunities will be taken to enhance existing habitats rather than replace them, and where practicable, create new habitats of value within the site landscaping proposals. Where habitat creation is required as mitigation, compensation, or enhancement, the location and quality will be of key importance. In this regard habitat creation should be focused on areas where the most ecological and ecosystems benefits can be realised. • mitigations required as a result of legal protection of habitats or species will be complied with."	
	NPS EN1 Paragraph 5.4.2 states that "The aim is to halt overall biodiversity loss in England by 2030 and then reverse loss by 2042, support healthy well-functioning ecosystems and establish coherent ecological networks, with more and better places for nature for the benefit of wildlife and people. This aim needs to be viewed in the context of the challenge presented by climate change. Healthy, naturally functioning ecosystems and coherent ecological networks will be more resilient and adaptable to climate change effects. Failure to address this challenge will result in significant adverse impact on biodiversity and the ecosystem services it provides."	The Project will make a significant contribution to the generation of renewable energy.
National Policy Statement for Renewable Energy Infrastructure (EN-3) (DESNZ, 2023b)	NPS EN-3 Paragraph 2.8.136 explains that "offshore wind fams 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;	The potential impacts are discussed throughout the ES, predominantly in Sections 12.7 – 12.8.

Legislation/Policy	Key Provisions	Section where comment addressed
	▪ displacement during the operational phase, resulting in loss of foraging/roosting area; and impacts on bird flight lines (i.e. barrier effect) and associated increased energy use by birds for commuting flights between roosting and foraging areas."	
	EN-3 Paragraph 2.8.144 states that "Applicants must undertake collision risk modelling, as well as displacement and population viability assessments for certain species of birds. Advice can be sought from Statutory Nature Conservation Body (SNCBs)."	Collision and displacement assessments are undertaken for relevant species in sections 12.7 – 12.8. Population Viability Analysis (PVA) is undertaken in section 1.10.2.
	EN-3 Paragraphs 2.8.239 and 2.8.240 "Applicants should undertake a review of up-to-date research and all potential mitigation options presented as part of the application, having consulted the relevant Joint Nature Conservation Committee (JNCC) mitigation guidelines" "Aviation and navigation lighting should be minimised and/or on demand (as encouraged in EN-1 Section 5.5) to avoid attracting birds, taking into account impacts on safety. Subject to other constraints, wind turbines should be laid out within a site, in a way that minimises collision risk."	Embedded mitigation in relation to Intertidal and Offshore Ornithology is set out in Section 12.5.
	EN-3 Paragraph 3.8.258 "Turbine parameters should also be developed to reduce collision risk where the assessment shows there is significant risk of collision (e.g. altering rotor height)."	As outlined in section 12.5, the minimum air gap has been raised from 22m to 40m mean sea level (MSL) to reduce the impacts of collision on birds.

13. Guidance provided within the Marine Strategy Framework Directive (MSFD), which was implemented in the UK by the Marine Strategy Regulations SI 2010/1627, has also been considered. The overarching goal of the MSFD was to achieve 'Good Environmental Status' (GES) by 2020 across Europe's marine environment. After exiting the EU, the UK remains committed to achieving GES through the UK Marine Strategy Part One. Descriptors considered relevant to the assessment of offshore and intertidal ornithology for the Project are presented in Table 12.2.

14. Alongside these documents, several other guidance documents are considered relevant, including, but not limited to the following:

- EIA guidance for offshore ornithology receptors provided by the Chartered Institute of Ecology and Environmental Management (CIEEM) (2022);
- SNCB guidance documents for the assessment of offshore windfarm (OWF) impacts on offshore ornithology receptors (Parker *et al.,* 2022; Natural England, 2022a; MIG-Birds, 2022); and
- Headroom in Cumulative Offshore Windfarm Impacts for Seabirds: Legal Issues and Possible Solutions (The Crown Estate and Womble Bond Dickinson, 2021).

Table 12.2: Summary of the UK Marine Strategy high level descriptors of Good Environmental Status considered relevant to the assessment of Offshore and Intertidal Ornithology for the Project

MSFD High level descriptor	Section where comment addressed
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.	Effects on biological diversity with respect to offshore and intertidal birds have been described and considered within the assessment for the Project alone and cumulatively (Sections 12.7 – 12.8).
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.	Potential effects are considered within the assessment for the Project alone and cumulatively (Sections 12.7 – 12.8), and in the description of inter-relationships (Section 12.11).
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 impact ornithological receptors through impacts on prey availability are presented within the assessment for the Project alone and cumulatively (Sections 12.7 – 12.8).
Contaminants – Concentrations of contaminants are at levels not giving rise to pollution effects	The effects of contaminants on ornithological receptors are expected to be negligible and have been scoped out of assessment.
Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment	The effects of underwater noise have been assessed in the context of indirect impacts due to effects on habitats and prey species (Sections 12.7 – 12.8).

12.3 Consultation

15. Consultation is a key part of the Development Consent Order (DCO) application process. Consultation regarding Intertidal and Offshore Ornithology has been conducted through the Evidence Plan Process (EPP) and as part of the EIA scoping process (Outer Dowsing Offshore Wind, 2022) and the Preliminary Environmental Information Report (PEIR) process (Outer Dowsing Offshore Wind, 2023). An overview of the Project's Technical Consultation (document reference 6.1.6) and wider consultation is presented in the Consultation Report (document reference 5.1).
16. A summary of the key issues raised during consultation to date, specific to Intertidal and Offshore Ornithology, is outlined in Table 12.3 below, together with how these issues have been considered in the production of this ES.

Table 12.3: Summary of consultation relating to Intertidal and Offshore Ornithology

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion Comments		
Scoping Opinion (The Planning Inspectorate, 9 September 2022)	The Planning Inspectorate does not support the scoping out of barrier effects across all phases. The justification that the Scoping Report contains limited information regarding the likely extent of areas at each phase that could form a barrier to movement. Additionally, the Scoping Report does not explain why displacement and barrier effects would not also occur during other phases of the Project. The ES should include information on the sources of impact and the receptors that could be subject to barrier effects during construction, O&M and decommissioning and assess the likely significance of such effects.	Barrier effects are recognised and accounted for by the inclusion of flying birds within the displacement assessment in Sections 12.7 and 12.8. Therefore, a separate assessment for barrier effects on Important Ornithological Features (IOFs) is not necessary.
Scoping Opinion (The Planning Inspectorate, 9 September 2022)	The Planning Inspectorate does not support the scoping out of disturbance and displacement within the ECC during O&M. The Planning Inspectorate is of the view that the Scoping Report contains limited information regarding the extent and nature of any likely maintenance or repair works in the intertidal and offshore ECC. The Planning Inspectorate suggests the ES should assess impacts on IOFs from disturbance and displacement during O&M, where	Impacts on IOFs from disturbance and displacement have been scoped into the assessment. This is assessed in Sections 12.7 and 12.8

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	significant effects are likely to occur; any assumptions made in the assessment should be clearly set out.	
Scoping Opinion (The Planning Inspectorate, 9 September 2022)	With regards to effects on prey species, the Planning Inspectorate notes that the scoping Report assessment relies on the data and impact assessments including Marine Physical Processes, Noise, Benthic Subtidal and Intertidal Ecology, and Fish and Shellfish. Noting the Applicant's assertion that the temporal and spatial extent of impacts will be small, this is yet to be evidenced. Therefore, the Planning Inspectorate does not agree to scope these effects out of assessment. The Planning Inspectorate is of the view that the ES should include an assessment of cumulative impacts where significant effects are likely to occur. The ES should also assess the potential for 'minor' effects to combine to produce a cumulative, significant effect.	Barrier effects and effects on prey have been scoped into the assessment. This is assessed in Sections 12.7 and 12.8
Scoping Opinion (The Planning Inspectorate, 9 September 2022)	The Planning Inspectorate advises the Applicant to make every effort to establish species of bird when analysing surveys for the ES, as many were recorded as 'no ID'.	Effort has been made to reduce the 'no ID' birds within the survey. The apportioning methodology is outlined within Volume 2, Appendix 12.1: Ornithology Technical Baseline.
Scoping Opinion (The Planning Inspectorate, 9 September 2022)	The Planning Inspectorate advises that effort is made to agree via the EPP the extent of study	Consultation on the survey methodology and study area has been undertaken through the EPP.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	area, the methodologies for data collection, characterisation of the baseline and key species for focus, and the assumptions made around connectivity of the populations within the study area to designated sites. The ES should fully explain how this 22has been established and the outcomes of consultation undertaken in relation to these matters.	Details can be found in Section 12.4 and Volume 2, Appendix 12.1: Ornithology Technical Baseline.
Scoping Opinion (The Planning Inspectorate, 9 September 2022)	The Planning Inspectorate recommends the Applicant seek to agree the surveys with relevant consultation bodies, such as NE, and other relevant stakeholders as part of the EPP with regards to the detail about the number, frequency, extent, or proposed methodology for the intertidal surveys.	Consultation on the intertidal survey methodology has been undertaken through the EPP. Details can be found in Appendix 22.3: Winter Bird Survey Report.
Scoping Opinion – Impact assessment Methodology (The Planning Inspectorate, 9 September 2022)	The Planning Inspectorate notes that the ES should also assess any likely significant effects to the North Norfolk Coast Special Protection Area (SPA) based on the proximity of the Proposed Development and the presence of breeding Sandwich tern at the SPA.	The North Norfolk Coast SPA is scoped into the assessments in Part 7, Document 7.1 – Report to Inform Appropriate Assessment.
Scoping Opinion – Mitigation measures (The Planning Inspectorate, 9 September 2022)	The Planning Inspectorate considers that seasonal timing of construction and O&M vessel movements should be considered as a potential measure within the ES. The ES should clearly identify the mechanism for securing and	Seasonality has been considered in the assessments and assumptions clearly stated. This is addressed in Sections 12.4 and 12.5.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	delivering such mitigation, where relied upon for the impact assessment.	
Scoping Opinion – Survey methodology (Natural England, 9 September 2022)	Natural England advises the Applicant to request that every effort be made to identify birds to at least species group and this data presented when analysing surveys for the ES, as many were recorded as 'no ID'.	Effort has been made to reduce the 'no ID' birds within the survey.
Scoping Opinion – Survey methodology (Natural England, 9 September 2022)	Natural England note that common tern, common gull, and little gull are not included as key IOFs. Natural England advises the inclusion of common tern, common gull, and little gull in the list of IOFs. Natural England welcome the applicant's willingness to add other IOFs as more survey data becomes available.	Common tern, common gull, and little gull have been included as key IOFs. Common tern and little gull have been assessed using migratory collision risk. Common gull were recorded in low numbers in the array area and were screened out for collision risk. Details can be found in Sections 12.4 and 12.8.
Scoping Opinion (Natural England, 9 September 2022)	Natural England note that breeding Sandwich tern are a feature of the NNC spa, therefore NE advises that the Applicant includes North Norfolk Coast SPA in the list of key designated sites for ornithology.	The North Norfolk Coast SPA is scoped into the assessments. This is assessed in Document 7 – Report to Inform Appropriate Assessment.
Scoping Opinion (Natural England, 9 September 2022)	Natural England raised concerns that the key species of focus for EIA and Habitats Regulation Assessment (HRA) are ambiguous. Natural England advise a full list of proposed key species is used.	Puffin, Sandwich tern, common tern, great black-backed gull, common gull, and little gull have been included for consideration as key species. These have been addressed in Sections 12.7 12.8 and 12.8

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	Natural England advise that puffin, Sandwich tern, common tern, great black-backed gull, common gull, and little gull included for consideration as key species at this stage. Justification being that these species have potential connectivity of the project areas with relevant designated sites where these species are features.	
Scoping Opinion (Natural England, 9 September 2022)	Natural England note that common scoter is also a potentially sensitive feature of the Greater Wash SPA and advise that it is included for consideration as a key species for the ECC.	Common scoter has been included for consideration as a key species within the ECC. This species has been addressed in Section 12.7.
Scoping Opinion (Natural England, 9 September 2022)	Natural England do not have sufficient confidence in the estimation of heights of individual seabirds using digital aerial survey (DAS) techniques, due largely to insufficient validation of the methodologies. Natural England advise that assessments of collision risk should present the proportions of birds at potential collision risk height (% Potential Collision Height (PCH)) for a project's turbine specifications based on both the 'generic' and the site-specific data. Natural England advise working with all round 4 developers to improve the knowledge base on	This is considered within the assessments and consultation undertaken to discuss suitable methodologies; addressed in Section 12.8 and Volume 2, Appendix 12.2: Collision Risk Modelling Assessment Appendix.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	flight height and to encourage further engagement.	
Scoping Opinion (Natural England, 9 September 2022)	Natural England welcome the applicant's commitment to further engagement as a stakeholder on collision risk modelling (CRM) methods and parameters. Natural England request to be consulted on the approach to seasonality and bio-seasons for all species assessed. Natural England requests that the 'air gap' between the sea surface and the rotor swept area is such that collision risk is reduced as much as is possible.	Natural England have subsequently been consulted during the EPP. The approach to bio-seasons was provided for comment within the minutes for Offshore Ornithology and Derogation and Compensation expert topic group (ETG) (Natural England, 27th March 2023). Natural England have also been consulted regarding displacement, CRM, and assessment methodology, including key matters such as the project's approach to seasonality. The Project has committed to a minimum air gap of 40m relative to MSL.
Scoping Opinion (Natural England, 9 September 2022)	Natural England do not agree with the projects statement that 'A range of potential impacts on intertidal and offshore ornithology have been identified which may occur during the construction, O&M, and decommissioning phases of the Project'. Natural England note that advice on construction phase displacement effects is to treat it as 50% of operational phase displacement effects for the years in which the construction occurs.	The advice has been noted and taken into consideration in Sections 12.7, 12.8, and 12.9.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
Scoping Opinion (Natural England, 9 September 2022)	Natural England raises concern about the additional displacement from wind turbine generator (WTGs) on the distribution of red-throated divers within the Greater Wash SPA, as well as from associated activities. Natural England advises that construction and operational maintenance vessels follow a route from their base port that avoids high concentrations of red throated diver. Natural England highlighted concerns in relation to disturbance and/or displacement of red-throated divers features from the more persistent presence of offshore windfarm and oil and gas related vessel activity which could make a meaningful contribution to in-combination effects to the Greater Wash SPA and indeed the adjacent Outer Thames Estuary SPA depending on the transit route. Natural England (NE) advise appropriate consideration of both seasonal timing of construction and O&M works and vessel transit route is included within the application. Natural England advises that where possible, any construction and O&M activities avoid the months of November to March inclusive. Vessel transit routes outside of existing navigation	The advice has been noted and taken into consideration in Sections 12.5, 12.7 and 12.8.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	routes through the Greater Wash SPA and Outer Thames Estuary, depending on the port of origin, should also be avoided during these winter months. Natural England advises as minimum use of best practice measures between 1st November and 31st March to mitigate and therefore minimise disturbance to red-throated diver namely: Selecting routes (when transiting to site) that avoid aggregations of red-throated diver and common scoter, where practicable.	
Scoping Opinion (Natural England, 9 September 2022)	Natural England hold the opinion that whilst the landfall area of search still includes waterbird SPAs like the Humber, it is premature to scope out intertidal cable operations and maintenance at this stage.	Intertidal cable operations and maintenance have been scoped into assessments. This is addressed in Sections 12.5 and 12.7.
Scoping Opinion (Natural England, 9 September 2022)	Natural England agree that 22 transects with 16.7% coverage is likely to be sufficient for baseline characterisation. However, Natural England note that should the analysis of the survey data show that coverage is insufficient, it may be necessary to increase this coverage by further analysing the survey data from the two additional DAS survey cameras. Natural England welcomes the inclusion of 24 months of survey data, of monthly surveys year-	This is noted. The Applicant has further supplemented the analysis with 6 months of additional data covering the 2023 breeding season to give a total of 30 months of survey data and 36 data points. The data have been used to provide an additional breeding season to the population estimates used in displacement analyses and the numbers of birds feeding into CRM. The use of these data in the assessment has been discussed with Natural England via the EPP, as detailed in

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	round and two surveys per month during the period between March and August 2022.	Volume 3, Appendix 6.1: Evidence Plan Process Consultation (document reference 6.3.6.1).
Scoping Opinion (Natural England, 9 September 2022)	Natural England welcome the inclusion of 24 months of survey data, of monthly surveys year-round and two surveys per month during the period between March and August 2022. Natural England agree with the use of a 4km buffer for non-Red Throated Diver species (RTDs). However Natural England note that initial survey outputs may identify the need for further data collection or analysis, therefore expect this to be a key topic for discussion as part of the evidence plan process. Natural England note a lack of detail regarding the methods of analysis of the survey data or how abundance and density estimates will be made. Natural England cannot therefore provide comments on these methods at this stage, and would welcome and encourage early engagement with the applicant on these methods. Natural England also advise the use of model-based estimates, evidence of the suitability of any novel modelling method and that design-based outputs are presented alongside model-	Methods of analysis are described in sections 1.7 and 1.8, and in Appendices 12.1, 12.2, 12.3 and 12.4 (document references 6.3.12.1 – 6.3.12.4).

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	based outputs, along with distribution maps of the raw survey data.	
Offshore Ornithology Expert Topic Group (ETG) (RSPB, 29 September 2022)	Royal Society for the Protection of Birds (RSPB) confirmed the migratory CRM within the Band model has not been used for a while and that Marine Scotland Science commissioned the British Trust for Ornithology (BTO) to update the sCRM for migratory species and this would be considered the most appropriate method.	The Project has used the Migropath tool from APEM for migratory collision risk assessment to inform the ES, with agreement from Natural England.
Offshore Ornithology ETG (RSPB, 29 September 2022)	The Project propose not assessing great black-backed gull, herring gull, Sandwich tern or fulmar for collision risk within the PEIR. This will be reassessed once the full two-year DAS data is obtained. RSPB confirmed agreement with the Project's proposed approach.	The Project has included assessments on great black-backed gull (GBBG), herring gull (HG) and Sandwich tern (ST) at ES, these can be found in Section 12.8
Offshore Ornithology ETG (Natural England, 29 September 2022)	The Project propose not assessing great black-backed gull, herring gull, Sandwich tern or fulmar for collision risk within the PEIR. This will be reassessed once the full two-year DAS data is obtained.	The Project has included assessments on GBBG, HG and ST at ES. Fulmar has been screened out for collision risk. Information regarding this can be found in section Sections 12.5 and 12.8.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	Natural England advice that information on large gulls is needed to populate ongoing in combination assessments, and therefore CRM should be carried out unless agreed otherwise. Natural England welcome the proposed reassessment following 2 years data collection, however, may not be able to provide useful comments at PEIR due to only one year of data being presented.	
Offshore Ornithology ETG (Natural England, 29 September 2022)	For apportioning, the project proposes to use the best practice interim guidance from NatureScot (2018). Natural England advises that the apportioning assessment should also draw on and reflect the findings of any colony-specific tracking data.	The Project has used the NatureScot methodology and colony-specific tracking data to inform apportioning. This has been included within the Appendix 7.4: Apportioning methodology (document reference 7.4).
Offshore Ornithology ETG (Natural England, 29 September 2022)	The Project do not intend to include population viability analysis (PVA) as part of the analysis at PEIR. Natural England advise that it might be useful for the PEIR to take an initial view on which species are likely to be subject to PVA, so stakeholders can consider this.	This has been included for relevant species conclusions within the assessments in Section 12.8.
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 28 November 2022)	The Project propose that Little Gull and Common Tern should only be considered for migratory collision risk.	Information regarding this can be found in Section 12.8.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	Natural England confirm they are happy for little gull and common tern to only be considered for migratory collision risk.	
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 28 November 2022)	The project proposes it will retrospectively apply the new avoidance rates to previous projects for the cumulative impact assessment in the future, though at this stage new avoidance rates have only been applied for the Project alone impacts. Natural England now support the use of the stochastic CRM (sCRM, McGregor et al 2018) as per the draft updated Collision Risk Modelling parameters. With regards to applying variance within the flight height distributions, Natural England advise the project to use the default option within the application, which uses the Johnston (2014) bootstrap samples to draw from in the simulation.	This advice has been noted. Information can be found in Section 12.8 and Volume 3, Appendix 12.2: Collision Risk Modelling Assessment Appendix (document reference 6.3.12.1).
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 28 November 2022)	The project states that the most appropriate guidance is being used for assessments on gannets, using interim avoidance rate guidance for collision risk and published Natural England advice for the displacement analysis. The Project intends to adjust the avoidance rates to include macro avoidance post CRM.	This has been included within the assessments in Section 12.8 and Volume 3, Appendix 12.2: Collision Risk Modelling Assessment Appendix (document reference 6.3.12.2).

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	Natural England agree that the approach is suitable.	
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 28 November 2022)	The project proposes that Sandwich tern is screened in for collision but not for displacement. Natural England agree with the project that Sandwich tern is screened in for collision but not for displacement	This methodology has been agreed and is assessed in Section 12.8
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 28 November 2022)	The project proposes that Fulmar are screened out of assessments. Natural England advises that justifications for screening out Fulmar should be clear, whether screened out as no likely significant effect (LSE) or if screened in and concluded as no AeoI.	Clear justification has been provided in Section 12.8. A similar justification has been provided for Manx shearwater in Section 12.8.
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 28 November 2022)	Natural England confirmed that kittiwake should not be considered for displacement impacts.	Kittiwake is only assessed for collision risk within the ES.
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 27th March 2023)	Interim guidance from Natural England (Natural England, 2022) on avoidance rates to be used. This document also includes guidance on suggested nocturnal activity factors, flights speeds.	This has been included within the assessments in Section 12.8 and Volume 3, Appendix 12.2: Collision Risk Modelling Assessment Appendix (document 6.3.12.2).
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 27th March 2023)	Confirmed that the CRM results for a range of WTG options will be presented at PEIR for both 30m and 40m MSL.	For ES, the Project has commitment to an air gap of 40m above MSL. The CRM results are presented in an Annex to Volume 3, Appendix 12.2: Collision

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
		Risk Modelling Assessment Appendix (document 6.3.12.2).
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 27th March 2023)	Natural England confirmed that the Lawson *et al.,* 2016 dataset for red-throated diver and common scoter densities within the Greater Wash SPA is still the most appropriate dataset to use in PEIR. However, there may be an update to this report by ES submission.	Data extracted from Lawson *et al.,* 2016 has been used to inform the displacement assessment for red-throated diver and common scoter within the ECC (Volume 3, Appendix 12.3: Displacement Assessment Appendix) (document 6.3.12.3).
Outer Dowsing/ Natural England Avian Influenza Workshop (Natural England, 29th March 2023)	Natural England requested to review all DAS survey data to date within the technical baseline but confirmed that all the data from DAS could be used at PEIR.	All 30-months of available DAS data were used within the assessments at ES: Volume 2, Appendix 12.1: Intertidal and Offshore Ornithology Technical Baseline; Volume 3, Appendix 12.2: Collision Risk Modelling Appendix; Volume 3, Appendix 12.3: Displacement Assessment Appendix (document 6.3.12.2 and 6.3.12.3 respectively). Natural England are aware that these data have been used for these assessments.
Offshore Ornithology and Derogation and Compensation ETG (Natural England, 20th November 2023)	The Project sought guidance on Natural England's preferred approach to CRM, including the most appropriate tool to use for modelling, macro-avoidance and avoidance rates, and the use of bootstrapped densities.	The Applicant has presented results from the Applicant's approach, and where different, from Natural England's preferred approach as well.
Offshore Ornithology and Derogation and Compensation workshop (Natural England and The Planning Inspectorate), 9th January 2024)	The applicant sought clarification from Natural England on the use of the migratory collision risk model (MCRM) tool.	The Migropath tool has been used to model migratory collision risk, as described in section 12.4

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
	Natural England advised that as the MCRM tool is based on the Stochlab CRM tool, which is still under review, they cannot endorse the use of the MCRM tool alone for migratory collision risk.	
Offshore Ornithology and Derogation and Compensation workshop (Natural England and The Planning Inspectorate), 9th January 2024)	The Applicant sought guidance from Natural England on the populations to use as context for impact assessment. The Applicant has supplied their suggested populations to Natural England	Natural England have provided preferred reference populations, and populations used in impact assessment are in line with those provided by Natural England (Table 12.8).
Offshore Ornithology and Derogation and Compensation workshop (Natural England and The Planning Inspectorate), 9th January 2024)	The Applicant sought guidance on Natural England's preferred demographic rates. Natural England noted that the planned update to Horswill and Robinson (2015) will not be available prior to submission. It was advised that the applicant should use demographic rates accepted by Natural England at a recently submitted project, e.g., SEP and DEP.	The demographic rates agreed with Natural England for SEP and DEP were used where appropriate. However, it was necessary to calculate average mortalities for some species where there was a lack of clarity in the numbers produced by SEP and DEP (Table 12.9).
Offshore Ornithology and Derogation and Compensation workshop (Natural England and The Planning Inspectorate), 9th January 2024)	The Applicant sought guidance on Natural England's advice on cumulative numbers. It was advised that the applicant should use numbers accepted by Natural England for SEP and DEP (Deadline 8).	The SEP and DEP (Deadline 8) numbers were used where appropriate, though for more recent projects not included in this source, they were also added.
Offshore Ornithology and Derogation and Compensation workshop (Natural	The Applicant sought guidance on thresholds for 'no material contribution' to additions to baseline mortality. For context, the Applicant	This is noted by the Applicant.

Date and consultation phase/type	Consultation and key issues raised	Section where comment addressed
England and The Planning Inspectorate), 9th January 2024)	has provided some impacts it considers to make 'no material contribution' Natural England have advised that due to complexities with population trends and conservation status, simple thresholds for conclusion of 'no material contribution' are not provided.	

17. As identified in Volume 1, Chapter 4 – Site Selection and Consideration of Alternatives (document reference 6.1.4) and Volume 1, Chapter 3 – Project Description (document reference 6.1.3), the Project Design Envelope has been refined and finalised. This process has taken account of stakeholder consultation feedback.

12.4 Baseline Environment

12.4.1 Study Area

18. The Project is located in the southern North Sea, with WTGs positioned at their closest point approximately 54km east of the Lincolnshire coast and 57km north of the Norfolk coast (Figure 12.1 of Volume 2 Appendix 12 (document reference 6.2.12.1)). The proposed array area covers 436km^2. The intertidal and offshore ornithology study area for the Project is defined as the offshore part of the ECC together with the Zones of Influence (ZoIs) and is based on an area which is considered to represent a realistic maximum spatial extent of potential impacts to Important Ornithological Features (IOFs). The study area for the offshore and intertidal ornithology assessment includes the agreement for lease (AfL) array area with a 4km buffer, the offshore ECC and the cable landfall area, as well as the areas for the provision of ANSs, ORCPs and biogenic reef (Figure 12.1 of Volume 2 Appendix 12 (document reference 6.2.12.1)). There was no DAS data collection from ANS areas, or locations for ORCPs as impacts were considered likely to be negligible. The study area has been reviewed and amended in response to the refinement of the array area, and stakeholder consultation.
19. The intertidal area and related assessments consider IOFs using the habitat between mean high-water springs (MHWS) and mean low-water springs (MLWS), while recognising that some IOFs may nest or roost on the shore above the MHWS.

12.4.2 Data Sources

20. The key sources of data presented in Table 12.4 have been used as the basis for the ES baseline characterisation.

Table 12.4. Key sources of information for intertidal and offshore ornithology

Source	Date	Summary	Coverage of study area
Existing project survey data			
Digital aerial survey data	2021 – 2023	Digital aerial surveys conducted by HiDef Digital Aerial Surveying Ltd. On a monthly basis between March 2021 and August 2023, with two surveys per month between March and August 2022. Details presented in the Technical Baseline report (Volume 1, Appendix 12.1: Ornithology Technical Baseline).	AfL array area plus 4km buffer. A total of 22 transects with 1.5km spacing totalling 16.7% coverage using two cameras. It should be noted that the ornithology study area encompasses the final array area plus a 4km buffer. Therefore the data presented in this report is primarily based on this reduced area, not the full AfL area plus 4km buffer, unless otherwise stated.
Intertidal bird surveys	2022/23	Intertidal bird surveys have taken place at the selected landfall site. For further information see Appendix 22.3: Winter Bird Survey Report 2022/2023.	Data cover the intertidal area and immediate onshore area of the landfall.
Kittiwake census on offshore structures	July 2022 and 2023	Ornithological census of 19 offshore oil and gas platforms within 20 km of the project AfL array area was carried out by RSK Biocensus, commissioned by the Applicant. The primary aim of the census was to quantify the number of birds breeding on offshore structures in proximity to the Project AfL array area. For further information see Part 7, Document 7.4: Offshore Artificial Nesting Structures Ecological Evidence & Roadmap.	All oil and gas platforms within 20km of The Project AfL Array Area.
Publicly available datasets			

Source	Date	Summary	Coverage of study area
Existing offshore windfarm 'grey literature'	Various dates	Information obtained from various offshore windfarm Environmental Statements (e.g., Hornsea 1, 2, 3 and 4, Triton Knoll, Sheringham Shoal, Dudgeon, Race Bank etc.).	Includes data in the ECC as well as context across the broader region for the array area.
Designated sites	Various dates	Information of Special Protection Areas (SPAs) and other designations relevant to Important Ornithological Features (IOFs) with potential connectivity to the Project. Key source of information will be Natural England designated sites portal.	Country wide information on designated sites.
British Trust for Ornithology (BTO) Non-Estuarine Waterbird Surveys (NEWS)	1984 – 2016	NEWS provides recordings focused on intertidal habitats along the UK coastline. These were conducted in 1984/1985, 1997/98, 2006/07 and 2015/16.	Covers part of the nearshore ECC.
BTO Wetland Bird Survey (WeBS)	Annual Reports	Annual survey reports of wetland waterbirds. Most recent being Frost *et al.*, (2020).	UK intertidal and wetland zones. Source contains information which can be drawn upon at a project-specific scale, or a wider regional scale.
National Bird Atlas (Balmer *et al.*, 2013)	2007-2011	Results of five years of breeding season and wintering surveys across the UK at a 10km resolution.	The ECC overlaps with 20km squares.
Local/County bird reports and atlases	Annual Reports	County atlases covering breeding and non-breeding birds within the surrounding east coast counties. Annual publications produced by local birdwatching groups which summarise sightings and surveys results for East Lincolnshire and the wider north-east coast region.	Coverage across region at various intertidal and wetland and coastal areas.
Wildfowl and Wetlands Trust – Aerial surveys of	2004-2009	Aerial surveys of waterbirds around the UK.	Coverage of inshore waters relevant to the Project from survey grids GW4, GW8, GW9 and GW10.

Source	Date	Summary	Coverage of study area
waterbirds in the UK			
Literature			
Potential impacts of offshore windfarms on birds	Various dates	Peer reviewed scientific literature regarding the potential impacts from OWF e.g. (Garthe and Hüppop, 2004; Drewitt and Langston, 2006; Stienen *et al.*, 2007; Speakman *et al.*, 2009; Langston, 2010; Band, 2012; Cook *et al.*, 2012; Furness and Wade, 2012; Wright *et al.*, 2012; Furness *et al.*, 2013; Johnston *et al.*, 2014a,b; Cook *et al.*, 2014; Dierschke *et al.*, 2016; SNCB, 2017 (updated 2022); Cook *et al.*, 2018; Jarrett *et al.*, 2018; Leopold and Verdaat, 2018; Mendel *et al.*, 2019; Goodale and Milman, 2020);	Generic information applicable to Project IOFs.
Bird distribution	Various dates	Publicly available reports of seabird distribution e.g., Stone *et al.*, 1995; Brown and Grice, 2005; Kober *et al.*, 2010; Waggitt *et al.*, 2019; Cleasby *et al.*, 2020; Bradbury *et al.*, 2014; Davies *et al.*, 2021.	UK wide coverage with information that can be drawn upon at a project-specific scale or a wider regional scale.
Bird breeding ecology	Various dates	Information on the breeding ecology of various bird species e.g., Cramp and Simmons, 1977-94; Del Hoyo *et al.*, 1992-2011; Robinson, 2005.	Generic information applicable to Project IOFs.
Bird population estimates and demographic rates	Various dates	Data on seabird populations and demographic rates for use in assessments e.g., Burnell *et al* 2023; BirdLife International, 2004; Holling *et al.*, 2011; Frost *et al.*, 2019; Musgrove *et al.*, 2013; Furness, 2015; Horswill *et al.*, 2017, JNCC, 2020.	These sources contain information which can be drawn upon at a project-specific scale, or a wider regional scale.
Bird migration and foraging movements	Various dates	Bird movements during breeding season foraging trips and migration e.g., Wernham *et al.*, 2002; Thaxter *et al.*, 2012; Wright *et al.*, 2012; Furness *et al.*, 2018; Woodward *et al.*, 2019; Wakefield *et al.*, 2017; Wakefield *et al.*, 2013; RSPB FAME and STAR tracking data.	These sources contain information which can be drawn upon at a project-specific scale, or a wider regional scale.

Source	Date	Summary	Coverage of study area
OWF Assessment guidance	Various dates	Publications on OWF best practice for assessments e.g., Parker *et al.* 2022, MIG-Birds, 2022, Natural England, 2022a, CIEEM 2019.	These sources contain guidance relevant to the ornithological assessments undertaken in coastal waters off England.

12.4.3 Existing Environment

21. Following an initial desk-based review of the data sources identified in Table 12.4 the distribution, abundance, conservation status, biological seasons, behaviour, and characteristics of birds in the offshore and intertidal environment have been used to characterise the study area for the purposes of this ES.
22. Previous literature and surveys demonstrate that the southern North Sea provides an important habitat for numerous bird species throughout the year. The results from previous offshore windfarm baseline surveys (e.g. Hornsea Projects 1, 2, 3, and 4 and the Dudgeon and Sheringham Shoal Extension Projects); evaluations conducted for their Environmental Statements and monitoring reports; extensive ornithological surveys (e.g. Stone *et al*., 1995); bird tracking studies (e.g. Frederiksen *et al*., 2012; Woodward *et al*., 2019); biogeographic population reviews (e.g. Stienen *et al*., 2007; Furness, 2015); and the analysis of population distribution (e.g. Bradbury *et al*., 2014; Wakefield *et al*., 2017) provide evidence for this.
23. During the breeding season, the southern North Sea region provides habitat for a range of seabirds, including (but not limited to) gannet, *Morus bassanus*, kittiwake, *Rissa tridactyla*, and various species of auk. During the non-breeding season, the region supports numerous species; divers and seaducks generally reside in more inshore waters, while auks are found further offshore. The southern North Sea also hosts a pronounced passage of birds during spring and autumn with species such as gannets, skuas, gulls, terns and auks travelling between breeding and non-breeding areas (Stienen *et al*., 2007). It is also subject to migratory movements of terrestrial birds moving from the UK to and from mainland Europe or further afield such as waders, wildfowl, and passerines. Due to the mix of birds present, it is probable that the proposed array area and offshore ECC is used at different times of the year by birds (i) overwintering in the area; (ii) foraging from nearby coastal breeding colonies; and (iii) on post-breeding dispersal and pre-breeding return migration.

24. HiDef Digital Aerial Surveying Ltd. Have undertaken 30 months of digital aerial surveys (DAS) for the Project, with surveys commencing in March 2021 and completed in August 2023, with two surveys per month between March and September 2022. These surveys provide the most detailed and up-to-date site-specific data on birds within the project area. These seabird population data have been summarised for the AfL array area, 2km buffer and the 4km buffer in the Technical Baseline report (Volume 3, Appendix 12.1: Ornithology Technical Baseline) to provide an initial insight into key species likely to be present at the Project. A list of key species recorded during DAS, and therefore most likely to be considered IOFs, is presented in Table 12.5Table along with their relevant nature conservation value. A full list of species recorded during the DAS and detailed information on their frequency and abundances is available in Volume 2, Appendix 12.1: Ornithology Technical Baseline.
25. ANS areas and locations of ORCP are offshore and as such may host a similar suite of species as the array area, but species sensitive to displacement are most likely to be impacted. One ORCP will be located within the Greater Wash SPA, which lists red-throated diver and common scoter as features. Impacts will be assessed for the C&D phase and anticipated impacts (from displacement/disturbance resulting from vessel traffic) will be small due to low numbers of vessel clusters used, low numbers of birds anticipated (each structure will be within a 10 km buffer from other OWF projects and as such, numbers of birds are expected to be low as a result), and the lack of overlap between the construction period for these structures and for the array. Monitoring of ANS will not contribute impact as monitoring will be carried out in the breeding season, during which the most sensitive species will be on breeding grounds and not using the area.

Table 12.5. Species conservation value for current key IOFs

Species	Nature Conservation Value
Common scoter	BoCC5 Red listed, Birds Directive Migratory Species, International Union for Conservation of Nature (IUCN) Red List 'Least Concern' status
Kittiwake	BoCC5 Red listed, Birds Directive Migratory Species, IUCN Red List 'Vulnerable' status
Great black-backed gull	BoCC5 Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status
Herring gull	BoCC5 Red listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status
Lesser black-backed gull	BoCC5 Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status
Little gull	BoCC5 Green listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status
Sandwich tern	BoCC5 Amber listed, Birds Directive Annex I, Migratory Species, IUCN Red List 'Least Concern' status
Common tern	BoCC5 Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status
Guillemot	BoCC5 Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status
Razorbill	BoCC5 Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status
Puffin	BoCC5 Red listed, Birds Directive Migratory Species, IUCN Red List 'Vulnerable' status
Red-throated diver	Birds of Conservation Concern Five (BoCC5) (Stanbury *et al.,* 2021) Green listed, Birds Directive Migratory Species, Birds Directive Annex I, International Union for Conservation of Nature (IUCN) Red List 'Least Concern'
Gannet	BoCC5 Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status

26. Several bird species are also likely to be reliant on the intertidal habitats in the vicinity of the cable landfall and the nearshore parts of the ECC. The intertidal environment of the Lincolnshire coast is dominated by mobile, sandy beaches backed by low, soft cliffs and sand dunes and is an area of active erosion. The Lincolnshire coast is bounded by the Humber Estuary to the north and The Wash to the south. Intertidal areas of both the Wash and Humber are important habitat for wading birds. However, the coastline between the two lacks any significant areas of intertidal estuary or muddy habitats. As a result, habitat and food resources for intertidal birds are limited and the populations of birds using the coast is known to be relatively low in comparison to other intertidal locations from the BTO NEWS survey data. Intertidal bird surveys have taken place throughout the winter of 2022/2023 at the selected landfall site.
27. For this ES, a review of the BTO NEWS survey data covering the area of interest in the vicinity of the offshore export cable landfall is summarised in Table 12.6. Although the survey area covers a larger region than the surrounding coastline, the data provide an indication of bird species present within the intertidal area over a prolonged period and enable the identification of the potential key species to be included within the assessment.

Table 12.6. Population estimates from BTO winter NEWS survey 2015/16. See Austin *et al.* (2017).

Species	Count	Population estimate	Nationally important (>1%)
Mute swan	41	41 (0-123)	No
Mallard	38	37 (0-79)	No
Common scoter	80	80 (0-160)	No
Great crested grebe	1	1 (0-3)	No
Oystercatcher	69	68 (4-169)	No
Ringed plover	23	18 (2-48)	No
Curlew	96	96 (0-288)	No
Bar-tailed godwit	5	5 (0-15)	No
Turnstone	6	6 (0-18)	No
Sanderling	132	124 (51-238)	No
Dunlin	1	1 (0-3)	No
Redshank	19	19 (0-57)	No
Black-headed gull	577	539 (266-810)	No
Common gull	450	414 (161-668)	No
Mediterranean gull	1	1 (0-3)	No
Great black-backed gull	80	76 (44-107)	No
Herring gull	752	686 (356-1,249)	No
Lesser black-backed gull	7	6 (1-11)	No
Red-throated diver	6	5 (2-11)	No
Great northern diver	1	1 (0-3)	No
Cormorant	55	54 (2-126)	No

Designated Sites

28. The impact assessment has considered potential connectivity of the Project with those statutory designated sites for nature conservation which have birds listed as qualifying features. Four classes of statutory designated sites have been considered: SPAs, potential Special Protection Areas (pSPAs), Ramsar sites and Sites of Special Scientific Interest (SSSI). Sites which may have qualifying features with connectivity to the Project include those designated for breeding seabirds, wintering birds and those for terrestrial, coastal or marine bird interests (typically migratory and/or non-breeding aggregations).
29. The ECC directly overlaps with the Greater Wash SPA which is designated for breeding terns and wintering red-throated diver and common scoter. Additionally, as breeding and migratory seabirds can travel significant distances it is necessary to consider designated sites beyond the study area. The extent of connectivity between relevant designated sites and offshore windfarms during the breeding season is largely a function of distance and species-specific foraging ranges (i.e. those identified in the review by Woodward *et al*. (2019). Outside the breeding season patterns of migration are used to infer the origins of species recorded. Terrestrial/coastal sites designated for migrant species outside the breeding season may therefore be connected on the grounds of passage movements through the site.
30. Full consideration of connectivity of European and Internationally designated sites (SPAs and Ramsar sites) is provided in a separate HRA Report to Inform Appropriate Assessment (Part 7, Document 7.1), and covers in more detail matters associated with the National Site Network. The RIAA has been discussed with relevant stakeholders throughout the pre-application phase, with the HRA developed in parallel with the EIA process.
31. For the EIA specifically, a review of SSSIs (often overlapping in extent with SPAs and Ramsar sites) has been undertaken to consider potential connectivity with the Project.
32. The key sites identified in relation to ornithological interest (based on proximity to the Project and designated features) are as follows:
    - **The Flamborough and Filey Coast (FFC) SPA**
    - **The Greater Wash**
    - **The Wash SPA**
    - **Humber Estuary SPA**
    - **North Norfolk Coast SPA**
    - **Flamborough Head Site of Special Scientific Interest** (SSSI) is approximately 318ha in area, encompassing terrestrial and coastal habitats. The area of the SSSI extends beyond the area of the FFC SPA as its interest features include grassland habitats and geological features but it does not extend beyond mean low water. The notified bird interest features are breeding fulmar, gannet, kittiwake, guillemot, razorbill and puffin.

- **Hornsea Mere** SSSI and SPA is a terrestrial wetland site noted for its large concentration of little gull that use this site in the late summer to wash and preen. These little gulls will feed in the offshore environment and are an interest feature of the Greater Wash SPA. Little gull is not an interest feature of the Hornsea Mere SSSI nor the Hornsea Mere SPA.

12.4.4 Future Baseline

33. The current baseline description above provides an accurate reflection of the current state of the existing environment. However, the assessment of impacts on offshore ornithology has also been carried out taking account of the range of pressures which are currently having an effect, and will continue to have an effect, on ornithological receptors in the North Sea and beyond.
34. Key anthropogenic pressures driving variation in seabird population sizes are considered prey availability, bycatch, invasive alien species, disturbance and displacement, collision risk and pollution (Dias *et al*., 2019; Mitchell *et al*., 2020; Royal HaskoningDHV, 2019). However, the most significant driver of population change is considered to be climate change, which is impacting seabirds both directly through impacts such as mortality or reduced breeding success due to extreme weather events, and indirectly such as through impacts on prey availability. Considering currently reported direct impacts, it is apparent that seabirds are susceptible to substantial population-level impacts arising from poor weather and extreme weather events (Daunt *et al*. 2017; Daunt and Mitchell, 2013; Jenouvrier, 2013; Mitchell *et al*. 2020; Morley *et al*. 2016; Newell *et al*. 2015). Indirect impacts are also reported, with seabirds reported struggling to find sufficient food for chicks as breeding season temperatures rise (Brander *et al*. 2016), alongside a range of reported interactions between prey availability and climate change (Lindegren *et al*., 2018; MacDonald *et al*., 2019, 2018, 2015; Régnier *et al*., 2019; Sandvik *et al*., 2012, 2005; Wright *et al*., 2018). Notably the impacts will vary spatially, for example prey recruitment in some areas may be less impacted (ClimeFish, 2019; Frederiksen *et al*. 2005). However, impacts are generally expected to increase in severity with increased incidences of warming and extreme weather predicted in climate models (Palmer *et al*. 2018), and therefore it is expected that 45um45ctts on seabirds will similarly increase in both frequency and magnitude.

35. Anthropogenic impacts on ornithological receptors vary greatly by geographic region. For example, the Common Fisheries Policy (CFP) Landings Obligation will reduce food supply for scavenging birds such as great black-backed gulls, lesser black-backed gulls, herring gulls, fulmars, kittiwakes and gannets, with impacts expected to be greater in areas where food supply is already limited (Votier *et al*. 2004; Bicknell *et al*. 2013; Votier *et al*. 2013; Foster *et al.* 2017). Additionally, in the North Sea, the most important prey fish stock for seabirds during the breeding season is sandeel (Furness and Tasker 2000). However, the North Sea stocks of this species have been significantly depleted by high levels of fishing, and in spite of the recent closure of the North Sea fishery are considered unlikely to recover fully because climate change has altered the North Sea food web to the detriment of productivity of fish populations (Dulvy *et al*. 2008; Hiddink *et al*. 2015). Seabirds in the North Sea are therefore expected to see continued food shortages and consequent population impacts, especially those that rely more heavily on sandeels, although the severity of these shortages are likely to be somewhat reduced by the closure of the sandeel fishery.

36. It is acknowledged that the short, medium and long-term impacts of recent highly pathogenic avian influenza (HPAI) outbreaks on seabird colony abundance and vital rates (productivity and survival) are unclear, though impacts are expected to be present from ~June 2022 onwards (Natural England, 2022b). However, based on abundance data presented within Volume 2, Appendix 12.1: Ornithology Technical Baseline, there are currently no clear impacts on the number of birds recorded. For example, in the46 summer months of 2022 where two surveys per month were undertaken, the variation between the data from the two surveys within the same month was often greater than that between the same month across two years. To ensure full consideration is given to the potential impacts of HPAI, the Applicant has been in consultation with Natural England and has agreed that there is no justification for excluding data at this stage (Section 12.3).

37. With the earliest expected date for the start of the offshore construction of the Project being 2026, with an expected operational life of approximately 35 years, there exists potential for the baseline environment to evolve between the time of assessment and the point of impact. However, any large-scale changes in baseline in relation to offshore ornithology usually occur over an extended period, and therefore the baseline is not anticipated to have fundamentally changed from its current state at the point in time when impacts occur.

38. Considering information presented in this section, the impact assessment will be carried out in a context of declining baseline populations for a number of species, taking into account whether a given impact is likely to exacerbate a decline and prevent a species from recovery should environmental conditions become more favourable. Though it is also noted that climate change has been identified as the strongest influence on future seabird population trends (Dias *et al.* 2019; Mitchell *et al.* 2020), and a key component of global strategies to combat climate change is the development of low-carbon renewable energy developments such as offshore windfarms.

12.4.5 Biological Seasons, Populations and Demographics for Offshore Ornithology Receptors

39. The abundance and behaviour of ornithological receptors will vary across the calendar year depending on the biological seasons (bio-seasons) that apply to different species. In this ES, separate bio-seasons are defined to establish the importance of the study area for different seabird species across different time periods. The biologically defined minimum population scales (BDMPS) bio-seasons are based on Furness (2015), and hereafter referred to as 'bio-seasons', in accordance with guidance in Parker *et al* (2022).

40. Within this ES, six bio-seasons are defined: return migration, migration-free breeding, post-breeding migration, migration-free winter, non-breeding, and breeding. These bio-seasons can be applied on a monthly basis to different periods within the annual cycle for most seabird species, though not all five are applicable for all species depending on the species-specific biology and life-history:

- Return migration: when birds are migrating from non-breeding to breeding grounds;
- Migration-free breeding: when birds are only 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 only over-wintering in an area;
- 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; and
- Breeding: extended bio-season from modal arrival of breeding birds to the colony to modal departure from the colony.

41. The bio-seasons and non-breeding season reference populations (UK North Sea and English Channel) applied to species assessed within this ES are outlined in Table 12.7, with bio-seasons and population estimates based on Furness (2015) unless stated otherwise. Notably, bio-seasons for little gull were based on Cramp and Simmons (1983) and expert judgement based on data presented in Volume 2, Appendix 12.1: Ornithology Technical Baseline. Breeding bio-season populations are presented in Table 12.8Table .

42. As a precautionary approach, the full breeding bio-season was used (as opposed to the migration-free breeding bio-season) for all species. Where non-breeding bio-season months overlapped with the breeding season, these were assigned to the breeding season.

Table 12.7. Bio-seasons used for assessment of key species for the Project based on Furness (2015).

Species	Migration-free breeding	Post-breeding migration	Return migration	Migration-free winter	Breeding	Non-breeding
Kittiwake	May-Jul	Sep-Dec	Jan-Feb	-	Mar-Aug	-
GBBG	-	-	-	-	Apr-Aug	Sep-Mar
Herring gull	-	-	-	-	Mar-Aug	Sep-Feb
Lesser Black-Backed Gull (LBBG)	May-Jul	Sep-Oct	Mar	Nov-Feb	Apr-Aug	-
Little gull[1]	-	Jul – Oct	-	-	May-Jun	Jul-April
Sandwich tern	Jun	Sep	Mar-Apr	-	May-Aug	-
Common tern	Jun	Sep	Apr	-	May-Aug	-
Arctic tern	Jun	Sep	Apr	-	May-Aug	-
Guillemot	-	-	-	-	Mar-Jul	Aug-Feb
Razorbill	Apr-Jun	Aug-Oct	Jan-Mar	Nov-Dec	Apr-Jul	-
Puffin	-	-	-	-	Apr-Jul	Aug-Mar
RTD	-	-	-	-	May – Aug	Sept – Apr
Gannet	Apr-Aug	Sep-Nov	Dec-Mar	-	-	-

43. As advised in recent Natural England guidance (Parker *et al.* 2022), and during consultation (Section 12.3) the regional population of each species during the breeding season was calculated by summing the breeding population located within the relevant regional BDMPS defined in Furness (2015) that the project sits within plus non-breeders and immature birds. In the case of Outer Dowsing this is generally the UK North Sea or UK North Sea and Channel BDMPS.

44. In addition to breeding birds, there will be additional juvenile and immature birds present during the breeding season. As a proportion of juvenile and immature birds are considered to remain within their wintering areas (whether connected to regional breeding colonies or not), the number of individuals present was calculated by adjusting the breeding individuals by the ratio of adults to immatures provided in Furness (2015). The defined seasonal populations are presented in Table 12.8.

45. Red-throated divers recorded within the array area during the breeding season are not considered to be breeding individuals because the Project is substantially beyond the mean max foraging range (plus 1 standard deviation (SD)) of any breeding birds. It was assumed that these were migratory birds, non-breeders or sabatticals, and therefore the migration BDMPS was used for the assessment of birds in the breeding season. For little gull and common tern, no value is provided since these species are assessed on migration only, as agreed during the Evidence Plan Process (EPP) (Paragraph 0). See Consultation 12.3 for more detail.

Table 12.8. Regional bio-season populations (calculated from or defined by Furness *et al.* (2015) plus additional juveniles and immature birds.

Species	Breeding season BDMPS	Autumn/post-breeding BDMPS	Winter/non-breeding BDMPS	Spring/pre-breeding BDMPS
Kittiwake	839,456	829,938	-	627,814
Great black-backed gull	25,917	-	91,398	-
Herring gull	324,887	-	466,510	-
Lesser black-backed gull	51,233	209,006	39,313	197,482
Sandwich tern	31,629	38,050	-	38,050
Common tern	28,753	144,900	-	144,900
Guillemot	2,045,078	-	1,617,305	-
Razorbill	158,031	591,875	218,621	591,875
Puffin	868,689	-	231,958	-
Red-throated diver	-	13,276	-	13,276
Gannet	400,326	456,299	-	248,385

46. When defining populations for EIA scale impacts Natural England currently recommend using the largest appropriate spatial scale during the non-breeding season, when birds are generally expected to represent a mix from the included colonies.

47. To assess the potential impact of the Project to seabird populations, the additional mortality was assessed against the baseline mortality rate for each species within each recognised bio-season. The average mortality across all age classes for each species is presented in Table 12.9 The method presented assumes that the risk of possible impacts of the proposed development is equal across all age classes, and as such the baseline mortality is a weighted average based on all age classes. To calculate the expected stable proportions in each age class for each species, demographic data from Horswill and Robinson (2015) were used. 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 12.9: 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		
Common scoter	Demographic rate	0.749	0.783	0.783	-	-	-	0.783	1.838	0.226
	Population age ratio	0.268	0.198	0.140	-	-	-	0.395		
Kittiwake	Demographic rate	0.790	0.854	0.854	0.854	-	-	0.854	0.690	0.156
	Population age ratio	0.155	0.123	0.105	0.089	-	-	0.530		
Great black-backed gull	Demographic rate	0.815	0.815	0.815	0.815	-	-	0.885	0.530	0.144
	Population age ratio	0.137	0.112	0.935	0.076	-	-	0.581		
Herring gull	Demographic rate	0.798	0.834	0.834	0.834	-	-	0.834	0.920	0.172
	Population age ratio	0.178	0.141	0.117	0.097	-	-	0.467		
Lesser black-backed gull	Demographic rate	0.820	0.885	0.885	0.885	-	-	0.885	0.530	0.124
	Population age ratio	0.134	0.109	0.095	0.083	-	-	0.579		
Little gull	Demographic rate	0.800	0.800	-	-	-	-	0.800	0.625	0.200

Species	Parameter	Survival (age class)							Productivity	Average mortality
		0-1	1-2	2-3	3-4	4-5	5-6	Adult		
	Population age ratio	0.175	0.145	-	-	-	-	0.680		
Sandwich tern	Demographic rate	0.358	0.741	0.741	0.741	-	-	0.898	0.702	0.240
	Population age ratio	0.200	0.063	0.063	0.063	-	-	0.610		
Common tern	Demographic rate	0.441	0.441	0.850	-	-	-	0.883	0.764	0.263
	Population age ratio	0.233	0.103	0.048	-	-	-	0.626		
Guillemot	Demographic rate	0.560	0.792	0.917	0.939	0.939	-	0.939	0.672	0.140
	Population age ratio	0.168	0.091	0.069	0.062	0.056	-	0.496		
Razorbill	Demographic rate	0.630	0.63	0.895	0.895	-	-	0.895	0.570	0.174
	Population age ratio	0.159	0.102	0.065	0.059	-	-	0.613		
Puffin	Demographic rate	0.709	0.709	0.760	0.805	-	-	0.906	0.617	0.167
	Population age ratio	0.162	0.115	0.082	0.063	-	-	0.577		
Red-throated diver	Demographic rate	0.600	0.620	-	-	-	-	0.840	0.571	0.228

Species	Parameter	Survival (age class)							Productivity	Average mortality
		0-1	1-2	2-3	3-4	4-5	5-6	Adult		
	Population age ratio	0.179	0.145	-	-	-	-	0.676		
Gannet	Demographic rate	0.424	0.829	0.891	0.895	-	-	0.912	0.700	0.191
	Population age ratio	0.191	0.081	0.067	0.060	-	-	0.600		

12.5 Basis of Assessment

12.5.1 Scope of the Assessment

Impacts Scoped in for Assessment

48. The following impacts have been scoped into this assessment following Natural England's best practice advice (Parker *et al*., 2022). Impacts that have been scoped out are presented in paragraph 49:

- Construction:
  - Impact 1: Disturbance and displacement: Offshore ECC, ANS areas and ORCPs;
  - Impact 2: Disturbance and displacement: Array area[1];
  - Impact 3: Indirect impacts on IOFs due to effects on prey species habitat loss: Array area and Offshore ECC; and
  - Impact 4: Disturbance and displacement: Artificial Nest Structure (ANS), Biogenic reef seeding and ORCPs.
- O&M:
  - Impact 5: Disturbance and displacement: Array area[1];
  - Impact 6: Collision risk: Array area
  - Impact 7: Collision risk to migratory birds: Array area; and
  - Impact 8: Indirect impacts on IOFs due to impacts on prey species habitat loss: Array area and offshore ECC.
- Decommissioning:
  - Impact 9: Disturbance and displacement: Array area;
  - Impact 10: Disturbance and displacement: Offshore ECC, ANS areas and ORCPs;
  - Impact 11: Indirect impacts on IOFs due to impacts on prey species habitat loss; and
  - Impact 12: Disturbance and displacement: Artificial Nest Structure (ANS), Biogenic reef seeding and ORCPs.

Impacts Scoped out of Assessment

49. In line with the Scoping Opinion (The Planning Inspectorate, 2022), and based on the receiving environment, expected parameters of the Project (Volume 1, Chapter 3: Project Description), and expected scale of impact/potential for a pathway for effect on the environment, the following impacts have been scoped out of the assessment:

- Construction phase:

[1] Consideration of barrier effects is incorporated within this impact.

    - Disturbance and displacement: Intertidal ECC;
- O&M phase:
    - Disturbance and displacement: Intertidal ECC;
    - Lit structures; and
- Decommissioning phase:
    - Disturbance and displacement: Intertidal ECC;

Barrier effects

50. During all phases of the Project, the presence of WTG (both operational and during construction/decommissioning) could create a barrier to the movement of flying seabirds. However, with the Project being located >50km offshore it is considered highly likely to be outside of the core foraging range of most seabird species. Therefore, individual birds of most species are highly unlikely to be making daily commutes past and around the windfarm. As such, the potential for impacts resulting from barrier effects is highly unlikely at the location of the Project.
51. Any impacts resulting from barrier effects are quantified within the displacement assessment. Both flying birds and birds on the water are considered in this displacement assessment as recommended by SNCBs in their latest guidance (MIG-Birds, 2022), and from Natural England (Parker *et al*., 2022). The inclusion of sitting birds within the analysis provides for an assessment of those potentially displaced from an area of sea they reside, whilst the inclusion of flying birds provides for an assessment of potential barrier effects to birds moving through the area of interest.
52. These documents outline the methodology for determining impacts from displacement and barrier effects, with the approach agreed through the EPP consultation and Scoping Opinion as the most appropriate method to assess these impacts. Considering the displacement assessment for the Project has considered both sitting and flying birds, it is considered that any impacts relating to barrier effects have therefore been recognised and accounted for within the assessment, with no further consideration needed as a result of barrier effects as an impact alone.

Disturbance and displacement: intertidal ECC, ANS areas and ORCPs (Construction and O&M phase)

53. The Project has committed to HDD at landfall, so no intertidal works are planned during construction. The horizontal directional drilling (HDD) exit pits will be a design target of 500m below MLWS and therefore not considered to result in any pathway of effect to the intertidal. Consequently, the main disturbance impact at landfall will be from vessel disturbance at the exit pit, and therefore it has been assessed as part of the consideration of impacts from activities within the offshore ECC.

54. Eight species were detected in excess of 50 times during intertidal surveys. These included several gull species including black-headed gull (174), common gull (308) and herring gull (68). Gull species have a low risk to displacement impacts (Bradbury *et al.,* 2014), and are often found aggregating around vessels as opposed to being displaced by them. Common gull, herring gull and black-headed gull, the most commonly recorded gull species, have large foraging ranges and therefore displacement from a restricted area will not result in any measurable impacts to these species.
55. Common scoter are particularly sensitive to vessel disturbance and were detected in moderate numbers (140 observations) over the 14 intertidal vantage point surveys. However, the risk to common scoter is considered to be low because works undertaken at the exit pit will be highly localised and carried out over a short time period. Any vessel disturbance is considered to be sufficiently covered within the ECC displacement assessment, which accounts for vessel activity using common scoter densities in the ECC from Lawson *et al.,* 2016 during the full construction period.
56. Four wader species were also observed in moderate numbers during intertidal vantage point surveys including wigeon (533), golden plover (57), curlew (60) and sanderling (84), none of which are considered to be vulnerable to displacement impacts (Bradbury *et al.,* 2014).
57. Likewise, during the O&M phase it is considered unlikely that regular maintenance would be taking place in the intertidal ECC and therefore disturbance will be minimal. When any activity is present in the nearshore Offshore ECC during the operational phase, best practice measures will be adopted, thereby minimising disturbance during key times for intertidal birds.
58. For ANS areas and ORCPs, disturbance and displacement impacts are considered to be minimal due to the low level of vessel traffic associated with their construction (a single vessel cluster for ANS, for example). The overlap of the ANS and ORCP locations with 10km buffers from other OWF arrays suggests baseline numbers of the most sensitive species (i.e., red-throated diver and common scoter) in these areas will be reduced and the presence of a single structure within these areas already affected by displacement due to the existing windfarms is not considered likely to contribute to any additional impact. Impacts during the O&M phase will be restricted to the passage of maintenance vessels, with impacts anticipated to be infrequent and reversable. Presence of the most sensitive species (i.e., common scoter and red-throated diver) will be restricted to the non-breeding season, so there will be no impacts from vessels carrying out monitoring of seabirds on ANS in the breeding season.

Lit structures

59. The presence of illuminated structures has the potential to impact birds, acting both as a deterrent to some species and an attractant to others. When deterred, this drives a change in flight directions and acts in line with effects resulting from displacement. An attractant effect may increase the likelihood of bird collisions and result in displacement-level impacts due to alterations in flight path.

60. Of the seabird species likely to be present in the largest numbers (fulmar, gannet, kittiwake and auk species), most birds are unlikely to be active at night, either returning to colonies overnight or roosting on the sea surface (Wade *et al*., 2016).

61. 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 and Manx shearwater is given a relatively high nocturnal activity rate, however very few flights are likely to be at collision risk height (Wade *et al*., 2016).

62. On migration, there could be potential for impacts if large numbers of birds pass through the site, leading to disorientation or collisions. However, there is insufficient evidence from current literature or any existing UK OWFs to suggest mass collision events occur because of aviation and navigation lighting at 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 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 as birds tend to fly down the centre of corridors, further away from the structures (Dirksen *et al*., 2000; Desholm and Kahlert, 2005). Therefore, the potential magnitude of impact from lighting is considered to be **negligible.**

12.5.2 Maximum Design Scenario (MDS)

63. The following section (Table 12.10) identifies the MDS in environmental terms, defined by the Project Design Envelope.

Table 12.10 Maximum design scenario for Intertidal and Offshore Ornithology for the Project alone

Potential effect	Maximum design scenario assessed	Justification
Construction phase		
Impact 1: Disturbance and displacement: Offshore ECC.	Construction Vessels within ECC: ▪ 3 cable laying vessels (20 return trips); ▪ 3 cable jointing vessels (16 return trips); ▪ 3 cable burial vessels (16 return tips); ▪ 16 support vessels (1,070 return trips); ▪ 16 helicopter return trips; and ▪ Single phase of offshore construction over approximately four years.	The assumption is that vessels would be in situ from start to finish, so any disturbance events would be throughout entire period.
Impact 2: Disturbance and displacement: Array area.	Construction Vessels/Helicopters within Array Area: ▪ Up to 10 construction vessels in a 5km^2 area at any one time; ▪ Single phase of offshore construction over approximately 4 years. WTG Installation: ▪ Up to 2 installation vessels (Jack-Up Vessels (JUV) or anchored) (47 return trips); ▪ Up to 18 support vessels (1376 return trips); ▪ Up to 10 transport vessels (140 return trips); and ▪ Up to 176 helicopter return trips. WTG Foundation Installation: ▪ 3 installation vessels (40 return trips); ▪ 10 support vessels (50 return trips); ▪ 8 transport/feeder vessels (including tugs) (372 return trips); ▪ 8 anchored transport/feeder vessels (including tugs) (372 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.

Potential effect	Maximum design scenario assessed	Justification
	▪ 93 helicopter return trips. Offshore Substation (OSS) and Accommodation Platform Installation: ▪ Up to 2 installation vessels (JUV or anchored) (24 return trips); ▪ Up to 12 support vessels (96 return trips); ▪ Up to 4 transport vessels (48 return trips); and ▪ Up to 40 helicopter return trips. OSS and Accommodation Platform Foundation Installation: ▪ 2 installation vessels, (16 return trips); ▪ 12 support vessels (48 return trips); ▪ 4 transport/feeder vessels (including tugs) (32 return trips); ▪ 28 helicopter return trips. Array and Interlink Cable Installation: ▪ 3 main cable laying vessels (22 return trips); ▪ 2 main cable burial vessels (16 return trips); ▪ 14 support vessels (1022 return trips); and ▪ 22 helicopter return trips.	
Impact 3: Indirect impacts on IOFs due to effects on prey species habitat loss: Array area and Offshore ECC.	See MDS for Fish and Shellfish Ecology assessment (Volume 1, Chapter 10 – Fish and Shellfish Ecology) and for the Benthic and Intertidal Ecology assessment (Volume 1, Chapter 9 – Benthic Subtidal 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.

Potential effect	Maximum design scenario assessed	Justification
		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 1, Chapter 10 – Fish and Shellfish Ecology and Volume 1, Chapter 9 – Benthic Subtidal and Intertidal Ecology.
Impact 4: Disturbance and displacement: Artificial Nest Structure (ANS), Biogenic reef seeding and ORCPs.	▪ Construction vessels making return trips to the ANS, biogenic reef and ORCP location(s). Two ORCPs = gravity-based structure (GBS) foundations ▪ Two ANS = monopile foundations ▪ One Biogenic reef ▪ Maximum extent of buoyed construction area ▪ 16 anchoring operations with a maximum disturbance of 800m2 per operation for installation of two ORCPs = 12,800m2 ▪ 16 anchoring operations with a maximum disturbance of 800m2 per operation for installation of two ANS = 12,800m2 ▪ 10 return trips for installation of the biogenic reef, and four monitoring return trips	Impacts have been considered with general construction impacts such as anchoring operations.
O&M		

Potential effect	Maximum design scenario assessed	Justification
Impact 5: Disturbance and displacement: Array area.	Array Area: ▪ WTG deployment across the full array area (436km^2). WTGs: ▪ Up to 100 WTGs; O&M: ▪ 1,339 vessel return trips to WTGs per year; ▪ 409 vessel return trips to WTG foundations per year; ▪ 55 vessel return trips to offshore platforms (structural scope) per year; ▪ 115 vessel return trips to offshore platforms (electrical scope) per year; ▪ 388 crew transfer shifts per year; ▪ A total of 2,306 total vessel return trips per year. The same number is considered for helicopter return trips per year; and ▪ Vessels include: CTVs, service operation vessels, supply vessels, cable and remedial protection vessels, and JUVs.	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 the extent/varying displacement from the array area and a buffer is species specific due to sensitivity levels.
Impact 6: Collision risk: Array area.	Array Area: ▪ WTG deployment across the full array area (436km^2) area. WTGs: ▪ 100 WTGs; ▪ Minimum height of lowest blade tip above MSL: 40m; and ▪ Rotor blade diameter: 236m.	This represents the greatest total swept area to be considered for collision risk, see Volume 2, Appendix 12.2: Collision Risk Modelling Assessment.

Potential effect	Maximum design scenario assessed	Justification
Impact 7: Collision risk to migratory birds: Array area.	Array Area: ▪ WTG deployment across the full array area (436km^2) area. WTGs: ▪ Up to 100 WTGs; ▪ Maximum rotor blade diameter: 236m.	This represents the entire array area and the maximum number of the largest WTGs, the greatest total swept area to be considered for collision risk.
Impact 8: Indirect impacts on IOFs due to impacts on prey species habitat loss: Array area and ECC.	See MDS for Fish and Shellfish Ecology assessment (Volume 1, Chapter 10 - Fish and Shellfish Ecology) and for the Benthic and Intertidal Ecology assessment (Volume 1, Chapter 9 – Benthic Subtidal 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 1, Chapter 10 - Fish and Shellfish Ecology) and Volume 1, Chapter 9 – Benthic Subtidal and Intertidal Ecology.
Decommissioning phase		
Impact 9: Disturbance and displacement: Array area.	MDS is identical (or less) to that of the construction phase.	MDS is identical (or less) to that of the construction phase.
Impact 10: Disturbance and displacement: Offshore ECC.	MDS is identical (or less) to that of the construction phase.	MDS is identical (or less) to that of the construction phase.

Potential effect	Maximum design scenario assessed	Justification
Impact 11: Indirect impacts on IOFs due to impacts on prey species habitat loss: ECC.	See MDS for Fish and Shellfish Ecology assessment (Volume 1, Chapter 10 - Fish and Shellfish Ecology) and for the Benthic and Intertidal Ecology assessment (Volume 1, Chapter 9 – Benthic Subtidal 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 1, Chapter 10 - Fish and Shellfish Ecology) and Volume 1, Chapter 9 - Benthic Subtidal and Intertidal Ecology.
Impact 12: Disturbance and displacement: Artificial Nest Structure (ANS), Biogenic reef seeding and ORCPs.	MDS is identical (or less) to that of the construction phase	MDS is identical (or less) to that of the construction phase.

12.5.3 Embedded Mitigation

64. Mitigation measures that have been identified and adopted as part of the evolution of the Project design (embedded into the Project design) and that are relevant to Intertidal and Offshore Ornithology are listed in Table 12.11. Only mitigation measures that would apply specifically to Intertidal and Offshore Ornithology issues associated with the study area are described.

Table 12.11 Embedded mitigation relating to Intertidal and Offshore Ornithology

Parameter	Mitigation measures embedded into the Project design
Site selection	The Order Limits selection was made following a series of constraints analyses, with the AfL array area, the array area, ANS and benthic compensation areas and Offshore ECC route selected to ensure the impacts on sensitive environmental receptors are minimised. As detailed in the Site Selection and Consideration of Alternatives chapter (Volume 1, Chapter 4 (document reference 6.1.4), the array area reduction from the 500km^2 AfL array area to the 436 km^2 ES array area took into account the densities of bird species across the array, in particular areas of high density for auks.
Minimum tip height	The design of the Project includes an air gap of 40m relative to MSL, being above the minimum air gap (22 m relative to MHWS (MCA, 2021)). Increasing the minimum tip height reduces the number of bird collisions.
Best practice protocol	Best practice protocol will be utilised during construction, operation and maintenance and decommissioning works to minimise disturbance of offshore ornithological receptors, especially red-throated divers and common scoter, through the following: ▪ Where possible, minimising vessel traffic during the most sensitive time in October to March; ▪ Where possible, restricting vessel movement to existing navigation routes; ▪ Where possible, maintaining direct transit routes, minimising transit distances through areas used by key species; ▪ Avoidance of rafting birds when necessary to go outside of navigational routes, and where possible avoid disturbance to areas with consistently high diver density; ▪ Avoidance of over-revving engines to minimise noise disturbance; and ▪ Briefing of vessel crew on the purpose and implications of these vessel management practices.

12.6 Assessment Methodology

65. 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.

66. These criteria have been adapted 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 aligned with the key guidance on ecological impact assessments from CIEEM (2022) and the PD 6900:2015 Environmental impact assessment for offshore renewable energy projects - Guide (British Standards Institute 2015).

67. 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 the Project'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.

68. The vulnerability of a receptor is one of the core components of the assessment of potential impacts and their effects on ornithological receptors. The conservation value of each receptor is also taken into account when coming to a reasoned judgement on the definition of the overall sensitivity of any receptor to any potential impact or effect. In that reasoned judgement account must 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 vulnerable to disturbance given its propensity to exploit a wide range of food resources and to utilise man-made resources 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. The vulnerability of receptors is defined in Table 12.12.

Table 12.12 Definitions of vulnerability levels of ornithological receptors

Receptor sensitivity/importance	Definition
Major	Bird species has very limited tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people.
Moderate	Bird species has limited tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people.
Minor	Bird species has some tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people.
Negligible	Bird species is generally tolerant of sources of disturbance such as noise, light, vessel movements and the sight of people.

69. The population from which individuals are predicted to originate also contributes to the conservation value of ornithological receptors. Conservation value levels assigned to birds reflects the current understanding of movements of the relevant species, with site-based protection (e.g. SPAs) generally limited to specific time-periods (e.g. the breeding season). Conservation value can therefore vary throughout 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. The conservation value assigned to a species will correspond to the degree of connectivity predicted between the proposed OWF, and protected populations. In Table 12.13 below, the criteria for defining conservation value are presented, with values assigned to species likely to vary throughout the year.

Table 12.13 Conservation value level definitions for ornithological receptors

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

70. The overall sensitivity of ornithological receptors in the assessment is determined from expert judgement (CIEEM, 2019), based on both the vulnerability (Table 12.12) and conservation value (Table 12.13) of each receptor.

71. Impacts on receptors are also judged based on their magnitude, referring to the scale of an impact; this is determined on a quantitative basis where possible. The impact magnitude may relate, for example, to the area of habitat lost to the development footprint in the case of a habitat feature or predicted loss of individuals in the case of a population of a species of bird. Four levels are used to determine impact magnitude, detailed in Table 12.14 below.

Table 12.14 Impact magnitude definitions for an ornithological receptor

Magnitude	Description/reason
High	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that is predicted to irreversibly alter the population in the short to long-term and to alter the long-term viability of the population and/or the integrity of the protected site. Recovery from that change predicted to be achieved in the long-term (i.e. more than five years) following cessation of the development activity.
Medium	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that occurs in the short and long-term, but which is not predicted to alter the long-term viability of the population and/or the integrity of the protected site. Recovery from that change predicted to be achieved in the medium-term (i.e. no more than five years) following cessation of the development activity.
Low	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that is sufficiently small-scale or of short duration to cause no long-term harm to the feature/population. Recovery from that change predicted to be achieved in the short-term (i.e. no more than one year) following cessation of the development activity.
Negligible	Very slight change from the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site. Recovery from that change predicted to be rapid (i.e. no more than circa six months) following cessation of the development activity.

72. The potential significance of the effect upon ornithological receptors is determined by considering the magnitude of the impact (Table 12.14) and the sensitivity of the receptor (Table 12.12). The method used to determine effect significance is presented in Table below, and definitions of each level of significance in Table 12.16. For the purposes of this assessment, any effects determined to have a significance level of 'minor' or less are deemed to be not significant in terms of the EIA Regulations.

Table 12.15 Matrix to determine effect significance

		Magnitude of impact			
		Negligible	*Low*	*Medium*	*High*
Sensitivity of receptor	*Negligible*	Negligible (Not significant)	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)
	Low	Negligible (Not significant)	Minor (Not significant)	Minor (Not significant)	Moderate (Significant)
	Medium	Minor (Not significant)	Minor (Not significant)	Moderate (Significant)	Major (Significant)
	High	Minor (Not significant)	Moderate (Significant)	Major (Significant)	Major (Significant)

73. The latest CIEEM guidance (CIEEM, 2022) suggests that, in addition to the matrix approach, conclusions should also incorporate expert judgement throughout the process. CIEEM also now suggests that some form of consideration should be provided in the confidence of assessments for each species/impact. This may be strong where evidence is agreed in terms of impact levels or when robust survey data is used within the assessments. Confidence in the assessment is deemed lower where, for example, there is less data or evidence underpinning the assessments.

Table 12.16 Definition of Impact Significance

Impact Significance	Definition
Major	Very large or large change in receptor condition, either adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and/or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision-making process.
Negligible	No discernible change in receptor condition.

12.7 Impact Assessment: Construction phase

74. The impacts of the offshore construction of the Project have been assessed on offshore and intertidal ornithology. The impacts resulting from the construction of the Project are presented in Table 12.10, along with the MDS which formed the basis of these impact assessment.

12.7.1 Disturbance and Displacement

75. During the construction phase of the Project, disturbance and subsequent potential displacement of seabirds may be caused by a range of drivers, including vessel movements (both major construction vessels and smaller crew transfer or support vessels), general WTG construction activities, and the physical presence of partially or wholly constructed but not operational WTGs or other installed infrastructure, though it is acknowledged that these are likely to be both spatially and temporally limited. As the construction phase progresses, more WTGs will be erected in the array area and the spatial scale will increase until a point when the entire array area is constructed, but not yet operational, and may present a similar displacement stimulus as is described for the O&M phase.
76. This section will consider both displacement within the array area and within the offshore ECC (which contain the ORCPs), Biogenic reef and ANS areas for relevant species.
77. Displacement of individual birds from an area could theoretically, at an extreme level, lead to the mortality of individuals (Searle *et al*., 2018), though this is considered unlikely during the construction phase of an OWF as disturbing activities are spatially and temporally restricted.
78. The susceptibility of seabirds to displacement from construction activities varies between species. An overview of this variation is provided by Dierschke *et al*. (2016), noting inter-species variation in both avoidance and attraction towards OWFs. Notably, guillemot, razorbill, puffin, common scoter and red-throated diver have all shown to exhibit behavioural responses to OWF construction activities and may be displaced as a consequence. Fulmar, gannet and gulls are not considered susceptible to disturbance since they are often associated with fishing boats (e.g. Camphuysen, 1995; Hüppop and Wurm, 2000), and have also been noted in association with both construction vessels at the Greater Gabbard Offshore Windfarm (GGOWL, 2011) and close to active foundation piling activity at the Egmond aan Zee (OWEZ) windfarm, where they showed no noticeable reactions to the works (Leopold and Camphuysen, 2007).

79. In order to identify species present within the Project array area and 4km buffer that may be susceptible to displacement and requiring further assessment, a screening process was undertaken. Species screened in/out are presented in Table 12.17. These species have been agreed with stakeholders through the EPP (Table 12.3). The relative frequency and abundances for each species used in the screening process were assigned qualitatively through assessment of the baseline survey data. Generally, low frequency refers to species present within the study area on only one or slightly more than one occasion during the survey programme. Medium frequency was used to describe species routinely present in the aerial survey study area during a particular season, or with patchy abundance across multiple seasons, whilst the high frequency descriptor was reserved for species recorded on most or all surveys. The abundance descriptors were used to describe numbers of birds relative to the background population from which they likely originated. Modelled abundance and frequencies for each species can be found in Volume 2, Chapter 12.1: Offshore and Intertidal Ornithology Technical Baseline.

80. Species which were only recorded in low numbers and/or frequencies within the Project array area and 4km buffer or had a low sensitivity to disturbance and displacement were screened out of further assessment, with agreement from Natural England. For species screened into further assessment, matrix-based assessments of displacement were carried out.

Table 12.17 Screening of seabird species recorded within the Project array area and 4km buffer for risk of disturbance and displacement during the construction phase

Receptor	Sensitivity to disturbance and displacement **	Relative frequency in the array area and 4km buffer	Relative abundance in the array area and 4km buffer	Screening result (in or out)
Common scoter*	Major	Low	Low	In
Oystercatcher	Unknown	Low	Low	Out
Kittiwake	Minor	High	High	Out
Great black-backed gull	Negligible	Medium	Medium	Out
Herring gull	Negligible	Medium	Medium	Out
Lesser black-backed gull	Negligible	Medium	Medium	Out
Common gull	Minor	Medium	Low	Out
Little gull	Moderate	Low to Medium	Low	Out
Black-headed gull	Minor	Low to Medium	Low	Out
Sandwich tern	Minor	Low to Medium	Low to Medium	Out
Common tern	Minor	Low	Medium	Out
Arctic tern	Minor	Low	Low	Out

Receptor	Sensitivity to disturbance and displacement **	Relative frequency in the array area and 4km buffer	Relative abundance in the array area and 4km buffer	Screening result (in or out)
Arctic skua	Minor	Low	Low	Out
Great skua	Minor	Low	Low	Out
Guillemot	Moderate	High	High	In
Razorbill	Moderate	High	High	In
Puffin	Moderate	High	Medium to High	In
Little auk	Moderate	Low	Low	Out
Red-throated diver	Major	Medium	Low to Medium	In
Great northern diver	Major	Low	Low	Out
Manx shearwater	Moderate	Low	Low	Out
Fulmar	Minor	Medium	Low	Out
Gannet	Minor to Moderate	High	Medium	In
Shag	Negligible	Low	Low	Out

*Included for assessment in the ECC only. **Bradbury *et al*. (2014); Dierschke *et al*. (2016)

81. Based on the screening process outlined above, guillemot, razorbill, puffin and red-throated diver have been screened in owing to their sensitivity to disturbance and displacement and/or their abundance in the Project survey area. Therefore, these species are considered further in relation to impacts from disturbance and displacement during the construction phase of the Project.
82. Notably, gannet has been screened in for assessment of displacement in the array area despite showing low to medium sensitivity to displacement. This has been done on a precautionary basis as this species may be influenced by construction activities, and in order to provide Natural England and the RSPB with confidence that any potential effects on gannet during the construction phase are considered in a quantitative manner.

83. It is acknowledged that while kittiwake is considered for displacement risk in assessments for Scottish sites based on recent guidance (NatureScot, 2023), it is not considered at risk of displacement based on advice provided by Natural England through the EPP process. Additionally, although the sensitivity of fulmar and Manx shearwater to displacement is considered variable (i.e., low in Bradbury *et al*. (2014), but higher in Diserschke *et al.* (2016)), their large foraging range and habitat flexibility score (as defined by Woodward *et al.* (2019) and Furness *et al.* (2013)) suggest this species will not be impacted by displacement impacts resulting from the Project. Finally, although Sandwich tern has been considered at risk of displacement for other projects, the Project is located at the extent of the mean max foraging range plus 1 SD of this species from the North Norfolk Coast SPA, and therefore any impacts resulting from displacement are considered minimal. These species are, therefore, not considered further in relation to displacement effects during the construction phase.

84. This section also considers species at risk of displacement within the offshore ECC (containing the ORCP areas, and a proportion of the areas identified for biogenic reefs), since the Project ECC has an area of approximately 151.2km^2 which directly overlaps with the Greater Wash SPA. The Greater Wash SPA hosts two designated species which are considered sensitive to disturbance and displacement from vessel activity: red-throated diver and common scoter. Both of these species have been shown to be sensitive to vessels at a distance of up to 1km (Schwemmer et al., 2011; Bradbury et al., 2014). Red-throated diver is therefore considered in relation to potential impacts resulting from displacement in both the array area and in the offshore ECC. Additionally, while common scoter was not recorded during the digital aerial surveys within the array area, they were screened in for disturbance within the Offshore ECC as a precautionary approach, owing to their high sensitivity to disturbance and displacement and the importance of the Greater Wash SPA for this species. This approach was agreed through the EPP (Section 12.3).

85. Risk of displacement from construction activities associated with Biogenic reef, ANS and ORCPs is also considered. Impacts from these activities are anticipated to result from vessel disturbance, with disturbance minimised due to the construction periods for these structures and the Array not overlapping. Many species considered for displacement are not sensitive to vessel disturbance (for example guillemot, razorbill and puffin), so displacement risk is confined to common scoter and red-throated diver. Impacts from displacement related to Biogenic reef, ANS and ORCP construction will be restricted to very low levels of vessel traffic (for example, a single vessel cluster for the construction of each ANS), so impacts in areas where bird numbers are anticipated to be low already (as structures will be located within 10km buffers of other OWF projects) are anticipated to be very low indeed.

86. Following the screening process, an assessment of displacement has been carried out for the Project. The assessment has been based on the following set of scenarios and assumptions that recognise that construction activities will be both temporally and spatially restricted:

- Construction activities being undertaken within only a small portion of the array area and Offshore ECC at any one time;

- Potential displacement will only occur in the array area, Biogenic reef, ORCP, ANS and Offshore ECC, where vessels and construction activities are present; and
- Construction activities are temporally restricted (over a maximum of 48 months).

87. The potential impacts on screened in species are assessed against the MDS outlined in Table 12.10. It should be noted that a large proportion of the ECC, ANS or Biogenic reef areas was not covered within baseline digital aerial surveys, and therefore data provided by Lawson *et al.* (2016) have been used to assess the densities and distributions of red-throated diver and common scoter within in the Greater Wash SPA. This is a robust dataset collected over multiple years of survey and the best source of data available at this time.
88. There are few studies which have provided definitive empirical displacement rates for the construction phase of OWF developments. Krijgsveld *et al.,* (2011) demonstrated higher flight paths of gannets next to operating vs non-operating WTGs. Displacement rates for auks during construction have been shown to be either significantly lower or comparable to the O&M phase (Royal Haskoning, 2013; Vallejo *et al*., 2017). These studies suggest that although the level of disturbance from construction activities can be high it is focussed around a spatially restricted area within the development. Therefore, displacement rates for the entire site reflect reduced displacement within the site away from construction areas including areas where built non-operational WTGs are present.
89. For the assessment of displacement in the array area during the construction phase, displacement rates used were half of those used in the O&M phase based on SNCB guidance (MIG-Birds, 2022). This approach is biologically realistic based on the limited available evidence, while still providing a sufficiently precautionary approach. For a full justification of rates used, reference should be made to the assessment of the operational phase (Section 12.8). For gannet, guillemot, razorbill and puffin, displacement effects are considered within the array area and a 2km buffer, based on Natural England guidance (MIG-Birds, 2022). For red-throated diver, effects are considered within the array area and a 4km buffer. The level of displacement used during the construction phase for the species assessed is provided below:
    - For gannet, a displacement rate of 35% is presented as the Applicant’s approach, with a range of 30-40% also presented;
    - For auk species (guillemot, razorbill and puffin), a displacement rate of 25% is presented as the Applicant’s approach, with a range of 15-35% also presented;
    - For red-throated diver a displacement rate of 50% is presented, as well as a range of 45-50%.
90. For the assessment of displacement in the offshore ECC, displacement rates for red-throated diver and common scoter were not halved, with rates instead based on the full rates recommended by current guidance (MIG-Birds, 2022):
    - For red-throated diver, a displacement rate of 100% is presented as the Applicants approach with a range of 90-100% also presented; and

- For common scoter, there are no rates specifically recommended for this species, however as a precautionary approach the same rates used for red-throated diver were applied.

91. A mortality rate of 1% is presented for all species as the Applicant's approach, however a range of 1-10% is also presented for auk species, and red-throated diver (and consequently also for common scoter) as recommended by SNCB guidance (MIG-Birds, 2022).

Common Scoter

Potential Magnitude of Effect – Offshore ECC, ANS, Biogenic reef and ORCP

92. Based on data by Lawson *et al.* (2016), an average density of 0.004 and a maximum density of 0.029 common scoters per km^2 are estimated to be present within the Project ECC. Based on a 2km buffer around each of the three cable-laying vessels, the area disturbed per vessel was calculated to be $12.6km^2$, resulting in a total worst-case area of $37.7km^2$ from which birds could be displaced. This is considered a precautionary approach, since vessels are unlikely to be spaced 2km apart at a given time. Biogenic reef, ANS and ORCP construction is likely to be restricted to single vessel clusters, at different periods from cable laying, so disturbance from these activities is anticipated to be small scale, short term and temporary.
93. Since a regional BDMPS population for common scoter is not included in Furness (2015), the predicted impacts are assessed against the Greater Wash SPA citation count of 3,449 individuals, which is considered a precautionary approach since this represents only a proportion of the birds which may potentially have connectivity to the Project. Based on a mortality rate of 0.226 (Table 12.9) the baseline mortality for this population is 769.8 individuals per annum.
94. Based on the average density of 0.004 birds per km^2, and the total disturbance of area of $37.7km^2$, less than one (0.1) common scoters are at risk of displacement. Of these, the total displacement consequent mortality is estimated at less than one (0.001) individual, based on 100% displacement and 1% mortality. Considering a displacement range of 90% to 100% and a mortality range of 1% to 10%, the total displacement and consequent mortality is estimated as 0.001 to 0.01 birds. This would represent a <0.01% increase even at the worst-case scenario of 100% displacement and 10% mortality, and therefore the impact is considered negligible.
95. Even using the over-precautionary maximum density of 0.7 birds per km^2, this increases to a mortality estimate of only 0.01 individuals, based on 100% displacement and 1% mortality, or a range of 0.01 – 0.1 birds based on 90% displacement and 1% mortality, and 100% displacement and 10% mortality respectively, representing a 0.001% – 0.012% increase in baseline mortality. This further precautionary assessment is therefore also assessed as a negligible magnitude. However, the use of the average density is considered more biologically relevant while still being precautionary, and therefore this will form the main basis of the assessment.

96. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of major, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms.**

97. Confidence in the conclusions of this assessment is high, as the scale of the impact is very small, site-specific (albeit older) data are used, the assessment is precautionary due to the assumptions made regarding vessel traffic, precautionary maximum densities are used, and impacts are presented within the context of the Greater Wash SPA population, rather than a larger BDMPS population.

Red-throated Diver

Potential Magnitude of Impact – Offshore ECC, ANS, Biogenic reef and ORCP

98. In addition to the information presented in the O&M section (Section 12.8), red-throated diver are considered to be particularly sensitive to human activities which may be occurring during the construction phase, notably disturbance effects of vessel and helicopter traffic and the presence of WTGs (Garthe and Hüppop 2004; Schwemmer *et al*., 2011; Furness and Wade 2012; Furness *et al*., 2013; Bradbury *et al*., 2014).

99. Birds are reported to avoid areas associated with shipping (e.g. Bellebaum *et al*., 2006; Irwin *et al*., 2019; Jarrett *et al*., 2018; Schwemmer *et al*., 2011), with birds recorded flushing due to the presence of ships, when up to 2km from the vessels (Fliessback et al. 2019), though the majority are expected to flush at 1km or less (Bellebaum et al., 2006; Jarrett et al., 2018; Topping and Petersen, 2011). As a precautionary approach, 100% displacement up to 2km from each of the three cable laying vessels is considered in this assessment, with a range of 90% to 100% also presented in line with SNCB guidance (MIG-Birds, 2022).

100. Based on data on red-throated diver densities presented by Lawson et al. (2016), an average density of 0.2 birds/km2 and a maximum density of 0.7 birds/km2 are estimated to be present within the Offshore ECC. Based on a 2km buffer around each of three construction vessels, the area disturbed per vessel was calculated to be 12.6km2, resulting in a total worst-case area of 37.7km2 from which birds could be displaced. This is considered a precautionary approach, since in reality vessels are unlikely to be spaced 2km apart at a given time, and there is also likely to be less than three vessels present at a time. Biogenic reef, ANS and ORCP construction is likely to be restricted to single vessel clusters, at different periods from cable laying, so disturbance from these activities is anticipated to be small scale, short term and temporary.

101. Based on the average density of 0.2 birds, and the total disturbance of area of 37.7km^2, a total of 9 (8.8) red-throated divers are at risk of displacement. Of these, the total displacement consequent mortality is estimated at less than one (0.1) individual, based on 100% displacement and 1% mortality. Considering a displacement range of 90% to 100% and a mortality range of 1% to 10%, the total displacement consequent mortality is estimated as 0.1 to 0.9 birds.

102. Based on the maximum density of 0.7 birds, this increases to a mortality estimate of 0.3 individuals, based on 100% displacement and 1% mortality, or a range of 0.2 – 2.6 birds based on 90% displacement and 1% mortality, and 100% displacement and 10% mortality respectively. However, the use of the average density is considered more biologically relevant while still being precautionary, and therefore this will form the main basis of the assessment.

103. The annual BDMPS population is defined as 13,277 individuals and, using the average baseline mortality rate of 0.228 (Table 12.9: Average mortality across all age classes. Average mortality calculated using age specific demographic rates and age class proportions.Table 12.9), the natural predicted mortality is 3,027 individuals per annum. The addition of less than one (0.2) mortality would increase baseline mortality by 0.006%.

104. The annual bio-geographic population is defined as 27,000 individuals. Using the average baseline mortality rate of 0.228 (Table 12.9) the natural predicted mortality is 6,156 individuals per annum. The addition of less than one (0.2) mortality would increase baseline mortality by 0.003%.

105. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of major, the effect significance is considered **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15. However, due to the impact being well under a single bird, an effect significance of **negligible** can be assumed here.

106. Confidence in the conclusions of this assessment is high due to precautionary displacement parameters used, the site-specific data, and the use of a maximum density to calculate impacts.

Potential magnitude of impact – array area

107. A mortality rate of 1% and a displacement rate of 50% were chosen for assessment of construction displacement and disturbance impacts on red-throated diver within the array area, based on rates being half of those assessed for the O&M phase. Based on the range of displacement and mortality rates suggested by SNCBs, an additional range is presented in Table 12.18using a mortality rate of 1% to 10% and displacement rate of 45% to 50%. However, the Applicant's approach of using a 1% mortality rate and 50% displacement for the construction phase will form the focus of the impact assessment. The magnitude of this impact is assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

108. During the breeding bio-season, the mean peak abundance for red-throated diver is 15 (15.0) individuals within the array area plus 4km buffer. Using a displacement rate range of 50% and a mortality rate 1% results in less than one (0.007) red-throated diver being subject to mortality during the migration-free breeding bio-season per annum. The regional population in the migration-free breeding bio-season is defined as 13,277 individuals and, using the average baseline mortality rate of 0.228 (Table 12.9), the natural predicted mortality in the migration-free breeding bio-season is 3,027 individuals per annum. The addition of less than one predicted mortality per annum would increase baseline mortality by 0.0003%.

109. This level of change is of negligible magnitude during the migration-free breeding bio-season, representing no discernible change to baseline mortality.

110. During the non-breeding bio-season, the mean peak abundance for red-throated diver is 188 (188.0) individuals within the array area plus 4km buffer. Using a displacement rate range of 50% and a mortality rate 1% results in less than 1 (0.094) red-throated diver being subject to mortality per annum. The regional population in the migration-free winter bio-season is defined as 10,177 individuals and, using the average baseline mortality rate of 0.235 (Table 12.9), the natural predicted mortality in the migration-free winter bio-season is 2,320 individuals per annum. The addition of less than one predicted mortality per annum would increase baseline mortality by 0.004%.

111. This level of change is considered to be of negligible magnitude during the migration-free winter bio-season, representing no discernible change to baseline mortality.

112. Across all bio-seasons combined, the total mean peak abundance for red-throated diver is 203 (203.0) individuals. The predicted maximum number of red-throated diver subject to mortality due to displacement from the Project is less than one (0.1) individual per annum, based on a displacement rate of 50% and a mortality rate of 1%. Using the largest UK North Sea and English Channel BDMPS of 13,277 individuals (Furness, 2015) and using the average baseline mortality rate of 0.228 (Table 12.9), the natural predicted mortality across all seasons is 3,027 per annum. The addition of less than one predicted mortality would increase the baseline mortality rate by 0.004%. When considering displacement impacts at the wider biogeographic population scale, then of the 27,000 population the natural annual mortality rate would be 6,156 individuals per annum. The addition of less than one predicted mortality would increase the biogeographic baseline mortality rate by 0.002%.

113. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains below 1%, and can therefore be considered to make no material difference to the baseline mortality of the species.

114. This level of change is considered to be of negligible (not significant) magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of major (Bradbury *et al*., 2014), the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15. However, due to the impact being well under a single bird, an effect significance of **negligible** can be assumed here.

115. Confidence in the conclusions of this assessment is high due to precautionary displacement parameters used, the site-specific data, the low level of impact and the use of a maximum density to calculate impacts.

Table 12.18 Bio-season displacement estimates for red-throated diver for the Project (construction phase)

Bio-season (months)	Seasonal abundance (array area plus 4km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during construction phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	50% displacement, 1% mortality	45-50% displacement, 1-10% mortality	50% displacement, 1% mortality	45-50% displacement, 1-10% mortality
Breeding (May-Sep)	15	13,277	3,027	0.007	0.006 – 0.07	0.0003	0.0002 – 0.002
Non-breeding (Oct – Apr)	188	10,177	2,320	0.094	0.085 – 0.94	0.004	0.004 – 0.041
Annual (BDMPS)	203	13,277	3,027	0.101	0.091 – 1.01	0.004	0.003 – 0.036
Annual (biogeographic)	203	27,000	6,156	0.101	0.091 – 1.01	0.002	0.001 – 0.016

Guillemot

Potential magnitude of impact – array area

116. A mortality rate of 1% and a displacement rate of 25% were chosen for assessment of guillemot, based on rates being half of those assessed for the O&M phase (paragraph 0). Based on the range of displacement and mortality rates suggested by SNCBs, an additional range is presented in Table 12.19using a mortality rate of 1% to 10% and displacement rate of 15% to 35%. However, the Applicant's approach of using a 1% mortality rate and 25% displacement for the construction phase will form the main focus of the impact assessment. The magnitude of this impact is assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

117. During the breeding bio-season, the mean peak abundance for guillemot is 16,445 (16,445.3) individuals within the array area plus 2km buffer. Using a displacement rate of 25% and a mortality rate of 1% results in 41 (41.1) guillemot being subject to mortality during the breeding season per annum. The regional population in the breeding bio-season is defined as 2,045,078 individuals and, using the average baseline mortality rate of 0.14 (Table 12.9), the natural predicted mortality in the breeding bio-season is 286,311 individuals per annum. The addition of 41 (41.1) predicted mortalities per annum would increase baseline mortality by 0.014%.

118. This level of change is considered to be of negligible magnitude during the breeding bio-season, representing no discernible change to baseline mortality.

119. During the non-breeding bio-season, the mean peak abundance for guillemot is 11,208 (11,208.0) individuals within the array area plus 2km buffer. Using a displacement rate of 25% and a mortality rate of 1% results in 28 (28.0) guillemots being subject to mortality during the non-breeding season per annum. The regional population in the non-breeding bio-season is defined as 1,617,306 individuals and, using the average baseline mortality rate of 0.14, the natural predicted mortality in the non-breeding bio-season is 226,422 individuals per annum. The addition of 28 predicted mortalities per annum would increase baseline mortality by 0.012%

120. This level of change is considered to be of negligible magnitude during the non-breeding bio-season, representing no discernible change to baseline mortality.

121. Across all bio-seasons combined, the total mean peak abundance for guillemot is 27,653 (27,653.3) individuals. The predicted maximum number of guillemot subject to mortality due to displacement from the Project is 69 (69.1) individuals per annum, based on a displacement rate of 25% and a mortality rate of 1%. Using the largest UK North Sea and English Channel BDMPS of 1,617,306 individuals (Furness, 2015) and the average baseline mortality rate of 0.14, the natural predicted mortality across all seasons is 226,422 per annum. The addition of 69 predicted mortalities would increase the baseline mortality rate by 0.030%. When considering displacement impacts at the wider biogeographic population scale, then of the 4,125,000 population the natural annual mortality rate would be 577,500 individuals per annum. The addition of 69 predicted mortalities would increase the biogeographic baseline mortality rate by 0.012%.

122. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of this species.

123. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.16.

124. Confidence in the conclusions of this assessment is high due to the site-specific data used in the assessment, the precautionary displacement and mortality rates used, and the temporary nature of the displacement at this phase.

Table 12.19 Bio-season displacement estimates for guillemot for the Project (construction phase)

Bio-season (months)	Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during construction phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	25% displacement, 1% mortality	15-35% displacement, 1-10% mortality	25% displacement, 1% mortality	15-35% displacement, 1-10% mortality
Breeding (Mar-Jul)	16,445	2,045,078	286,311	41.1	24.7 – 575.6	0.014	0.008 – 0.203
Non-breeding (Aug-Feb)	11,208	1,617,306	226,422	28.0	16.8 – 392.3	0.012	0.007 – 0.175
Annual (BDMPS)	27,653	1,617,306	226,422	69.1	41.5 – 967.9	0.030	0.018 – 0.433
Annual (biogeographic)	27,65345,421	4,125,000	577,500	69.1	41.5 – 967.9	0.012	0.007 – 0.170

Razorbill

Potential magnitude of impact – array area

125. A mortality rate of 1% and a displacement rate of 25% were chosen for assessment of razorbill, based on rates being half of those assessed for the O&M phase (paragraph 0). Based on the range of displacement and mortality rates suggested by SNCBs, an additional range is presented in Table 12.20 using a mortality rate of 1% to 10% and displacement rate of 15% to 35%. However, the Applicant's approach of using a 1% mortality rate and 25% displacement for the construction phase will form the main focus of the impact assessment. The magnitude of this impact is assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

126. During the return migration bio-season, the mean peak abundance for razorbill is 6,210 individuals within the array area plus 2km buffer. Using a displacement rate of 25% and a mortality rate 1% results in 15.52 razorbill being subject to mortality during the return. migration bio-season per annum. The regional population in the return migration bio-season is defined as 591,874 individuals and, using the average baseline mortality rate of 0.174 (Table 12.9), the natural predicted mortality in the breeding bio-season is 102,986 individuals per annum. The addition of 16 predicted mortalities per annum would increase baseline mortality by 0.015%.

127. This level of change is considered to be of negligible magnitude during the return migration bio-season, representing no discernible change to baseline mortality.

128. During the migration-free breeding bio-season, the mean peak abundance for razorbill is 3,596 individuals within the array area plus 2km buffer. Using a displacement rate of 25% and a mortality rate 1% results in nine (8.99) razorbill being subject to mortality during the migration-free breeding bio-season per annum. The regional population in the migration-free breeding bio-season is defined as 282,582 individuals and, using the average baseline mortality rate of 0.174, the natural predicted mortality in the migration-free breeding bio-season is 49,169 individuals per annum. The addition of nine predicted mortalities per annum would increase baseline mortality by 0.018%.

129. This level of change is considered to be of negligible magnitude during the migration-free breeding bio-season, representing no discernible change to baseline mortality.

130. During the post-breeding migration bio-season, the mean peak abundance for razorbill is 2,390 individuals within the array area plus 2km buffer. Using a displacement rate of 25% and a mortality rate 1% results in six (5.97) razorbill being subject to mortality during the post-breeding migration bio-season per annum. The regional population in the post-breeding migration bio-season is defined as 591,874 individuals and, using the average baseline mortality rate of 0.1743 (Table 12.9), the natural predicted mortality in the post-breeding migration bio-season is 102,986 individuals per annum. The addition of six predicted mortalities per annum would increase baseline mortality by 0.005%.

131. This level of change is considered to be of negligible magnitude during the post-breeding migration bio-season, representing no discernible change to baseline mortality.

132. During the migration-free winter bio-season, the mean peak abundance for razorbill is 1,956 individuals within the array area plus 2km buffer. Using a displacement rate range of 25% and a mortality rate 1% results in five (4.89) razorbill being subject to mortality during the migration-free winter bio-season per annum. The regional population in the migration-free winter bio-season is defined as 218,622 individuals and, using the average baseline mortality rate of 0.174, the natural predicted mortality in the migration-free winter bio-season is 38,047 individuals per annum. The addition of five predicted mortalities per annum would increase baseline mortality by 0.013%.

133. This level of change is considered to be of negligible magnitude during the migration-free winter bio-season, representing no discernible change to baseline mortality.

134. Across all bio-seasons combined, the total mean peak abundance for razorbill is 14,152 individuals. The predicted maximum number of razorbill subject to mortality due to displacement from the Project is (35.4) individuals per annum, based on a displacement rate of 25% and a mortality rate of 1%. Using the largest UK North Sea and English Channel BDMPS of 591,874 individuals (Furness, 2015) and using the average baseline mortality rate of 0.174 , the natural predicted mortality across all seasons is 102,986 per annum. The addition of 35 predicted mortalities would increase the baseline mortality rate by 0.034%. When considering displacement impacts at the wider biogeographic population scale, then of the 1,707,000 population the natural annual mortality rate would be 297,018 individuals per annum. The addition of 35 predicted mortalities would increase the biogeographic baseline mortality rate by 0.011% (Table 12.15).

135. Over the range of displacement and mortality scenarios assessed the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of this species.

136. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

137. Confidence in the conclusions of this assessment is high due to the site-specific data used in the assessment, the precautionary displacement and mortality rates used, and the temporary nature of the displacement at this phase.

Table 12.20 Bio-season displacement estimates for razorbill for the Project (construction phase)

Bio-season (months)	Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during construction phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	25% displacement, 1% mortality	15-35% displacement, 1-10% mortality	25% displacement, 1% mortality	15-35% displacement, 1-10% mortality
Return migration (Jan-Mar)	6,210	591,874	102,968	15.5	9.3 – 217.4	0.015	0.008 – 0.190
Migration-free breeding (Apr-Jul)	3,596	158,662	49,169	8.9	5.3 – 125.9	0.018	0.017 – 0.411
Post-breeding migration (Aug-Oct)	2,390	591,874	102,968	5.9	3.5 – 83.7	0.006	0.003 – 0.073
Migration-free winter (Nov-Dec)	1,956	218,622	38,047	8.9	5.3 – 68.5	0.013-	0.007 – 0.162
Annual (BDMPS)	14,152	591,874	102,968	35.4	21.2 – 495.3	0.034	0.018 – 0.433
Annual (biogeographic)	14,152	1,707,000	297018	35.4	21.2 – 495.3	0.012	0.006 – 0.150

Puffin

Potential magnitude of impact – array area

138. A mortality rate of 1% and a displacement rate of 25% were chosen for assessment of puffin, based on rates being half of those assessed for the O&M phase (Paragraph 0). Based on the range of displacement and mortality rates suggested by SNCBs, an additional range is presented in Table 12.21using a mortality rate of 1% to 10% and displacement rate of 15% to 35%. However, the Applicant's approach of using a 1% mortality rate and 25% displacement for the construction phase will form the main focus of the impact assessment. The magnitude of this impact is assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

139. During the breeding bio-season, the mean peak abundance for puffin is 760 individuals within the array area plus 2km buffer. Using a displacement rate of 25% and a mortality rate 1% results in two (1.9) puffin being subject to mortality during the breeding bio-season per annum. The regional population in the breeding bio-season is defined as 868,689 individuals and, using the average baseline mortality rate of 0.167 (Table 12.9), the natural predicted mortality in the breeding bio-season is 145,071 individuals per annum. The addition of two predicted mortalities per annum would increase baseline mortality by 0.001%.

140. This level of change is considered to be of negligible magnitude during the breeding bio-season, representing no discernible change to baseline mortality.

141. During the non-breeding bio-season, the mean peak abundance for puffin is 637 individuals within the array area plus 2km buffer. Using a displacement rate of 25% and a mortality rate 1% results in two (1.6) puffins being subject to mortality during the non-breeding bio-season per annum. The regional population in the non-breeding bio-season is defined as 231,957 individuals and, using the average baseline mortality rate of 0.167, the natural predicted mortality in the non-breeding bio-season is 35,730 individuals per annum. The addition of two predicted mortalities per annum would increase baseline mortality by 0.005%.

142. This level of change is considered to be of negligible magnitude during the non-breeding bio-season, representing no discernible change to baseline mortality.

143. Across all bio-seasons combined, the total mean peak abundance for puffin is 1,397 individuals. The predicted maximum number of puffin subject to mortality due to displacement from the Project is four (3.5) individuals per annum, based on a displacement rate of 25% and a mortality rate of 1%. Using the largest UK North Sea and English Channel BDMPS of 231,957 individuals (Furness, 2015) and using the average baseline mortality rate of 0.167, the natural predicted mortality across all seasons is 35,730 per annum. The addition of four predicted mortalities would increase the baseline mortality rate by 0.011%. When considering displacement impacts at the wider biogeographic population scale, then of the 11,840,000 population the natural annual mortality rate would be 1,977,280 individuals per annum. The addition of four predicted mortalities would increase the biogeographic baseline mortality rate by less than 0.001%.

144. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of this species.

145. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

146. Confidence in the conclusions of this assessment is high due to the site-specific data used in the assessment, the precautionary displacement and mortality rates used, the low levels of predicted impact, and the temporary nature of the displacement at this phase.

Table 12.21 Bio-season displacement estimates for puffin for the Project (construction phase)

Bio-season (months)	Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during construction phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	25% displacement, 1% mortality	15-35% displacement, 1-10% mortality	25% displacement, 1% mortality	15-35% displacement, 1-10% mortality
Breeding (Apr-Jul)	760	868,689	145,071	1.9	1.1 – 26.6	0.001	0.006 – 0.017
Non-breeding (Aug-Mar)	637	231,957	35,730	1.5	0.9 – 22.3	0.005	0.002 – 0.05
Annual (BDMPS)	1397	231,957	35,730	3.5	2.1 – 48.9	0.011	0.004 – 0.120
Annual (biogeographic)	1397	11,840,000	1,977,280	3.5	2.1 – 48.9	0.000	0.000 – 0.002

Gannet

Potential magnitude of impact – array area

147. A mortality rate of 1% and a displacement rate of 35%, were selected for assessment of gannet, based on rates being half of those assessed for the O&M phase (Paragraph 228). Based on the range of displacement and mortality rates suggested by SNCBs, an additional range is presented in Table 12.22using a mortality rate of 1% and displacement rate of 30% to 40%. However, the Applicant's approach of using a 1% mortality rate and 35% displacement for the construction phase will form the main focus of the impact assessment. The magnitude of this impact is assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age-specific demographic rates and age class proportions presented in Table 12.9.

148. During the return migration bio-season, the mean peak abundance for gannet is 91 individuals within the array area plus 2km buffer. Using a displacement rate of 35% and a mortality rate 1% results in less than one (0.3) gannet being subject to mortality during the return migration bio-season per annum. The regional population in the return migration bio-season is defined as 248,385 individuals and, using the average baseline mortality rate of 0.191 (Table 12.9), the natural predicted mortality in the return migration bio-season is 47,442 individuals per annum. The addition of less than one predicted mortality per annum would increase baseline mortality by less than 0.001%.

149. This level of change is considered to be of negligible magnitude during the return migration bio-season, representing no discernible change to baseline mortality.

150. During the migration-free breeding bio-season, the mean peak abundance for gannet is 635 individuals within the array area plus 2km buffer. Using a displacement rate of 35% and a mortality rate 1% results in two (2.2) gannets being subject to mortality during the migration-free breeding bio-season per annum. The regional population in the migration-free breeding bio-season is defined as 400,325 individuals and, using the average baseline mortality rate of 0.191, the natural predicted mortality in the migration-free breeding bio-season is 76,4621 individuals per annum. The addition of two mortalities per annum would increase baseline mortality by 0.003%.

151. This level of change is considered to be of negligible magnitude during the migration-free breeding bio-season, representing no discernible change to baseline mortality.

152. During the post-breeding migration bio-season, the mean peak abundance for gannet is 496 individuals within the array area plus 2km buffer. Using a displacement rate of 35% and a mortality rate 1% results in two (1.7) gannet being subject to mortality per annum. The regional population in the post-breeding migration bio-season is defined as 456,298 individuals and, using the average baseline mortality rate of 0.191 (Table 12.9), the natural predicted mortality in the post-breeding migration bio-season is 87,151 individuals per annum. The addition of less than two predicted mortality per annum would increase baseline mortality by 0.002%.

153. This level of change is considered to be of negligible magnitude during the post-breeding migration bio-season, representing no discernible change to baseline mortality.

154. Across all bio-seasons combined, the total mean peak abundance for gannet is 1,222 individuals. The predicted maximum number of gannets subject to mortality due to displacement from the Project is four (4.3) individuals per annum, based on a displacement rate of 35% and a mortality rate of 1%. Using the largest UK North Sea and English Channel BDMPS of 456,298 individuals (Furness, 2015) and using the average baseline mortality rate of 0.191, the natural predicted mortality across all seasons is 87,151 per annum. The addition of four predicted mortalities would increase the baseline mortality rate by 0.005%. When considering displacement impacts at the wider biogeographic population scale, then of the 1,180,000 population the natural annual mortality rate would be 225,380 individuals per annum. The addition of four predicted mortalities would increase the biogeographic baseline mortality rate by 0.002%.

155. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of this species.

156. This level of change is of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of minor to moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

157. Confidence in the conclusions of this assessment is high due to the site-specific data used in the assessment, the precautionary displacement and mortality rates used, the low levels of predicted impact, and the temporary nature of the displacement at this phase.

Table 12.22 Bio-season displacement estimates for gannet for the Project (construction phase)

Bio-season (months)	Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during construction phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	35% displacement, 1% mortality	30-40% displacement, 1% mortality	35% displacement, 1% mortality	30-40% displacement, 1% mortality
Return migration (Dec-Mar)	91	248,385	47,442	0.3	0.25 – 0.36	0.000	0.001 – 0.001
Migration-free breeding (Apr-Aug)	635	400,325	76,462	2.2	1.9 – 2.5	0.003	0.001 – 0.003
Post-breeding migration (Sep-Nov)	496	456,298	87,151	1.7	1.5 – 1.9	0.002	0.001 – 0.002
Annual (BDMPS)	1,222	456,298	87,151	4.3	3.7 – 4.9	0.005	0.004 – 0.006
Annual (biogeographic)	1,222	1,180,000	225,380	4.3	3.7 – 4.9	0.002	0.002 – 0.002

12.7.2 Indirect impacts due to impacts on prey

158. During construction of the Project, potential impacts on the availability of prey species may indirectly have effects on offshore birds. Increases in underwater anthropogenic noise resulting from, for example, piling activity may result in mobile prey species avoiding the construction area. Additionally, suspended sediments from construction activity in the array or along the Offshore ECC may result in fish and mobile invertebrates avoiding affected areas and may smother immobile benthic prey. The resulting increase in turbidity of the water column may also make it harder for seabirds to see their prey. These impacts could therefore result in a reduction in prey available to foraging seabirds within the construction area. The potential impacts on benthic invertebrates and fish have been assessed in Volume 1, Chapter 10 – Fish and Shellfish Ecology and Volume 2, Chapter 9 – Benthic Subtidal and Intertidal Ecology.

159. The main prey items of seabirds such as gannets and auks are species such as sandeels, herring and sprat. Impacts on these species may arise from underwater noise impacts and due to changes to the seabed and to increases in suspended sediment levels (also covered in Volume 2, Chapter 10 – Fish and Shellfish Ecology). Impacts arising from noise and suspended sediment and deposition during the construction phase are assessed to be minor (not significant) for all fish groups and therefore no impacts of note are expected.

160. Given the conclusion that the impacts arising from the construction of the Project will give rise to limited effects on prey species, the significance of effect on ornithological receptors is concluded to be **negligible, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

12.8 Impact Assessment: O&M phase

161. The impacts of the offshore O&M of the Project have been assessed on offshore and intertidal ornithology. The impacts resulting from the O&M of the Project are presented in Table 12.10, along with the MDS which formed the basis of these impact assessments.

12.8.1 Disturbance and displacement

162. The presence of WTGs and other infrastructure within the array area has the potential to directly disturb and displace seabirds that use this area. This may result in a reduced area in which those seabirds can forage, loaf or moult. Displacement may increase individual birds' energetic requirements, which at an extreme or repeated level could lead to the mortality of some individuals.

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

164. The joint interim displacement advice note (MIG-Birds, 2022) provides the latest advice for UK development applications on how to consider, assess and present information and potential consequences of seabird displacement from OWFs. This guidance note has been considered in preparing the following assessment.

165. Some species are more susceptible than others to disturbance from OWF operation, which may lead to displacement. Dierschke *et al*. (2016) noted both displacement and avoidance to varying degrees by some seabird species while others were attracted to OWFs.

166. A screening process was undertaken to identify those species of birds present within the Project survey area that may be at most risk of displacement. For the O&M phase, the screening process matched that completed for construction and decommissioning, with the omission of common scoter, since this species was only assessed for disturbance and displacement within the Offshore ECC during the construction phase (Table 12.17). Considering the screening outcome is identical to the construction and decommissioning, except the exclusion of common scoter, the table has not been re-presented here.

167. The five species that were screened in for assessment for disturbance and displacement within the array area are guillemot, razorbill, puffin, red-throated diver and gannet. Kittiwake, Sandwich tern, fulmar and Manx shearwater were not considered for displacement as justified in Paragraph 83.

Red-throated diver

Displacement rate evidence base

168. Red-throated diver has been identified as being particularly sensitive to human activities in marine areas, including through the disturbance effects of ship and helicopter traffic and the presence of WTGs (Garthe and Hüppop, 2004; Schwemmer *et al*., 2011; Furness and Wade, 2012; Furness *et al*., 2013; Bradbury *et al*., 2014). The below evidence of susceptibility to disturbance from the presence of WTGs is provided in addition to evidence presented in the Offshore ECC displacement assessment (Section 12.7) on susceptibility to disturbance from ship and helicopter traffic.

169. A review of red-throated diver displacement rates was provided for East Anglia ONE North and East Anglia TWO (MacArthur Green and Royal HaskoningDHV, 2021). The study consisted of a modelling analysis using survey data collected in the Outer Thames region between 2002-2018, from before any OWF construction began in the region (prior to 2005), through to completed construction of Kentish Flats, Gunfleet Sands, London Array, Thanet and Greater Gabbard. The model was run separately based on 2013 and 2018 density distributions. Using the 2013 model, the predicted reduction in density as a result of EA1N was predicted to be a maximum of 42.2% within the EA1N array area, with reduced impact in each buffer zone out to a maximum of 8km from the array area, beyond which there was no predicted decrease in density. Using the 2018 density distribution, the model predicted a 44.2% reduction in density within the EA1N array area and no reduction in density beyond 9km from the array area. It was noted that the total number of birds predicted to be displaced (34 based on 2013 data and 9 based on 2018 data) were similar to the numbers estimated using an approach of 100% displacement from the array area plus 4km buffer (40 and 12 birds displaced, based on 2013 and 2018 input data, respectively).

170. For the Project, the Applicant has considered a precautionary approach of 100% displacement, though a range of values between 90% and 100% are also presented based on SNCB guidance (MIG-Birds, 2022).

Mortality rate evidence base

171. There is currently no evidence that red-throated divers suffer mortality because of displacement. Displacement consequent mortality is likely to be a result of increased density of birds being displaced to areas with poorer feeding, or requirements to expend more energy in acquiring food. Red-throated divers typically forage for three to five hours during the non-breeding season, almost exclusively during daylight hours. This suggests that they may have the capacity to adapt to, or accommodate, changes that impact their energetic requirements (Thompson, 2023). However, these impacts are expected to be negligible, with literature reviews undertaken Norfolk Vanguard Ltd (2019b) and MacArthur Green and Royal HaskoningDHV (2021) identifying clear evidence that red-throated diver populations are not constrained by resources in wintering grounds, but rather by available breeding habitat. This would suggest that an increase in density in wintering areas as a result of displacement would not have a negative impact on survival, as there is more than sufficient resource to maintain the current population. The reviews also noted that considering the area of OWFs already constructed, and extensive vessel traffic within the North Sea, if displacement led to a 10% mortality rate, this ought to be evident from an increase in population-level mortality rates, but no such increase has been observed. Both Norfolk Vanguard Ltd (2019b) and MacArthur Green and Royal HaskoningDHV (2021) concluded that based on available evidence, even a 1% mortality rate is likely to be precautionary and presented this as the respective applicants' preferred value.

172. SNCB guidance (MIG-Birds, 2022) suggests a mortality rate of up to 10% for the assessment of red-throated divers when considered displacement and disturbance during the operation of an OWF. Considering the natural mortality of red-throated diver is 16% (Horswill and Robinson, 2015), the value of 10% is considered over-precautionary since it equates to over half the natural annual mortality rate. Therefore, a mortality rate of 1% will form the main basis of this assessment with a range of up to 10% also presented, in line with approaches used by recently submitted projects.

Potential magnitude of impact - Array area

173. This section considers the magnitude of impact on red-throated diver from the presence of WTGs and other infrastructure within the array area.

174. A mortality rate of 1% and a displacement rate of 100% were chosen for assessment of red-throated diver. Based on SNCB guidance (MIG-Birds, 2022), an additional displacement range of 90% to 100% and a mortality rate range of 1% to 10% is presented in Table 12.23. The magnitude of this impact is assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

175. During the breeding bio-season, the mean peak abundance for red-throated diver is 15 (15.0) individuals within the array area plus 4km buffer. Using a displacement rate range of 100% and a mortality rate 1% results in less than one (0.15) red-throated diver being subject to mortality during the migration-free breeding bio-season per annum. The regional population in the migration-free breeding bio-season is defined as 13,277 individuals and, using the average baseline mortality rate of 0.228, the natural predicted mortality in the migration-free breeding bio-season is 3,027 individuals per annum. The addition of less than one mortality per annum would increase baseline mortality by 0.005%.

176. This level of change is considered to be of negligible magnitude during the migration-free breeding bio-season, representing no discernible change to baseline mortality.

177. During the non-breeding bio-season, the mean peak abundance for red-throated diver is 188 (188.0) individuals within the array area plus 4km buffer. Using a displacement rate range of 100% and a mortality rate 1% results in two (1.88) red-throated diver being subject to mortality during the migration-free winter bio-season per annum. The regional population in the migration-free winter bio-season is defined as 10,177 individuals and, using the average baseline mortality rate of 0.228, the natural predicted mortality in the migration-free winter bio-season is 2,320 individuals per annum. The addition of two mortalities per annum would increase baseline mortality by 0.081%.

178. This level of change is considered to be of negligible magnitude during the migration-free winter bio-season, representing no discernible change to baseline mortality.

179. Across all bio-seasons combined, the total mean peak abundance for red-throated diver is 203 (203.0) individuals. The predicted maximum number of red-throated divers subject to mortality due to displacement from the Project is two (2.0) individuals per annum. An annual displacement matrix for red-throated diver within the array area plus a 4km buffer is also presented in Table 12.23 below. Using the largest UK North Sea and English Channel BDMPS of 13,277 individuals (Furness, 2015) and the average baseline mortality rate of 0.228, the natural predicted mortality across all seasons is 3,027 per annum. The addition of two predicted mortalities would increase the baseline mortality rate by 0.067%. When considering displacement impacts at the wider biogeographic population scale then, of the 27,000 population, the natural annual mortality rate would be 6,156 individuals per annum. The addition of two predicted mortalities would increase the biogeographic baseline mortality rate by 0.033%.

180. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of this species.

181. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of major, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

182. Confidence in the conclusions of this assessment is high due to the site-specific data used in the assessment, the precautionary displacement and mortality rates used, the low levels of predicted impact, and the flexibility within the foraging energy budgets red-throated divers in the non-breeding season.

Table 12.23 Bio-season displacement estimates for red-throated diver for the Project (O&M phase).

Bio-season (months)	Seasonal abundance (array area plus 4km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during O&M phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	100% displacement, 1% mortality	90-100% displacement, 1-10% mortality	100% displacement, 1% mortality	90-100% displacement, 1-10% mortality
Breeding (May-Sep)	15	13,277	3,027	0.15	0.1 – 1.5	0.000	0.0004 – 0.005
Non-breeding Oct – Apr)	188	10,177	2,320	1.88	1.69 – 18.8	0.081	0.0016 – 0.18
Annual (BDMPS)	203	13,277	3,027	2.03	1.82 – 20.3	0.067	0.065 – 0.73
Annual (biogeographic)	203	27,000	6,156	2.03	1.82 – 20.3	0.033	0.029 – 0.33

Table 12.24 Annual displacement matrix for red-throated diver within the Project array area plus 4km buffer, values in light blue represent the range-based values advocated by SNCBs and the darker shade of blue representing the Applicant's approach value.

Annual (Array + 4km Buffer)	Mortality Rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	1	2	4	6	8	10	12	14	16	18	20
20	0	1	2	4	8	12	16	20	24	28	32	37	41
30	1	1	3	6	12	18	24	30	37	43	49	55	61
40	1	2	4	8	16	24	32	41	49	57	65	73	81
50	1	2	5	10	20	30	41	51	61	71	81	91	102
60	1	2	6	12	24	37	49	61	73	85	97	110	122
70	1	3	7	14	28	43	57	71	85	99	114	128	142
80	2	3	8	16	32	49	65	81	97	114	130	146	162
90	2	4	9	18	37	55	73	91	110	128	146	164	183
100	2	4	10	20	41	61	81	102	122	142	162	183	203

Potential magnitude of impact - Offshore ECC

183. This section considers the magnitude of impact on red-throated diver from vessel disturbance during O&M within the offshore ECC. Disturbance in the intertidal ECC, ANS and ORCP areas were scoped out as described in the 'Impacts Scoped out of Assessment' Section.

184. Although red-throated diver is particularly sensitive to human activities such as vessel traffic, during the O&M phase of development, vessels will primarily be using existing, busy shipping lanes and follow vessel best guidance protocol as outlined in the Outline Vessel Management Plan (document reference 8.20). Therefore, impacts from displacement are not predicted to be significantly greater than baseline levels and will be restricted to routine and emergency maintenance activity.

185. Whether individual, isolated, structures, such as an ORCP or ANS have a displacement impact on red-throated diver is currently uncertain, with no studies having looked at this specifically. However, it is considered that any displacement effects would be much reduced compared to that seen from a windfarm, due to the lack of moving parts and the structures being substantially smaller than a WTG. For the ORCP which would be positioned within the Greater Wash SPA, the proposed locations are within 10km of existing windfarm projects (See Figure 12.2 of Volume 2, Appendix 12.1 [document reference: 6.2.12.1]) and therefore, it is considered that any displacement effect from the ORCPs would be contained within that from the existing baseline and therefore not contribute to any additional impact. For the ANSs, the density of red-throated diver is expected to be low within these areas and as such, any displacement is expected to be **negligible**.

186. The MDS clearly demonstrates that the vessel traffic is considerably lower during O&M compared to construction (Table 12.10). Therefore, any displacement impacts will be considerably lower than during construction for which the matrix approach concluded an impact to red-throated diver of negligible. For the ORCP and ANSs, it is expected that any displacement from the presence of these structures would be negligible. It can therefore be concluded that impacts to this species during O&M will be negligible or lower, which is not significant in EIA terms.

187. Red-throated diver winter in the Greater Wash SPA, therefore it should be noted that any disturbance from monitoring of ANS will not cause any disturbance to this species as it will occur in the breeding season when kittiwakes are breeding on the structures, and red-throated divers are absent.

Auk species

Displacement rate evidence base

188. 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). A review by Dierschke *et al*. (2016) has summarised auk displacement responses in relation to OWFs across thirteen European OWF sites, comparing changes in seabird abundance between baseline and post-construction surveys. From the review, the outcomes for auks was 'weak displacement' but highly variable across all OWFs. 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).

189. More recently, a summary of all current post-consent monitoring studies undertaken to date within the North Sea and UK western waters was submitted for the Hornsea Four OWF (Orsted, 2021b). The review was completed by APEM (APEM, 2022) and provides an extensive analysis of data from multiple OWFs, expanding work undertaken for other studies, such as that submitted by Norfolk Vanguard (2018). The review found auk displacement was highly variable within different study sites, ranging from attraction to no significant effects, to displacement effects. Across the studies analysed, positive displacement effects were observed at one OWF, no significant effect or weak displacement at eight OWFs, three had inferred displacement effects (but not statistically tested), and negative displacement was observed at eight OWFs. From studies which provided a defined displacement rate, rates ranged from +112% to -75%. Notably some study datasets were found to not be using the most appropriate statistical modelling methods for the data collected and coincidently had high displacement rates due to low abundance and high numbers of zero counts, making displacement rate prediction highly problematic given natural spatial and temporal variation in auk abundance and distribution. Consequently, displacement effects reported in these studies are considered to be likely unreliable. From this literature, it is concluded that a displacement rate of up to 50% for the array area and 2km buffer would be the most applicable, and also suitably precautionary for assessment.

190. A displacement rate of 50% as a precautionary approach is further supported by a review of OWF data in the German North Sea, undertaken by Peschko *et al.* (2020). The review indicated that guillemot displacement rates are reduced during the breeding season by approximately 20% compared with the non-breeding season, which is an important consideration given that the mean displacement rates derived from the Dierschke *et al*. (2016) review was predominantly from data collected in the non-breeding season.

191. Studies have also indicated that auks show habituation to OWFs with respect to displacement rates. Recently, this was demonstrated at the Thanet OWF, whereby statistically significant auk displacement was demonstrated, but only in the short term; from year two of post construction monitoring, abundances increased within the OWF, suggesting a level of habituation after one year of operation. Compared with the first year of operation, year two and three displacement rates fell from a range of 75% to 85% in year one, to a low of 31% to 41% (Royal Haskoning, 2013). There is also further emerging evidence as additional post-construction monitoring of OWFs continues, with reports of auk numbers increasing and observations of foraging behaviour within the windfarm itself (Leopold and Verdaat, 2018). This would suggest that displacement rates are expected to diminish over the operational life of OWFs.

192. Post construction monitoring at the Beatrice OWF has shown that although guillemot and razorbill distribution changed between the pre and post construction surveys, there is little evidence to suggest that this is in response to the presence of the windfarm as a whole, and that both species showed no avoidance of individual WTGs, even when active. Modelling of auk distribution was carried out in relation to real WTG distribution, in comparison with randomised WTG locations, on data collected in 2019 and 2021. Each year was analysed independently, and the model took rotor speed into account. The analyses demonstrated that birds within the array area did not avoid active WTGs.

193. Considering the above evidence, an auk displacement rate of 50% within the OWF array area and out to a 2km buffer is considered as strongly evidenced and also sufficiently precautionary.

Mortality rate evidence base

194. Considering mortality, current expert opinion has advised the use of a range of 1-10% mortality for guillemots and other auk species (MIG-Birds, 2022). However, it has been advised by environmental consultants working on behalf of a range of developers that 1% or 2% mortality is more appropriate (Norfolk Boreas Limited, 2019; SPR, 2019; Orsted, 2018). In support of this, anecdotal evidence has implied low additional auk mortality as a result of the Helgoland OWF cluster and Butendiek (Peschk *et al*., 2020).

195. In further support of a lower mortality rate, a study by van Kooten *et al*. (2019) demonstrated that a 1% mortality for displaced auks is more appropriate than the overly precautionary 10% rate. They also note that 1% is considered precautionary, considering the study reported a modelled additional non-breeding season mortality rate of 0.1% for a 50% displacement rate and 0.4% for a 100% displacement rate. It should also be noted that due to the large expanse of available habitat outside of the Project 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**.

196. Based on the above presented evidence, a displacement rate of 50% and a mortality rate of 1% are presented by the Applicant, deemed to be reflective of current available evidence whilst remaining sufficiently precautionary. To reflect the most recent SNCB guidance (MIG-Birds, 2022), a displacement range of 30-70% and a mortality range of 1-10% will also be presented.

Guillemot

Potential magnitude of impact

197. A mortality rate of 1% and a displacement rate of 50%, were selected for assessment of guillemot. Based on SNCB guidance (MIG-Birds, 2022), an additional displacement range of 30% to 70% and a mortality rate range of 1% to 10% is presented in Table 12.26. The magnitude of this impact is assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

198. During the breeding bio-season, the mean peak abundance for guillemot is 16,445 individuals within the array area plus 2km buffer. Using a displacement rate of 50% and a mortality rate 1% results in 82 (82.2) guillemots being subject to mortality during the breeding bio-season per annum. The regional population in the breeding bio-season is defined as 2,045,078 individuals and, using the average baseline mortality rate of 0.14 (Table 12.9), the natural predicted mortality in the breeding bio-season is 286,311 individuals per annum. The addition of 82 mortalities per annum would increase baseline mortality by 0.029%.

199. This level of change is considered to be of negligible magnitude during the breeding bio-season, representing no discernible change to baseline mortality.

200. During the non-breeding bio-season, the mean peak abundance for guillemot is 11,208 individuals within the array area plus 2km buffer. Using a displacement rate of 50% and a mortality rate 1% results in 56 (56.4) guillemots being subject to mortality during the non-breeding bio-season per annum. The regional population in the non-breeding bio-season is defined as 1,617,306 individuals and, using the average baseline mortality rate of 0.14, the natural predicted mortality in the non-breeding bio-season is 226,422 individuals per annum. The addition of 56 mortalities per annum would increase baseline mortality by 0.025%.

201. This level of change is considered to be of negligible magnitude during the non-breeding bio-season, representing no discernible change to baseline mortality.

202. Across all bio-seasons, the combined total mean peak abundance for guillemot is 27,653 individuals. The predicted maximum number of guillemots subject to mortality due to displacement from the Project is 138 (138.3) individuals per annum, based on a displacement rate of 50% and a mortality rate of 1%. An annual displacement matrix for guillemot within the array area plus a 2km buffer is presented in Table 12.26below. Using the largest UK North Sea and English Channel BDMPS of 1,617,306 individuals (Furness, 2015) and using the average baseline mortality rate of 0.14, the natural predicted mortality across all seasons is 226,422 per annum. The addition of 138 predicted mortalities would increase the baseline mortality rate by 0.061%. When considering displacement impacts at the wider biogeographic population scale, then of the 4,125,000 population the natural annual mortality rate would be 577,500 individuals per annum. The addition of 138 predicted mortalities would increase the biogeographic baseline mortality rate by 0.024%.

203. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of this species.

204. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of moderate, the effect significance is considered **minor (not significant)** at worst, based on the matrix approach defined in Table 12.15.

205. Confidence in the conclusions of this assessment is high due to the precautionary displacement and mortality rates used, the site-specific dataset, and the likelihood of habituation to WTGs over the lifespan of the project.

Table 12.25 Bio-season displacement estimates for guillemot for the Project (O&M phase).

Bio-season (months)	Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during O&M phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality
Breeding (Mar-Jul)	16,445	2,045,078	286,311	82.2	49.3 – 1,151	0.029	0.017 – 0.407
Non-breeding (Aug-Feb)	11,208	1,617,306	226,422	56.0	33.6 – 784	0.025	0.015 – 0.351
Annual (BDMPS)	27,653	1,617,306	226,422	138.2	82.9 – 1,935.7	0.061	0.037 – 0.867
Annual (biogeographic)	27,653	4,125,000	577,500	138.2	82.9 – 1,935.7	0.024	0.014 – 0.340

Table 12.26 Annual displacement matrix for guillemot within the Project array area plus 2km buffer, values in light blue represent the range-based values advocated by SNCBs and the darker shade of blue representing the Applicant's approach value.

Non-breeding (2km Buffer)	Mortality Rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	28	55	138	277	553	830	1,106	1,383	1,659	1,936	2,212	2,489	2,765
20	55	111	277	553	1,106	1,659	2,212	2,765	3,318	3,871	4,425	4,978	5,531
30	83	166	415	830	1,659	2,489	3,318	4,148	4,978	5,807	6,637	7,466	8,296
40	111	221	553	1,106	2,212	3,318	4,425	5,531	6,637	7,743	8,849	9,955	11,061
50	138	277	691	1,383	2,765	4,148	5,531	6,913	8,296	9,679	11,061	12,444	13,827
60	166	332	830	1,659	3,318	4,978	6,637	8,296	9,955	11,614	13,274	14,933	16,592
70	194	387	968	1,936	3,871	5,807	7,743	9,679	11,614	13,550	15,486	17,422	19,357
80	221	442	1,106	2,212	4,425	6,637	8,849	11,061	13,274	15,486	17,698	19,910	22,123
90	249	498	1,244	2,489	4,978	7,466	9,955	12,444	14,933	17,422	19,910	22,399	24,888
100	277	553	1,383	2,765	5,531	8,296	11,061	13,827	16,592	19,357	22,123	24,888	27,653

Razorbill

Potential magnitude of impact

206. A mortality rate of 1% and a displacement rate of 50%, were selected for assessment of razorbill. Based on SNCB guidance (MIG-Birds, 2022), an additional displacement range of 30% to 70% and a mortality rate range of 1% to 10% is presented in Table 12.27. The magnitude of this impact is assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

207. During the return migration bio-season, the mean peak abundance for razorbill is 5,537 individuals within the array area plus 2km buffer. Using a displacement rate range of 50% and a mortality rate 1% results in 27.7 razorbills being subject to mortality during the return migration bio-season per annum. The regional population in the return migration bio-season is defined as 591,874 individuals and, using the average baseline mortality rate of 0.174 (Table 12.9), the natural predicted mortality in the return migration bio-season is 102,986 individuals per annum. The addition of 27.7 mortalities per annum would increase baseline mortality by 0.026%.

208. This level of change is considered to be of negligible magnitude during the return migration bio-season, representing no discernible change to baseline mortality.

209. During the migration-free breeding bio-season, the mean peak abundance for razorbill is 3,596 individuals within the array area plus 2km buffer. Using a displacement rate range of 50% and a mortality rate 1% results in 18 (17.9) razorbills being subject to mortality during the migration-free breeding bio-season per annum. The regional population in the migration-free breeding bio-season is defined as 158,662 individuals and, using the average baseline mortality rate of 0.174 (Table 12.9), the natural predicted mortality in the migration-free breeding bio-season is 27,607 individuals per annum. The addition of 18 mortalities per annum would increase baseline mortality by 0.065%.

210. This level of change is considered to be of negligible magnitude during the migration-free breeding bio-season, representing no discernible change to baseline mortality.

211. During the post-breeding migration bio-season, the mean peak abundance for razorbill is 2,390 (2,390.0) individuals within the array area plus 2km buffer. Using a displacement rate range of 50% and a mortality rate 1% results in 12 (11.9) razorbills being subject to mortality during the post-breeding migration bio-season per annum. The regional population in the post-breeding migration bio-season is defined as 591,874 individuals and, using the average baseline mortality rate of 0.174 (Table 12.9), the natural predicted mortality in the post-breeding migration bio-season is 102,986 individuals per annum. The addition of 12 mortalities per annum would increase baseline mortality by 0.012%.

212. This level of change is considered to be of negligible magnitude during the post-breeding migration bio-season, representing no discernible change to baseline mortality.

213. During the migration-free winter bio-season, the mean peak abundance for razorbill is 1,956 individuals within the array area plus 2km buffer. Using a displacement rate range of 50% and a mortality rate 1% results in 10 (9.8) razorbills being subject to mortality during the migration-free winter bio-season per annum. The regional population in the migration-free winter bio-season is defined as 218,622 individuals and, using the average baseline mortality rate of 0.174 (Table 12.9), the natural predicted mortality in the migration-free winter bio-season is 38,047 individuals per annum. The addition of 10 mortalities per annum would increase baseline mortality by 0.025%.

214. This level of change is considered to be of negligible magnitude during the migration-free winter bio-season, representing no discernible change to baseline mortality.

215. Across all bio-seasons combined, the total mean peak abundance for razorbill is 13,479 individuals. The predicted maximum number of razorbills subject to mortality due to displacement from the Project is 67 (67.4) individuals per annum, based on a displacement rate of 50% and a mortality rate of 1%. An annual displacement matrix for razorbill within the array area plus a 2km buffer is presented in Table 12.28 below. Using the largest UK North Sea and English Channel BDMPS of 591,874 individuals (Furness, 2015) and using the average baseline mortality rate of 0.174 (Table 12.9), the natural predicted mortality across all seasons is 102,986 per annum. The addition of 67 predicted mortalities would increase the baseline mortality rate by 0.065%. When considering displacement impacts at the wider biogeographic population scale, then of the 1,707,000 population the natural annual mortality rate would be 297,018 individuals per annum. The addition of 67 predicted mortalities would increase the biogeographic baseline mortality rate by 0.023%.

216. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of this species.

217. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

218. Confidence in the conclusions of this assessment is high due to the precautionary displacement and mortality rates used, the site-specific dataset, and the likelihood of habituation to WTGs over the lifespan of the project.

Table 12.27 Bio-season displacement estimates for razorbill for the Project (O&M phase).

Bio-season (months)	Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during O&M phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality
Return migration (Jan-Mar)	5,537	591,874	102,986	27.6	16.6 – 387.5	0.026	0.014 – 0.339
Migration-free breeding (Apr-Jul)	3,596	158,662	27,607	17.9	10.7 – 251.7	0.065	0.035 – 0.822
Post-breeding migration (Aug-Oct)	2,390	591,874	102,986	11.9	7.1 – 167.3	0.012	0.006 – 0.146
Migration-free winter (Nov-Dec)	1,956	218,622	38,047	9.8	5.9 – 136.9	0.025	0.013 – 0.324
Annual (BDMPS)	13,479	591,874	102,986	67.4	42.4 – 943.5	0.065	0.035 – 0.826
Annual (biogeographic)	13,479	1,707,000	297,018	67.4	42.4 – 943.5	0.023	0.012 – 0.286

Table 12.28 Annual displacement matrix for razorbill within the Project array area plus 2km buffer, values in light blue represent the range-based values advocated by SNCBs and the darker shade of blue representing the Applicant's approach value.

Return migration (2km Buffer)	Mortality Rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	13	27	67	135	270	404	539	674	809	944	1,078	1,213	1,348
20	27	54	135	270	539	809	1,078	1,348	1,618	1,887	2,157	2,426	2,696
30	40	81	202	404	809	1,213	1,618	2,022	2,426	2,831	3,235	3,639	4,044
40	54	108	270	539	1,078	1,618	2,157	2,696	3,235	3,774	4,313	4,853	5,392
50	67	135	337	674	1,348	2,022	2,696	3,370	4,044	4,718	5,392	6,066	6,740
60	81	162	404	809	1,618	2,426	3,235	4,044	4,853	5,661	6,470	7,279	8,088
70	94	189	472	944	1,887	2,831	3,774	4,718	5,661	6,605	7,548	8,492	9,435
80	108	216	539	1,078	2,157	3,235	4,313	5,392	6,470	7,548	8,627	9,705	10,783
90	121	243	607	1,213	2,426	3,639	4,853	6,066	7,279	8,492	9,705	10,918	12,131
100	135	270	674	1,348	2,696	4,044	5,392	6,740	8,088	9,435	10,783	12,131	13,479

Puffin

Potential magnitude of impact

219. A mortality rate of 1% and a displacement rate of 50%, were selected for assessment of puffin. Based on SNCB guidance (MIG-Birds, 2022), an additional displacement range of 30% to 70% and a mortality rate range of 1% to 10% is presented in Table 12.31. The magnitude of this impact is assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

220. During the breeding bio-season, the mean peak abundance for puffins is 784 884 (883.8 individuals within the array area plus 2km buffer. Using a displacement rate range of 50% and a mortality rate 1% results in four (3.9) puffins being subject to mortality during the breeding bio-season per annum. The regional population in the breeding bio-season is defined as 868,689108,23 individuals and, using the average baseline mortality rate of 0.167 (Table 12.9), the natural predicted mortality in the breeding bio-season is 145,071 individuals per annum. The addition of four mortalities per annum would increase baseline mortality by 0.003%.

221. This level of change is considered to be of negligible magnitude during the breeding bio-season, representing no discernible change to baseline mortality.

222. During the non-breeding bio-season, the mean peak abundance for puffins is 645 individuals within the array area plus 2km buffer. Using a displacement rate range of 50% and a mortality rate 1% results in three (3.2) puffins being subject to mortality during the non-breeding bio-season per annum. The regional population in the non-breeding bio-season is defined as 231,957 individuals and, using the average baseline mortality rate of 0.167 (Table 12.9), the natural predicted mortality in the non-breeding bio-season is 35,730 individuals per annum. The addition of three mortalities per annum would increase baseline mortality by 0.008%.

223. This level of change is considered to be of negligible magnitude during the breeding bio-season, representing no discernible change to baseline mortality.

224. Across all bio-seasons combined, the total mean peak abundance for puffin is 1,429 individuals. The predicted maximum number of puffins subject to mortality due to displacement from the Project is seven (7.1) individuals per annum, based on a displacement rate of 50% and a mortality rate of 1%. An annual displacement matrix for puffin within the array area plus a 2km buffer is also presented in Table 12.30 below. Using the largest UK North Sea and English Channel BDMPS of 231,957 individuals (Furness, 2015) and using the average baseline mortality rate of 0.167 (Table 12.9), the natural predicted mortality across all seasons is 35,730 per annum. The addition of seven predicted mortalities would increase the baseline mortality rate by 0.019%. When considering displacement impacts at the wider biogeographic population scale, then of the 11,840,000 population the natural annual mortality rate would be 1,977,280 individuals per annum. The addition of seven predicted mortalities would increase the biogeographic baseline mortality rate by less than 0.001%.

225. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of this species.

226. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

227. Confidence in the conclusions of this assessment is high due to the precautionary displacement and mortality rates used, the site-specific dataset, the very low level of impact predicted. and the possibility of habituation to WTGs over the lifespan of the project.

Table 12.29 Bio-season displacement estimates for puffin for the Project (O&M phase).

Bio-season (months)	Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during O&M phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality
Breeding (Apr-Jul)	784	868,689	145,071	3.9	2.3 – 54.8	0.003	0.002 – 0.036
Non-breeding (Aug-Mar)	645	231,957	35,730	3.2	1.9 – 45.2	0.008	0.004 – 0.111
Annual (BDMPS)	1,429	231,957	35,730	7.1	4.3 – 100.0	0.019	0.010 – 0.246
Annual (biogeographic)	1,429	11,840,000	1,977,280	7.1	4.3 – 100.3	0.0003	0.000 – 0.004

Table 12.30 Annual displacement matrix for puffin within the Project array area plus 2km buffer, values in light blue represent the range-based values advocated by SNCBs and the darker shade of blue representing the Applicant's approach value.

Annual (2km Buffer)	Mortality Rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	3	7	14	29	43	57	71	86	100	114	129	143
20	3	6	14	29	57	86	114	143	171	200	229	257	286
30	4	9	21	43	86	129	171	214	257	300	343	386	429
40	6	11	29	57	114	171	229	286	343	400	457	514	572
50	7	14	36	71	143	214	286	357	429	500	572	643	715
60	9	17	43	86	171	257	343	429	514	600	686	772	857
70	10	20	50	100	200	300	400	500	600	700	800	900	1,000
80	11	23	57	114	229	343	457	572	686	800	915	1,029	1,143
90	13	26	64	129	257	386	514	643	772	900	1,029	1,157	1,286
100	14	29	71	143	286	429	572	715	857	1,000	1,143	1,286	1,429

Gannet

228. 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 windfarm (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%.

229. Based on available evidence, a displacement rate of 70% is presented by the Applicant. However, to reflect the most recent SNCB guidance (MIG-Birds 2022), a range of 60-80% is also presented.

230. A mortality rate of 1% was selected based on expert judgement supported by additional evidence that suggests that gannet have a large mean-maximum (315km) and maximum (709km) 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 Project array area and 2km buffer. This is further supported by information provided in Furness *et al*. (2013), which gives gannet a habitat use flexibility score of 1, indicating high flexibility in habitat use, and therefore indicating a low risk in mortality as a result of displacement impacts from the Project.

Potential magnitude of impact

231. A mortality rate of 1% and a displacement rate of 70%, were selected for assessment of gannet. Based on SNCB guidance (MIG-Birds, 2022), an additional displacement range of 60% to 80% is presented in Table 12.31. The magnitude of this impact is assessed against BDMPS non-breeding season populations (presented in Table 12.17) and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

232. During the return migration bio-season, the mean peak abundance for gannet is 91 individuals within the array area plus 2km buffer. Using a displacement rate range of 70% and a mortality rate 1% results in one (0.6) gannet being subject to mortality during the return migration bio-season per annum. The regional population in the return migration bio-season is defined as 248,385 individuals and, using the average baseline mortality rate of 0.191 (Table 12.9), the natural predicted mortality in the return migration bio-season is 47,442 individuals per annum. The addition of one mortality per annum would increase baseline mortality by 0.001%.

233. This level of change is considered to be of negligible magnitude during the return migration bio-season, representing no discernible change to baseline mortality.

234. During the migration-free breeding bio-season, the mean peak abundance for gannet is 635 individuals within the array area plus 2km buffer. Using a displacement rate range of 70% and a mortality rate 1% results in four (4.4) gannets being subject to mortality during the migration-free breeding bio-season per annum. The regional population in the migration-free breeding bio-season is defined as 400,325 individuals and, using the average baseline mortality rate of 0.191 (Table 12.9), the natural predicted mortality in the migration-free breeding bio-season is 76,462 individuals per annum. The addition of four mortalities per annum would increase baseline mortality by 0.005%

235. This level of change is considered to be of negligible magnitude during the migration-free breeding bio-season, representing no discernible change to baseline mortality.

236. During the post-breeding migration bio-season, the mean peak abundance for gannet is 496 individuals within the array area plus 2km buffer. Using a displacement rate range of 70% and a mortality rate 1% results in three (3.4) gannet being subject to mortality during the post-breeding migration bio-season per annum. The regional population in the post-breeding migration bio-season is defined as 456,298 individuals and, using the average baseline mortality rate of 0.191 (Table 12.9), the natural predicted mortality in the post-breeding migration bio-season is 87,151 individuals per annum. The addition of three predicted mortalities per annum would increase baseline mortality by 0.004%

237. This level of change is considered to be of negligible magnitude during the post-breeding migration bio-season, representing no discernible change to baseline mortality.

238. Across all bio-seasons combined, the total mean peak abundance for gannet is 1,222 individuals. The predicted maximum number of gannets subject to mortality due to displacement from the Project is nine (8.6) individuals per annum, based on a displacement rate of 70% and a mortality rate of 1%. An annual displacement matrix for gannet within the array area plus a 2km buffer is presented in Table 12.32 below. Using the largest UK North Sea and English Channel BDMPS of 456,298 individuals (Furness, 2015) and using the average baseline mortality rate of 0.191 (Table 12.9), the natural predicted mortality across all seasons is 87,151 per annum. The addition of nine predicted mortalities would increase the baseline mortality rate by 0.010%. When considering displacement impacts at the wider biogeographic population scale, then of the 1,180,000 population the natural annual mortality rate would be 225,380 individuals per annum. The addition of nine predicted mortalities would increase the biogeographic baseline mortality rate by 0.004%.

239. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of the species.

240. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of minor to moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

241. Confidence in the conclusions of this assessment is high due to the precautionary displacement and mortality rates used, the use of a site-specific dataset, the small scale of the predicted impact, and the flexibility of potentially displaced gannets to travel to, and forage in new areas.

Table 12.31 Bio-season displacement estimates for gannet for the Project (O&M phase).

Bio-season (months)	Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated mortality level during O&M phase.		Increase in baseline mortality (%) during construction phase.	
		Population	Baseline mortality	70% displacement, 1% mortality	60-80% displacement, 1% mortality	70% displacement, 1% mortality	60-80% displacement, 1% mortality
Return migration (Dec-Mar)	91	248,385	47,442	0.6	0.5 – 0.7	0.001	0.001 – 0.001
Migration-free breeding (Apr-Aug)	635	400,235	76,462	4.4	3.8 – 5.8	0.005	0.005 – 0.007
Post-breeding migration (Sep-Nov)	496	456,298	87,151	3.5	2.9 – 3.9	0.003	0.003 – 0.005
Annual (BDMPS)	1,222	456,298	87,151	8.5	7.3 – 9.8	0.009	0.008 – 0.011
Annual (biogeographic)	1,222	1,180,000	225,380	8.5	7.3 – 9.8	0.004	0.003 – 0.004

Table 12.32 Annual displacement matrix for gannet within the Project array area plus 2km buffer, values in light blue represent the range-based values advocated by SNCBs and the darker shade of blue representing the Applicant's approach value.

Annual (2km Buffer)	Mortality Rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	3	6	13	26	39	52	65	78	91	104	117	130
20	3	5	13	26	52	78	104	130	156	182	208	234	260
30	4	8	19	39	78	117	156	195	234	273	312	351	389
40	5	10	26	52	104	156	208	260	312	364	415	467	519
50	6	13	32	65	130	195	260	325	389	454	519	584	649
60	8	16	39	78	156	234	312	389	467	545	623	701	779
70	9	18	45	91	182	273	364	454	545	636	727	818	909
80	10	21	52	104	208	312	415	519	623	727	831	935	1,039
90	12	23	58	117	234	351	467	584	701	818	935	1,052	1,168
100	13	26	65	130	260	389	519	649	779	909	1,039	1,168	1,222

12.8.2 Collision risk: array area

Overview

242. There is potential risk to birds from offshore windfarms through collision with WTGs resulting in injury or fatality. This may occur when birds fly through the Project array area whilst foraging for food, commuting between breeding sites and foraging areas, or during migration.

243. Collision risk modelling (CRM) has been carried out for the Project, with detailed methods and results presented in Volume 2, Appendix 12.2: Collision Risk Modelling Assessment, to provide information for seabird species of interest identified as potentially at risk and of interest for impact assessment.

244. To determine which species were of interest for the CRM assessment, a screening exercise was undertaken, considering the abundance and frequency of species recorded flying within the array area, and their vulnerability from collision (identified from published literature, notably Bradbury *et al*., 2014). Species were screened out if they their risk of collision was considered very low, such as fulmar that fly very close to the sea surface and are unlikely to interact with WTGs, and/or if their densities in flight within the array area were low, indicating a low risk of collision. Results of the screening exercise are presented in Table 12.33 below.

Table 12.33 Screening of seabird species recorded within the Project array area and 4km buffer for risk of collision during the O&M phase.

Receptor	Sensitivity to collision*	Relative frequency in the array area	Relative abundance in the array area	Screening result (in or out)
Common scoter	Minor	Low	Low	Out
Oystercatcher	Minor	Low	Low	Out
Kittiwake	Moderate	High	High	In
Great black-backed gull	Major	Medium	Medium	In
Herring gull	Major	Medium	Medium	In
Lesser black-backed gull	Major	Medium	Medium	In
Common gull	Moderate	Medium	Low	Out
Little gull	Minor	Low to Medium	Low	In
Black-headed gull	Moderate	Low to Medium	Low	Out
Sandwich tern	Minor	Low to Medium	Low to Medium	In

Receptor	Sensitivity to collision*	Relative frequency in the array area	Relative abundance in the array area	Screening result (in or out)
Common tern	Minor	Low	Medium	In
Arctic tern	Minor	Low	Low	Out
Arctic skua	Moderate	Low	Low	Out
Great skua	Moderate	Low	Low	Out
Guillemot	Minor	High	High	Out
Razorbill	Minor	High	High	Out
Puffin	Minor	High	Medium to High	Out
Little auk	Minor	Low	Low	Out
Red-throated diver	Minor	Medium	Low to Medium	Out
Great northern diver	Minor	Low	Low	Out
Manx shearwater	Minor	Low	Low	Out
Fulmar	Minor	Medium	Low	Out
Gannet	Moderate	High	Medium	In
Shag	Minor	Low	Low	Out

*Bradbury *et al*. 2014, Dierschke *et al*. 2016

245. Following screening, eight species were included in CRM analysis: gannet, kittiwake, herring gull, great black-backed gull, lesser black-backed gull, little gull, common tern and Sandwich tern.

246. The CRM assessment was undertaken for each screened in species using the stochastic CRM (sCRM), developed by Marine Scotland (McGregor, 2018). The development and testing of the sCRM was funded by Marine Scotland Science (MSS) and provides the most up-to date version of the CRM originally created by Band (2012) and addresses the uncertainty in developments and other key input parameters as progressed initially by Masden (2015). This method is supported by Natural England in their most recent interim CRM guidance (Natural England, 2022a), with the key difference to the previously used basic band model being the incorporation of uncertainty in input parameters (i.e. WTG parameters, bird densities, bird biometrics and behaviours) and output parameters (i.e. collision estimates) by running at least 1,000 iterations of the model. On each run, the model randomly assigns values for each parameter from a set distribution. This results in a mean collision rate and a variance around the mean presented as 95% confidence intervals.

247. Corrected bootstrap density estimates for birds in flight derived from the Project DAS data were used as an input to the sCRM tool (as opposed to using a mean and standard deviation), with densities pooled from surveys conducted in the same calendar months. For comparison, collision impacts calculated from mean densities and associated SD are provided in Appendix 2 of Volume 3, Chapter 12.2 Collision Risk Modelling (document reference: 6.3.12.2).

248. The assessment is based on Band CRM Option 2, as advocated in recent guidance from Natural England (Parker *et al*., 2022). This option uses generic estimates of flight height for each species based on the percentage of birds flying at PCH derived from data from a number of offshore windfarm sites, presented in Johnston *et al*. (2014). Modelling was undertaken based on parameters outlined in the MDS (Table 12.10).

249. CRM accounts for several 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. Parameters used were based on the most recent interim guidance from Natural England (Natural England, 2022a), accounting for updates to avoidance rates and nocturnal activity factors provided in this recent guidance. These values are presented in Table 12.34 below, though a full overview of CRM input parameters and results is provided in (Volume 2, Appendix 12.2: Collision Risk Modelling Assessment Annex).

250. It should be noted that, based on available evidence, these parameters are precautionary. Regarding avoidance rates, research funded by the Offshore Renewables Joint Industry Programme (ORJIP), studied birds around Thanet OWF over two years (between 2014 and 2016). The study found that of 12,000 birds recorded during the two-year period, only six birds (all gull species) were reported to have collided with WTGs (Skov *et al*., 2018). Further review undertaken for gannet by both Cook (2018) and APEM (2014) have found that measured gannet avoidance rates are likely higher than the rate used, with APEM reporting an actual avoidance rate as high as 100% during migratory periods (though a rate of 0.995 was suggested as more realistically appropriate).

251. Additionally, a recent report undertaken at Aberdeen Offshore Windfarm Limited (AOWFL, 2023) at the European Offshore Wind Development Centre (EOWDC) found that collision rates of birds are likely to be significantly lower than predicted based on input parameters, implying further precaution of the current methodology used. The two-year study used a combination of radar and video analysis to look at WTG avoidance and found that no collisions or even narrow escapes were recorded in over 10,000 bird videos, highlighting that avoidance rates are likely to be even higher in reality.

252. Considering flight speeds, a review undertaken for Norfolk Boreas Offshore Windfarm (Royal HaskoningDHV, 2020) estimate that the flight speed of 13.1m/sec used for kittiwake is an overestimate, and that a value of 10.8m/s (± 0.9) is more realistic based on a range of monitoring methods. A study undertaken by Skov *et al.* (2018) estimated an even lower value of 8.7m/s (±3.2) to be more appropriate, and also suggested a value of 13.3m/s (±4.2) would be more appropriate for gannet than the currently used 14.9m/s, and a value of 9.8m/s (± 3.6) for large gull species. This data was based on large sample sizes of bird species recorded in Thanet OWF. The assessment presented within this ES has followed the Natural England guidance, however, if these lower flight speeds and lower nocturnal activity factors were used in the models then the collision rates would be lowered considerably (e.g. >30% based on the evidenced lower kittiwake flight speed). As a result, this assessment is considered precautionary.

Table 12.34 Seabird parameters used in the CRM assessment

Species	Avoidance rate (± SD)	Nocturnal activity factor (± SD)	Flight speed (m/s) (± SD)
Kittiwake	0.993 (±0.0003)	0.375 (± 0.0637)	13.1 (± 0.4)
Great black-backed gull	0.994 (± 0.0004)	0.375 (± 0.0637)	13.7 (± 1.2)
Herring gull	0.994 (± 0.0004)	0.375 (± 0.0637)	12.8 (± 1.8)
Lesser black-backed gull	0.994 (± 0.0004)	0.375 (± 0.0637)	13.1 (± 1.9)
Little gull	0.991 (± 0.0004)	0.000 (± 0.0000)	12.2
Sandwich tern	0.991 (± 0.0004)	0.000 (± 0.0000)	10.3 (± 3.4)
Common tern	0.991 (± 0.0004)	0.000 (± 0.0000)	10.5
Gannet	0.993 (± 0.0003)	0.080 (± 0.1000)	14.9 (± 0.0)

253. For gannet, predicted collision mortalities are further adjusted based on reported macro-avoidance behaviour displayed in this species, following Natural England interim guidance on CRM (Natural England, 2022a). The use of a range of macro-avoidance rates between 65% to 85%, and a single rate of 70% are used in the analysis and presented below.

Results

254. The CRM outputs for each species include a mean estimated collision mortality for each month, along with standard deviations to incorporate uncertainty in the estimates. These results are presented in Table 12.35 below for screened in species. A full overview of these results is provided in Volume 2, Appendix 12.2: Collision Risk Modelling Assessment Annex.

255. Monthly collision estimates are grouped into seasonal mortality estimates for each species, based on bio-seasons presented in Table 12.7. The magnitude of estimated impacts are assessed against BDMPS non-breeding season populations and breeding season populations (presented in Table 12.8) and relative to the baseline mortality values, which are based on age specific demographic rates and age class proportions presented in Table 12.9.

256. Collisions of little gull and common tern have been further considered through migratory CRM analyses and, as such, are not covered further in this section.

Table 12.35 Monthly mean collision estimates (plus 95% confidence intervals) for key seabird species.

Option 2	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
Kittiwake	Mean	0.9	1.7	5.2	9.7	3.6	2.5	2.0	2.4	0.9	0.3	0.6	1.0	**30.9**
	2.5% CI	0.1	0.7	2.4	3.7	0.5	0.6	0.2	0.3	0.0	0.1	0.2	0.4	**8.9**
	97.5% CI	2.7	3.3	10.5	19.6	12.7	7.1	6.4	8.0	2.8	0.8	1.4	1.8	**77.0**
Great black-backed gull	Mean	0.7	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.4	0.2	**1.9**
	2.5% CI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	97.5% CI	3.0	0.0	0.5	0.0	0.4	0.4	0.0	0.7	1.0	0.4	1.0	0.7	**8.0**
Herring gull	Mean	0.2	0.0	0.1	0.1	0.1	0.5	0.2	0.0	0.0	0.0	0.1	0.2	**1.4**
	2.5% CI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	97.5% CI	0.7	0.0	0.3	0.7	0.5	2.2	0.8	0.0	0.0	0.0	0.3	1.0	**6.5**
Lesser black-backed gull	Mean	0.0	0.0	0.0	0.2	0.0	0.4	0.1	0.2	0.0	0.0	0.0	0.0	**1.1**
	2.5% CI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	97.5% CI	0.0	0.0	0.4	0.7	0.3	1.9	0.6	1.5	0.0	0.3	0.2	0.0	**5.9**
Little gull	Mean	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.2	3.3	3.0	0.2	0.0	**7.0**
	2.5% CI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	97.5% CI	0.0	0.0	3.1	0.0	0.0	0.0	0.0	2.8	44.4	54.7	3.1	0.0	**108.1**
Sandwich tern	Mean	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	**0.2**
	2.5% CI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	97.5% CI	0.0	0.0	0.0	0.3	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	**1.2**
Common tern	Mean	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.4	0.0	0.0	0.0	**0.6**
	2.5% CI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	97.5% CI	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.2	2.0	0.0	0.2	0.0	**2.6**
Gannet[3]	Mean	0.1	0.2	0.4	1.1	0.6	0.4	0.5	0.4	0.2	0.4	0.8	0.0	**4.9**
	2.5% CI	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.2**
	97.5% CI	0.2	0.7	1.2	3.7	3.9	1.3	1.8	1.4	1.0	1.3	3.0	0.0	**19.3**

Kittiwake

Potential magnitude of impact

257. The monthly estimated mortality rates are presented in Table 12.35, which vary from a minimum mean of less than one (0.3) individuals in October to a maximum mean of ten (9.7) individuals in April. On an annual basis, the estimated mortality rate for collision risk from the Project is 31 (30.9) individuals, which is further broken down into relevant bio-seasons in Table 12.36.

Table 12.36 Bio-season collision risk estimates for kittiwake for the Project.

Bio-season (months)	Mean collisions	Regional baseline populations and baseline mortality rates (individuals per annum)		Increase in baseline mortality (%)
		Population	Baseline mortality	
Return migration (Jan-Feb)	2.6	627,816	97,939	0.003
Breeding (Mar-Aug)	25.5	839,456	130,955	0.019
Post-breeding migration (Sep-Dec)	2.8	829,937	129,470	0.002
Annual (BDMPS)	30.9	829,937	129,470	0.024
Annual (biogeographic)	30.9	5,100,000	795,600	0.004

258. During the return migration bio-season, three (2.6) kittiwakes may be subject to collision mortality. The regional population in the return migration bio-season is defined as 627,816 individuals and using an average baseline mortality rate of 0.156 (Table 12.9), the natural predicted mortality in the return migration bio-season is 97,939 individuals per annum. The addition of three predicted mortalities during the return migration bio-season would increase the baseline mortality rate by 0.003%.

259. 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 the small number of estimated collisions.

260. During the breeding bio-season, 26 (25.5) kittiwakes may be subject to mortality. The regional population in the migration-free breeding bio-season is defined as 839,456 individuals and using an average baseline mortality rate of 0.156, the natural predicted mortality in the breeding bio-season is 130,955 individuals per annum. The addition of 26 predicted mortalities during the migration-free breeding bio-season would increase the baseline mortality rate by 0.019%.

261. 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 the small number of estimated collisions.

262. During the post-breeding migration bio-season, three (2.8) kittiwakes may be subject to mortality. The regional population in the return migration bio-season is defined as 829,937 individuals and using an average baseline mortality rate of 0.156, the natural predicted mortality in the post-breeding migration bio-season is 129,470 individuals per annum. The addition of three predicted mortalities during the post-breeding migration bio-season would increase the baseline mortality rate by 0.002%.

263. 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 the small number of estimated collisions.

264. The annual total of kittiwakes subject to mortality due to collision is estimated to be 31 (30.9) individuals. Using the largest BDMPS population of 829,937 with an average baseline mortality of 0.156, the natural predicted mortality is 129,470 per annum. The addition of 31 individuals 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 5,100,000 individuals across all seasons is 795,600 individuals per annum. The addition of 31 predicted mortalities would increase baseline mortality by 0.004%.

265. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to collision of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

266. Confidence in the conclusions of this assessment is high, due to the precautionary nature of the input parameters for CRM (e.g., the over-estimates of flight speed and nocturnal activity used, the precautionary avoidance rates, and the modelling approach which does not consider any potential displacement effects).

Great black-backed gull

Potential magnitude of impact

267. The monthly estimated mortality rates are presented in Table 12.35, which vary from a minimum mean of zero (0.0) individuals in February, April and July to a maximum of one (1.2) individual in January. On an annual basis, the estimated mortality rate for collision risk from the Project is approximately three (3.0) individuals, which is further broken down into relevant bio-seasons in Table 12.37.

Table 12.37 Bio-season collision risk estimates for great black-backed gull for the Project.

Bio-season (months)	Mean collisions	Regional baseline populations and baseline mortality rates (individuals per annum)		Increase in baseline mortality (%)
		Population	Baseline mortality	
Breeding (Apr-Aug)	0.4	59,329	8,543	0.005
Non-breeding (Sep-Mar)	2.6	91,399	13,152	0.023
Annual (BDMPS)	3.0	91,399	13,152	0.023
Annual (biogeographic)	3.0	235,000	33,840	0.009

268. During the breeding bio-season, less than one (0.4) great black-backed gull may be subject to collision mortality. The regional population in the breeding bio-season is defined as 59,329 individuals and using an average baseline mortality rate of 0.144 (Table 12.9), the natural predicted mortality in the breeding bio-season is 8,543 individuals per annum. The addition of less than one predicted mortality during the breeding bio-season would increase the baseline mortality rate by 0.005%.

269. 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 the small number of estimated collisions.

270. During the non-breeding bio-season, three (2.6) great black-backed gulls may be subject to collision mortality. The regional population in the non-breeding bio-season is defined as 91,399 individuals and using an average baseline mortality rate of 0.144, the natural predicted mortality in the breeding bio-season is 13,152 individuals per annum. The addition of three predicted mortalities during the non-breeding bio-season would increase the baseline mortality rate by 0.023%.

271. 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 the small number of estimated collisions.

272. The annual total of great black-backed gulls subject to mortality due to collision is estimated to be three (3.0) individuals. Using the largest BDMPS population of 91,399 individuals with an average baseline mortality of 0.144, the natural predicted mortality is 13,152 individuals per annum. The addition of three predicted mortalities would increase the baseline mortality rate by 0.0233%. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality for the biogeographic population of 235,000 individuals across all seasons is 33,840 individuals per annum. The addition of three predicted mortalities would increase baseline mortality by 0.009%.

273. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to collision of major, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

274. Confidence in the conclusions of this assessment is high, due to the precautionary nature of the input parameters for CRM (e.g., the over-estimates of flight speed and nocturnal activity used, the precautionary avoidance rates, the adaptability of large gulls, and the modelling approach which does not consider any potential displacement effects)

Lesser black-backed gull

Potential magnitude of impact

275. The monthly estimated mortality rates are presented in Table 12.35, which vary from a minimum mean of zero (0.0) individuals across four months to a maximum of one (0.7) individual in June. On an annual basis, the estimated mortality rate for collision risk from the Project is two (1.8) individuals, which is further broken down into relevant bio-seasons in Table 12.38.

Table 12.38 Bio-season collision risk estimates for lesser black backed gull for the Project.

Bio-season (months)	Mean collisions	Regional baseline populations and baseline mortality rates (individuals per annum)		Increase in baseline mortality (%)
		Population	Baseline mortality	
Return migration (Mar)	0.06	197,483	24,290	0.000
Breeding (Apr-Aug)	1.5	101,189	12,446	0.012
Post-breeding migration (Sep-Dec)	0.07	209,007	25,708	0.000
Migration-free winter (Nov-Feb)	0.1	39,314	4,836	0.002
Annual (BDMPS)	1.7	209,007	25,708	0.007

Bio-season (months)	Mean collisions	Regional baseline populations and baseline mortality rates (individuals per annum)		Increase in baseline mortality (%)
		Population	Baseline mortality	
Annual (biogeographic)	1.7	864,000	106,272	0.002

276. During the return migration bio-season, less than one (0.06) lesser black-backed gull may be subject to collision mortality. The regional population in the return migration bio-season is defined as 197,483 individuals and using an average baseline mortality rate of 0.124 (Table 12.9), the natural predicted mortality in the return migration bio-season is 24,290 individuals per annum. The addition of less than one predicted mortality during the return migration bio-season would increase the baseline mortality rate by less than 0.001%.

277. 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 the small number of estimated collisions.

278. During the breeding bio-season, two (1.5) lesser black-backed gulls may be subject to collision mortality. The regional population in the migration-free breeding bio-season is defined as 101,189 individuals and using an average baseline mortality rate of 0.124, the natural predicted mortality in the migration-free breeding bio-season is 12,446 individuals per annum. The addition of two predicted mortalities during the migration-free breeding bio-season would increase the baseline mortality rate by 0.012%.

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

280. During the post-breeding migration bio-season, less than one (0.07) lesser black-backed gull may be subject to collision mortality. The regional population in the post-breeding migration bio-season is defined as 209,007 individuals and using an average baseline mortality rate of 0.124, the natural predicted mortality in the post-breeding migration bio-season is 25,708 individuals per annum. The addition of less than one predicted mortality during the post-breeding migration bio-season would increase the baseline mortality rate by less than 0.001%.

281. 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 the small number of estimated collisions.

282. During the migration-free winter bio-season, less than one (0.1) lesser black-backed gull may be subject to collision mortality. The regional population in the migration-free winter bio-season is defined as 39,314 individuals and using an average baseline mortality rate of 0.124, the natural predicted mortality in the migration-free winter bio-season is 4,836 individuals per annum. The addition of less than one predicted mortality during the migration-free winter bio-season would increase the baseline mortality rate by 0.002%.

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

284. The annual total of lesser black-backed gulls subject to mortality due to collision is estimated to be two (1.7) individuals. Using the largest BDMPS population of 209,007 individuals with an average baseline mortality of 0.124, the natural predicted mortality is 25,708 individuals per annum. The addition of two predicted mortalities would increase the baseline mortality rate by 0.007%. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality for the biogeographic population of 864,000 across all seasons is 106,272 per annum. The addition of two predicted mortalities would increase baseline mortality by 0.002%.

285. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to collision of major, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

286. Confidence in the conclusions of this assessment is high, due to the precautionary nature of the input parameters for CRM (e.g., the over-estimates of flight speed and nocturnal activity used, the precautionary avoidance rates, the adaptability of large gulls, and the modelling approach which does not consider any potential displacement effects).

Herring gull

Potential magnitude of impact

287. The monthly estimated mortality rates are presented in Table 12.35, which vary from a minimum of zero (0.0) individuals across four months to a maximum of one (0.8) individual in June. On an annual basis, the estimated mortality rate for collision risk from the Project is approximately two (2.2) individuals, which is further broken down into relevant bio-seasons in Table 12.39.

Table 12.39 Bio-season collision risk estimates for herring gull for the Project.

Bio-season (months)	Mean collisions	Regional baseline populations and baseline mortality rates (individuals per annum)		Increase in baseline mortality (%)
		Population	Baseline mortality	
Breeding (Mar-Aug)	1.5	272,795	46,648	0.003
Non-breeding (Sep-Feb)	0.7	466,511	79,773	0.001
Annual (BDMPS)	2.2	466,511	79,773	0.003
Annual (biogeographic)	2.2	1,098,000	187,758	0.001

288. During the breeding bio-season, two (1.5) herring gulls may be subject to collision mortality. The regional population in the breeding bio-season is defined as 272,795 individuals and using an average baseline mortality rate of 0.172 (Table 12.9), the natural predicted mortality in the breeding bio-season is 46,648 individuals per annum. The addition of two predicted mortalities during the breeding bio-season would increase the baseline mortality rate by 0.003%.

289. 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 the small number of estimated collisions.

290. During the non-breeding season, one (0.7) herring gull may be subject to mortality. The regional population in the non-breeding bio-season is defined as 466,511 individuals and using an average baseline mortality rate of 0.172, the natural predicted mortality in the breeding bio-season is 79,773 individuals per annum. The addition of one predicted mortality during the non-breeding bio-season would increase the baseline mortality rate by 0.001%.

291. 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 the small number of estimated collisions.

292. The annual total of herring gulls subject to mortality due to collision is estimated to be two (2.2) individuals. Using the largest BDMPS population of 466,511 with an average baseline mortality of 0.172 (Table 12.9), the natural predicted mortality is 79,773 per annum. The addition of two predicted mortalities would increase the baseline mortality rate by 0.002%. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality for the biogeographic population of 864,000 across all seasons is 106,272 per annum. The addition of two predicted mortalities would increase baseline mortality by 0.002%.

293. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to collision of major, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

294. Confidence in the conclusions of this assessment is high, due to the precautionary nature of the input parameters for CRM (e.g., the over-estimates of flight speed and nocturnal activity used, the precautionary avoidance rates, the adaptability of large gulls, and the modelling approach which does not consider any potential displacement effects).

Sandwich tern

Potential magnitude of impact

295. The monthly estimated mortality rates are presented in Table 12.35, which vary from a minimum mean of zero individuals across nine months to a maximum mean of less than one (0.2) individual in May. On an annual basis, the estimated mortality rate for collision risk from the Project is less than one (0.4) individual, which is further broken down into relevant bio-seasons in Table 12.40.

Table 12.40 Bio-season collision risk estimates for Sandwich tern for the Project.

Bio-season (months)	Collisions	Regional baseline populations and baseline mortality rates (individuals per annum)		Increase in baseline mortality (%)
		Population	Baseline mortality	
Return migration (Apr)	0.0	38,051	9,056	0.000
Breeding (May - Aug)	0.4	27,906	6,642	0.005
Post-breeding migration (Sep)	0.0	38,051	9,056	0.000
Annual (BDMPS)	0.4	38,051	9,056	0.004
Annual (biogeographic)	0.4	148,000	35,224	0.001

296. During the return migration bio-season, less than one (0.0) Sandwich tern may be subject to mortality. The regional population in the return migration bio-season is defined as 38,051 individuals and using an average baseline mortality rate of 0.241 (Table 12.9), the natural predicted mortality in the return migration bio-season is 9,056 individuals per annum. The addition of less than one predicted mortality during the return migration bio-season would increase the baseline mortality rate by less than 0.001%.

297. 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 the small number of estimated collisions.

298. During the breeding bio-season, less than one (0.4) Sandwich tern may be subject to mortality. The regional population in the migration-free breeding bio-season is defined as 27,906 individuals and using an average baseline mortality rate of 0.241, the natural predicted mortality in the migration-free breeding bio-season is 6,642 individuals per annum. The addition of less than one predicted mortality during the migration-free breeding bio-season would increase the baseline mortality rate by 0.005%.

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

300. During the post-breeding migration bio-season, less than one (0.0) Sandwich tern may be subject to mortality. The regional population in the post-breeding migration bio-season is defined as 38,051 individuals and using an average baseline mortality rate of 0.241), the natural predicted mortality in the post-breeding migration bio-season is 9,056 individuals per annum. The addition of less than one predicted mortality during the post-breeding migration bio-season would increase the baseline mortality rate by less than 0.001%.

301. 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 the small number of estimated collisions.

302. The annual total of Sandwich terns subject to mortality due to collision is estimated to be less than one (0.4) individuals. Using the largest BDMPS population of 38,051 with an average baseline mortality of 0.241, the natural predicted mortality is 9,056 per annum. The addition of less than one predicted mortalities would increase the baseline mortality rate by 0.004%. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality for the biogeographic population of 148,000 individuals across all seasons is 35,224individuals per annum. The addition of less than one predicted mortalities would increase baseline mortality by 0.001%.

303. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to collision of minor, the effect significance is considered **negligible, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

304. Confidence in the conclusions of this assessment is high, due to the precautionary nature of the input parameters for CRM (e.g., the over-estimates of flight speed and nocturnal activity used, the precautionary avoidance rates, and the modelling approach which does not consider any potential displacement effects).

Gannet

Potential magnitude of impact

305. The monthly estimated mortality rates are presented in Table 12.35, which vary from a minimum mean of zero individuals in December to a maximum mean of four (3.8) individuals in April. On an annual basis, the estimated mortality rate for collision risk from the Project is 12 (12.2) individuals. This is reduced to five (4.9) individuals in total after adjusting for 70% macro-avoidance, which is further broken down into relevant bio-seasons in Table 12.41. Results are based on 70% macro-avoidance, with an additional range of 65% to 85% macro-avoidance presented in text. However, results from 70% macro-avoidance will form the main basis of this assessment.

Table 12.41 Bio-season collision risk estimates for gannet for the Project.

Bio-season (months)	Mean collisions (range based on 65% to 85% macro-avoidance)	Regional baseline populations and baseline mortality rates (individuals per annum)		% Increase in baseline mortality (range based on 65% to 85% macro-avoidance)
		Population	Baseline mortality	
Return migration (Dec-Feb)	0.07 (0.08 – 0.03)	248,385	47,442	0.000 (0.000 – 0.000)
Breeding (Mar-Sep)	1.05 (1.22 – 0.52)	294,276	761,628	0.001 (0.002 – 0.001)
Post-breeding migration (Oct-Nov)	0.36 (0.52 – 0.18)	456,298	87,151	0.0000 (0.001 – 0.000)
Annual (BDMPS)	1.48 (1.72 – 0.74)	456,298	87,151	0.002 (0.002 – 0.001)
Annual (biogeographic)	1.48 (1.72 – 0.74)	1,180,000	225,380	0.001 (0.001 – 0.000)

306. During the return migration bio-season, less than one (0.07) gannet may be subject to collision mortality. The regional population in the return migration bio-season is defined as 248,385 individuals and using an average baseline mortality rate of 0.191 (Table 12.9), the natural predicted mortality in the return migration bio-season is 47,442 individuals per annum. The addition of less than one predicted mortality during the return migration bio-season would increase the baseline mortality rate by less than 0.001%.

307. 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 the small number of estimated collisions.

308. During the breeding bio-season, one (1.05) gannet may be subject to mortality. The regional population in the migration-free breeding bio-season is defined as 294,276 individuals and using an average baseline mortality rate of 0.191, the natural predicted mortality in the migration-free breeding bio-season is 761,628 individuals per annum. The addition of one predicted mortality during the migration-free breeding bio-season would increase the baseline mortality rate by 0.013%.

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

310. During the post-breeding migration bio-season, one (0.4) gannet may be subject to mortality. The regional population in the post-breeding migration bio-season is defined as 456,298 individuals and using an average baseline mortality rate of 0.191, the natural predicted mortality in the post-breeding migration bio-season is 87,151 individuals per annum. The addition of one predicted mortalities would increase the baseline mortality rate by less than 0.001%.

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

312. The annual total of gannets subject to mortality due to collision is estimated to be one (1.48) individual. Using the largest BDMPS population of 456,298 with an average baseline mortality of 0.191, the natural predicted mortality is 87,151 per annum. The addition of one individual would increase the baseline mortality rate by 0.002%. When considering the annual potential level of impact at the biogeographic scale, the natural predicted mortality for the biogeographic population of 1,180,000 individuals across all seasons is 225,380 individuals per annum. The addition of five predicted mortalities would increase baseline mortality by 0.001%.

313. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to collision of moderate, the effect significance is considered **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

314. Confidence in the conclusions of this assessment is high, due to the precautionary nature of the input parameters for CRM (e.g., the over-estimates of flight speed and nocturnal activity used, the precautionary avoidance rates, and the modelling approach which does not consider any potential displacement effects).

12.8.3 Combined Operational Disturbance and Collision Risk – Gannet

315. Due to gannet being scoped in for both displacement and collision risk assessments during the O&M phase, there is potential for these two combined impacts to adversely affect gannet populations. The collision and displacement assessments both concluded minor (not significant) effect significance as a result of the Project. 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 provided.

316. It is recognised that assessing both displacement and collision risk for gannet together amounts to assessing two pathways to mortality for some of the same birds, since displaced birds would not be subject to collision, as they are already assumed to have avoided the array area. Similarly, birds which are subject to collision mortality cannot also have been displaced. However, a combined approach is undertaken for this assessment as a precautionary approach and based on recommendations from SNCB guidance (Parker *et al*., 2022).

Potential magnitude of impact

317. As presented in Table 12.22 the total displacement consequent mortality is estimated as nine (8.5) birds, based on a displacement rate of 70% and a mortality rate of 1%. The collision consequent mortality is estimated as two (1.5) birds, as presented in Table 12.41. The combined potential mortality is therefore estimated as 10 (10.0) birds.

318. Considering the largest BDMPS population of 456,298 individuals with a baseline mortality of 87,151 individuals per annum, the addition of 10 predicted mortalities would result in a 0.011% increase in baseline mortality. Considering the biogeographic population of 1,180,000 individuals, with a baseline mortality of 220,660 individuals, the addition of 10 predicted mortalities would increase baseline mortality by 0.004%.

319. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to collision of medium and a sensitivity to displacement of minor to moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

320. Confidence in the conclusions of this assessment is high due to the precautionary displacement and mortality rates used, the use of a site-specific dataset, the small scale of the predicted impact, the flexibility of potentially displaced gannets to travel to, and forage in new areas, the precautionary nature of the input parameters for CRM (e.g. the over-estimates of flight speed and nocturnal activity used, the precautionary avoidance rates, and the modelling approach which does not consider any potential displacement effects).

12.8.4 Migratory Collision risk: array area

321. In addition to the seabirds considered individually above, there is potential risk to migrant seabirds and waterbirds colliding with WTGs while flying through the array area during the O&M phase.

322. Migratory birds moving through the Project array area may not be reliably detected using digital aerial surveys or other standard survey methods owing to their movements through the area in short pulses, in poor weather, at night (when no surveys take place), or at high altitudes. As such, the project undertook analyses of migratory collision risk using a modelling approach.

323. For the purpose of this ES, a review of potential collision risk was undertaken, considering data presented by other OWFs in the North Sea, including:

- Hornsea Project One;
- Hornsea Project Two;
- Hornsea Three;
- Norfolk Vanguard; and
- Hornsea Project Four.

324. The aim of this review was to identify the potential for significant effects as a result of the operation of the Project, and consequently whether migratory collision risk assessments should be screened in or screened out of the final EIA report. Information used for the basis of this review is predominantly based upon data presented for the Hornsea Four PEIR (Orsted, 2019), updated to reflect the most up to date data based on Hornsea Four's full EIA (Orsted 2021c).

Hornsea Project One

325. 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 identify which species were most likely to be passing through the proposed windfarm, apply the Migropath model (developed by APEM) and the migratory routes described by Wright *et al*. (2012) to calculate the numbers of these species passing through the proposed windfarm 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 12.42.

Hornsea Project Two

326. 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 windfarm, 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 12.42.

Hornsea Three

327. 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 windfarm (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 12.42.

Norfolk Vanguard

328. 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 windfarm (Norfolk Vanguard Ltd, 2018). For migrant seabirds the approach taken followed the migrant corridor, rather than broad front, approach of Wildfowl and Wetlands Trust (WWT) and MacArthur Green (2013) which placed the proposed windfarm 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 12.42.

Hornsea Project Four

329. The approach to assessing the potential scope and scale of collision risk to migrant non-seabirds (waterbirds) taken by Hornsea Project Four was the same as that for Hornsea Project One and Two 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 windfarm, informed by the migratory routes described by Wright *et al.* (2012) and the population estimates of Furness (2015). For migratory seabirds, BO2 CRM was also undertaken, using the maximum likelihood values in the Johnson *et al*. (2014) flight height spreadsheets, which supplemented the SOSS-02 project (Cook *et al*., 2012). 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 12.42.

Outer Dowsing

330. The approach to assessing the potential scope and scale of collision risk to migrant non-seabirds (waterbirds) taken by Outer Dowsing has been with the application of the APEM Migropath model and Band CRM migrant variant (SMartWind, 2015). Migratory routes, described by Wright *et al*. (2012), were used to calculate the numbers of these species passing through the proposed windfarm, with population estimates taken from Woodward *et al.* (2023). 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 windfarm, informed by the migratory routes described by Wright *et al.* (2012) and the population estimates of Woodward *et al.* (2023). For migratory seabirds, BO2 CRM was also undertaken, using the maximum likelihood values in the Johnson *et al*. (2014) flight height spreadsheets, which supplemented the SOSS-02 project (Cook *et al*., 2012). 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 12.42.

Table 12.42 Summary of collision risk assessment on migrant seabirds and waterbirds from 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 Project Four collisions per annum	Impact magnitude*	Significance of effect
Dark-bellied brent goose	1	0	23	1	n/a	Negligible	Negligible or Minor adverse
Taiga bean goose	0	0	0	n/a	0.00	Negligible	Negligible or Minor adverse
Berwick's swan	0	0	4	0	0.12	Negligible	Negligible or Minor adverse
Shelduck	4	0	2	n/a	0.97	Negligible	Negligible or Minor adverse
Shoveler	n/a	n/a	n/a	1	n/a	Negligible	Negligible
Wigeon	20	0	11	13	6.74	Negligible	Negligible or Minor adverse
Gadwall	n/a	n/a	n/a	1	0.10	Negligible	Negligible
Teal	n/a	n/a	n/a	6	5.99	Negligible	Negligible
Pintail	n/a	n/a	n/a	1	n/a	Negligible	Negligible
Pochard	n/a	n/a	n/a	2	n/a	Negligible	Negligible

Species	Hornsea Project One Collisions per annum	Hornsea Project Two Collisions per annum	Hornsea Three Collisions per annum	Norfolk Vanguard Collisions per annum	Hornsea Project Four collisions per annum	Impact magnitude*	Significance of effect
Tufted duck	n/a	n/a	n/a	3	n/a	Negligible	Negligible
Common scoter	n/a	n/a	n/a	0	n/a	Negligible	Negligible
Goldeneye	n/a	n/a	n/a	1	0.35	Negligible	Negligible
Oystercatcher	n/a	n/a	n/a	15	7.68	Negligible	Negligible
Avocet	n/a	n/a	n/a	1	n/a	Negligible	Negligible
Lapwing	48	0	25	22	14.89	Negligible	Negligible or Minor adverse
Golden plover	16	0	23	21	7.08	Negligible	Negligible or Minor adverse
Grey plover	2	0	2	2	0.71	Negligible	Negligible or Minor adverse
Ringed plover	n/a	n/a	n/a	1	0.63	Negligible	Negligible
Curlew	n/a	n/a	n/a	10	4.32	Negligible	Negligible
Bar-tailed godwit	2	0	2	2	1.63	Negligible	Negligible or Minor adverse
Turnstone	n/a	n/a	n/a	2	0.79	Negligible	Negligible

Species	Hornsea Project One Collisions per annum	Hornsea Project Two Collisions per annum	Hornsea Three Collisions per annum	Norfolk Vanguard Collisions per annum	Hornsea Project Four collisions per annum	Impact magnitude*	Significance of effect
Knot	12	0	1	12	5.26	Negligible	Negligible or Minor adverse
Sanderling	n/a	n/a	n/a	1	0.59	Negligible	Negligible
Dunlin	10	0	23	27	6.25	Negligible	Negligible or Minor adverse
Redshank	n/a	n/a	n/a	22	4.09	Negligible	Negligible
Little gull	10	1	1	0	0.03	No Change/Negligible	Negligible or Minor Adverse
Sandwich tern	n/a	n/a	n/a	n/a	0.02	Negligible	Negligible
Roseate tern	n/a	n/a	n/a	n/a	n/a	No Change/Negligible	No Change/Negligible
Common tern	0	9	1	0	0.20	No Change/Negligible	Negligible or Minor adverse
Arctic skua	0	10	0	0	0.00	No Change/Negligible	Negligible or Minor Adverse

Species	Hornsea Project One Collisions per annum	Hornsea Project Two Collisions per annum	Hornsea Three Collisions per annum	Norfolk Vanguard Collisions per annum	Hornsea Project Four collisions per annum	Impact magnitude*	Significance of effect
Arctic tern	0	50	0	0	0.04	No Change/Negligible	Negligible or Minor adverse
Great skua	1	1	0	0	0.00	No Change/Negligible	Negligible or Minor Adverse
Marsh harrier	n/a	n/a	n/a	0	n/a	Negligible	Negligible

*for little gull, common tern, Sandwich tern, arctic tern, roseate tern, arctic skua and great skua, BO2 CRM outputs were provided for Hornsea Four

Magnitude of impact

331. Evidence presented across Hornsea Project One, Hornsea Project Two, Hornsea Project Three, Norfolk Vanguard and Hornsea Project Four concludes negligible collision risks and no significant effects provide a reliable guide to the potential risks for the Project. The potential for the Project to generate significant collision risks while virtually none were predicted for other OWFs in similar areas of the North Sea is considered to be minimal.

332. The modelled migrant bird collisions for the Project are presented in Table 12.43.

Table 12.43 Results of Migropath and 'Broad Front' modelling of migrant bird collisions

Species	Avoidance Rate	Annual **Collision Rate BO1**	Annual **Collision Rate BO2**	UK population (IND)	Baseline mortality (IND)	Increase in baseline mortality (%)
Migropath Modelling						
Dark-bellied brent goose	95.00%	2.1257	NA	98,500	9,917	0.0214
	98.00%	0.8505	NA	98,500	9,917	0.0086
	99.00%	0.4253	NA	98,500	9,917	0.0043
	99.50%	0.2127	NA	98,500	9,917	0.0021
Pink-footed goose	95.00%	27.0666	NA	510,000	85,500	0.0317
	98.00%	10.8302	NA	510,000	85,500	0.0127
	99.00%	5.4157	NA	510,000	85,500	0.0063
	99.50%	2.7080		510,000	85,500	0.0032
Shelduck	95.00%	3.5564	NA	51,000	7,125	0.0499
	98.00%	1.4230	NA	51,000	7,125	0.0200
	99.00%	0.7116	NA	51,000	7,125	0.0100
	99.50%	0.3558	NA	51,000	7,125	0.0050
Wigeon	95.00%	38.2002	NA	450,000	225,600	0.0169
	98.00%	15.2843	NA	450,000	225,600	0.0068
	99.00%	7.6429	NA	450,000	225,600	0.0034
	99.50%	3.8216	NA	450,000	225,600	0.0017
Mallard	95.00%	134.3476	NA	675,000	307,202.8	0.0437
	98.00%	53.7554	NA	675,000	307,202.8	0.0175
	99.00%	26.8804	NA	675,000	307,202.8	0.0088
	99.50%	13.4409	NA	675,000	307,202.8	0.0044
Pochard	95.00%	1.9681	NA	29,000	12,825	0.0153
	98.00%	0.7875	NA	29,000	12,825	0.0061
	99.00%	0.3938	NA	29,000	12,825	0.0031
	99.50%	0.1969	NA	29,000	12,825	0.0015
Scaup	95.00%	0.6308	NA	6,400	1,330	0.0474

Species	Avoidance Rate	Annual **Collision Rate BO1**	Annual **Collision Rate BO2**	UK population (IND)	Baseline mortality (IND)	Increase in baseline mortality (%)
	98.00%	0.2524	NA	6,400	1,330	0.0190
	99.00%	0.1262	NA	6,400	1,330	0.0095
	99.50%	0.0631	NA	6,400	1,330	0.0047
Common scoter	95.00%	16.4586	NA	135,000	29,334.06	0.0561
	98.00%	6.5852	NA	135,000	29,334.06	0.0224
	99.00%	3.2929	NA	135,000	29,334.06	0.0112
	99.50%	1.6465	NA	135,000	29,334.06	0.0056
Goldeneye	95.00%	1.8933	NA	21,000	8,550	0.0221
	98.00%	0.7575	NA	21,000	8,550	0.0089
	99.00%	0.3788	NA	21,000	8,550	0.0044
	99.50%	0.1894	NA	21,000	8,550	0.0022
Oystercatcher	95.00%	26.9590	NA	305,000	43,068	0.0626
	98.00%	10.7868	NA	305,000	43,068	0.0250
	99.00%	5.3939	NA	305,000	43,068	0.0125
	99.50%	2.6971	NA	305,000	43,068	0.0063
Avocet (Wintering)	95.00%	0.4579	NA	8,700	2,879.8	0.0159
	98.00%	0.1832	NA	8,700	2,879.8	0.0064
	99.00%	0.0916	NA	8,700	2,879.8	0.0032
	99.50%	0.0458	NA	8,700	2,879.8	0.0016
Golden plover	95.00%	43.7177	NA	410,000	890,055	0.0049
	98.00%	17.4916	NA	410,000	890,055	0.0020
	99.00%	8.7465	NA	410,000	890,055	0.0010
	99.50%	4.3734	NA	410,000	890,055	0.0005
Ringed plover	95.00%	3.4021	NA	42,500	66,010.56	0.0052
	98.00%	1.3612	NA	42,500	66,010.56	0.0021
	99.00%	0.6806	NA	42,500	66,010.56	0.0010
	99.50%	0.3403	NA	42,500	66,010.56	0.0005
Curlew (Wintering)	95.00%	11.8293	NA	125,000	14,251.1	0.0830
	98.00%	4.7332	NA	125,000	14,251.1	0.0332
	99.00%	2.3668	NA	125,000	14,251.1	0.0166
	99.50%	1.1835	NA	125,000	14,251.1	0.0083
Bar-tailed godwit (Wintering)	95.00%	5.3695	NA	53,500	193,800	0.0028
	98.00%	2.1484	NA	53,500	193,800	0.0011
	99.00%	1.0743	NA	53,500	193,800	0.0006
	99.50%	0.5372	NA	53,500	193,800	0.0003

Species	Avoidance Rate	Annual **Collision Rate BO1**	Annual **Collision Rate BO2**	UK population (IND)	Baseline mortality (IND)	Increase in baseline mortality (%)
Black-tailed godwit (Icelandic; Wintering)	95.00%	1.1516	NA	41,000	18,180	0.0063
	98.00%	0.4608	NA	41,000	18,180	0.0025
	99.00%	0.2304	NA	41,000	18,180	0.0013
	99.50%	0.1152	NA	41,000	18,180	0.0006
Knot	95.00%	21.8059	NA	265,000	57,240	0.0381
	98.00%	8.7244	NA	265,000	57,240	0.0152
	99.00%	4.3626	NA	265,000	57,240	0.0076
	99.50%	2.1814	NA	265,000	57,240	0.0038
Ruff	95.00%	0.0580	NA	920	14,756	0.0004
	98.00%	0.0232	NA	920	14,756	0.0002
	99.00%	0.0116	NA	920	14,756	0.0001
	99.50%	0.0058	NA	920	14,756	0.0000
Sanderling	95.00%	1.5872	NA	20,500	34,000	0.0047
	98.00%	0.6350	NA	20,500	34,000	0.0019
	99.00%	0.3175	NA	20,500	34,000	0.0009
	99.50%	0.1588	NA	20,500	34,000	0.0005
Dunlin	95.00%	23.2984	NA	350,000	525,670.08	0.0044
	98.00%	9.3216	NA	350,000	525,670.08	0.0018
	99.00%	4.6611	NA	350,000	525,670.08	0.0009
	99.50%	2.3307	NA	350,000	525,670.08	0.0004
Redshank *britannica*	95.00%	1.4378	NA	44,000	109,200	0.0013
	98.00%	0.5753	NA	44,000	109,200	0.0005
	99.00%	0.2877	NA	44,000	109,200	0.0003
	99.50%	0.1438	NA	44,000	109,200	0.0001
Redshank *robustica*	95.00%	4.4133	NA	100,000	109,200	0.0040
	98.00%	1.7658	NA	100,000	109,200	0.0016
	99.00%	0.8830	NA	100,000	109,200	0.0008
	99.50%	0.4415	NA	100,000	109,200	0.0004
Redshank *totanus*	95.00%	4.4260	NA	100,000	109,200	0.0041
	98.00%	1.7709	NA	100,000	109,200	0.0016
	99.00%	0.8855	NA	100,000	109,200	0.0008
	99.50%	0.4428	NA	100,000	109,200	0.0004

Species	Avoidance Rate	Annual Collision Rate BO1	Annual Collision Rate BO2	UK population (IND)	Baseline mortality (IND)	Increase in baseline mortality (%)
Red throated diver	95.00%	1.2845	NA	21,500	3,440	0.0373
	98.00%	0.5140	NA	21,500	3,440	0.0149
	99.00%	0.2570	NA	21,500	3,440	0.0075
	99.50%	0.1285	NA	21,500	3,440	0.0037
Bittern	95.00%	0.0724	NA	795	214.2	0.0338
	98.00%	0.0290	NA	795	214.2	0.0135
	99.00%	0.0145	NA	795	214.2	0.0068
	99.50%	0.0072	NA	795	214.2	0.0034
Hen harrier	95.00%	0.0910	NA	1,090	207.1	0.0439
	98.00%	0.0364	NA	1,090	207.1	0.0176
	99.00%	0.0182	NA	1,090	207.1	0.0088
	99.50%	0.0091	NA	1,090	207.1	0.0044
'Broad Front' Modelling						
Common tern	95.00%	2.80	0.10	11,838	10,453	0.0010
	98.00%	1.12	0.04	11,838	10,453	0.0004
	99.00%	0.56	0.02	11,838	10,453	0.0002
	99.50%	0.28	0.01	11,838	10,453	0.0001
Little gull	95.00%	0.23	0.02	50,000	44,150	0.0000
	98.00%	0.09	0.01	50,000	44,150	0.0000
	99.00%	0.05	0.00	50,000	44,150	0.0000
	99.20%	0.04	0.00	50,000	44,150	0.oi0000

333. Due to the low levels of increase to existing baseline mortalities the significance of effect is concluded to be **negligible, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

334. Confidence in the conclusions of this assessment is high due to the precautionary nature of the input parameters for CRM, and the low levels of migrating non-seabird species recorded during the DAS campaign.

12.8.5 Indirect impacts due to impacts on prey

335. During the O&M phase of the Project, potential effects impacting the availability of prey species may indirectly have effects on offshore ornithology. Increases in underwater anthropogenic noise resulting from the WTGs may result in mobile prey species avoiding the area around the WTGs. Additionally, suspended sediments from maintenance activity may result in fish and mobile invertebrates avoiding the area and may smother and hide immobile benthic prey. The resulting increase in turbidity of the water column may also make it harder for seabirds to see their prey. These impacts could therefore result in a reduction in prey available to foraging seabirds within the construction area. The potential impacts on benthic invertebrates and fish have been assessed in Volume 1, Chapter 10 – Fish and Shellfish Ecology and Volume 2, Chapter 9 – Benthic Subtidal and Intertidal Ecology.

336. The main prey items of seabirds such as gannets and auks are considered to be species such as sandeels, herring and sprat. Impacts on these species may arise from underwater noise impacts and due to changes to the seabed and to suspended sediment levels (also covered in Volume 2, Chapter 9 – Benthic Subtidal and Intertidal Ecology). Impacts arising from noise during the O&M phase are assessed to be minor (not significant) for all fish groups and therefore no impacts of note are expected. Considering impacts arising from suspended sediment concentration, impacts on all species are assessed to be minor (non-significant).

337. Therefore, the significance of effect is therefore concluded to be **negligible, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

12.9 Impact Assessment: Decommissioning

338. The impacts of decommissioning of the Project have been assessed on offshore and intertidal ornithology. The impacts resulting from the construction of the Project are presented in Table 12.10, along with the MDS which formed the bases of these impact assessments.

12.9.1 Disturbance and displacement: array area

339. Decommissioning activities within the array area associated with foundations and WTGs may lead to disturbance and displacement of species within the array area and different degrees of buffers surrounding it. The MDS for decommissioning activities within the Project array area is equal to or less than that for the construction phase, and so for the purpose of this assessment, the impacts are deemed to be similar.

340. Since potential disturbance and displacement effects within the construction phase were deemed to be not significant, no significant effects are expected within the decommissioning phase.

12.9.2 Indirect impacts due to impacts on prey

341. During decommissioning phase of the Project, the potential impacts arising from indirect impacts due to impacts on prey are considered to be of similar magnitude of those predicted in the construction phase. Therefore, the significance of effect is therefore concluded to be **negligible, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

12.10 Cumulative Impact Assessment

12.10.1Overview and methodology

342. Cumulative effects refer to the impacts upon a single receptor from the Project combined with the impacts from 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.

343. To determine the potential impacts arising from the Project in combination with other projects, a screening exercise was undertaken, and is presented in Table 12.44 below.

Table 12.44 Screening for potential cumulative effects.

Impact	Screening outcome	Rationale
Construction phase		
Impact 1: Disturbance and displacement (Offshore ECC)	In	Potential for temporal and spatial coincidence of disturbance/displacement from other plans or projects in the area acting on the same populations. These differ from array assessments in the suite of species considered.
Impact 2: Disturbance and displacement (array area)	In	Red-throated diver only. Displacement of all other seabirds during the construction phase of the Project are assessed as negligible at most, spatially restricted and temporary for all species and with very little temporal overlap with the construction phases of other projects. Further explanation provided in Paragraph 357.
Impact 3: Indirect impacts through effects on habitats and prey availability	Out	There is no potential of cumulative impacts since the contribution from the Project is low, and is dependent on a temporal and spatial co-incidence of disturbance/displacement from other plans or projects.

Impact	Screening outcome	Rationale
Impact 4: Disturbance and displacement: Artificial Nest Structure (ANS), Biogenic reef seeding and ORCPs.	Out	Highly spatial and temporally constrained. Construction will not occur at the same time as the rest of the Project.
O&M phase		
Disturbance and displacement (array area)	In	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Indirect impacts through effects on habitats and prey availability	Out	There is no potential of cumulative impacts since the contribution from the Project is low.
Collision risk	In	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Combined O&M collision risk and displacement	In	There is a sufficient likelihood of a cumulative impact to justify quantitative cumulative impact assessment.
Decommissioning phase		
Disturbance and displacement (ECC)	In	Potential for temporal and spatial coincidence of disturbance/displacement from other plans or projects in the area acting on the same populations. These differ from array assessments in the suite of species considered.
Disturbance and displacement (array area)	In	Red-throated diver only. Displacement of all other seabirds during the decommissioning phase of the Project are assessed as negligible at most, spatially restricted and temporary for all species and with very little temporal overlap with the construction phases of other projects. Further explanation provided in Paragraph 357.
Indirect impacts through effects on habitats and prey availability	Out	There is no potential of cumulative impacts since the contribution from the Project is low, and is dependent on a temporal and spatial co-incidence of disturbance/displacement from other plans or projects.

344. All impacts for ornithological receptors identified in Table 12.44 were considered for cumulative assessment. Where the potential impact magnitude on a species from the Project alone was assessed as both negligible (not significant), and also highly unlikely to make any material contribution to an existing cumulative impact, a full assessment was not undertaken. This was the case for common scoter only, with the impact assessment concluding an (insignificant) extremely low impact (0.01 birds). While impacts for all other species were concluded to be either negligible or minor adverse, both of which are not significant in EIA terms, they are considered within this section as a precautionary approach.

345. Carbon capture utilisation and storage (CCUS) licences were awarded in September 2023, with several within the vicinity of the Project. In addition to these licences, CCUS activities also require a storage agreement for lease granted by The Crown Estate (TCE), enabling applicants to proceed with a Permit application and a lease if successful. At the time of writing, none have been awarded for the areas licensed in September 2023, including those listed in Table 10.23 and Table 10.24. As such, no information is currently publicly available on the scope or timing of potential works associated with CCUS activities, and there is therefore insufficient data on which to undertake a quantitative or semi-quantitative assessment. As such, no assessment has been made of potential cumulative effects on key seabird receptors with carbon storage licences CS017, CS018, and CS028.

Projects considered for cumulative impacts

346. The projects and plans selected as relevant to the assessment of impacts to Intertidal and Offshore Ornithology are based upon an initial screening exercise undertaken on a long list. Each project, plan or activity has been considered and scoped in or out on the basis of effect-receptor pathway, data confidence and the temporal and spatial scales involved. For the purposes of assessing the impact of the Project on Intertidal and Offshore Ornithology in the region, the cumulative effect assessment technical note submitted through the EIA Evidence Plan (presented in Volume 3, Appendix 5.1: Offshore Cumulative Impact Assessment) screened in a number of projects and plans as presented in Table 12.46.

347. A number of project types could potentially be considered for the cumulative assessment of offshore ornithological receptors, notably:

- Offshore windfarms;
- Marine aggregate extraction;
- Oil and gas exploration and extraction;
- Sub-sea cables and pipelines; and
- Commercial shipping.

348. Considering these project types, the cumulative assessment takes into account the fact that birds may already be habituated to long-term, on-going activities and therefore these may be considered to be part of the baseline conditions. While other cable laying operations (e.g. interlink cables) or instillation of infrastructure (e.g. ORCP) could take place at the same time as the installation of cables within the Project Offshore ECC, it is considered unlikely that this would contribute to an inter-related disturbance effect as the duration of cable laying operations within sensitive ornithological areas (such as the Greater Wash SPA) will last no more than a few weeks for any particular project, and the zone of effect is considered comparatively small e.g. 2km radius around cable laying vessels.

349. Therefore, to avoid double-counting or exaggerating potential cumulative impacts, the above project types, excluding offshore windfarms, are scoped out and the cumulative assessment focuses only on offshore windfarms. It is also acknowledged that a further development, the Endurance Carbon Capture Utilisation and Storage (CCUS) project, is proposed 43.2km to the north of the Project array area. However, no data are currently available on potential impacts to offshore ornithology and as such this project has also been screened out from further consideration.

350. All offshore windfarms at all stages of development have been considered within the screening for cumulative effects.

351. For the cumulative effects assessment, it should be noted that some identified developments may not actually be taken forward or fully built out as outlined within their MDS, particularly projects which are 'proposed' or identified in development plans. To account for this, there is a need to factor in consideration of the level of uncertainty of the potential impacts assigned to such developments (i.e., developments not yet approved are less likely to contribute to cumulative impacts than projects under construction). To factor in this uncertainty, a tiered approach was used, assigning 'tiers; and 'sub-tiers' to projects to reflect their current stage within the planning and development process. An explanation of the tiers used is presented in Table 12.45.

Table 12.45 Description of tiers used to describe the development stage of other developments.

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	Sub-Tier	Description of stage of development of project
	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

352. The plans and projects selected as relevant to the cumulative assessment of impacts to offshore and intertidal ornithology are based on an initial screening exercise undertaken on a long list (see Volume 2, Appendix 5.1: Offshore Cumulative Impact Assessment).

353. Where planned and operational projects were screened out of further consideration for potential cumulative effects on offshore and intertidal ornithology, this was based on there not being a potential impact-receptor-pathway (during construction, O&M, and decommissioning phases) 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.

354. The projects screened into the cumulative impact assessment and their allocated tiers (and sub-tiers) are presented in Table 12.46. The operational projects included within the table are included due to their completion/ commissioning subsequent to the data collection process for the Project 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 2, Appendix 5.1: Offshore Cumulative Impact Assessment.

Table 12.46 Projects considered within the Intertidal and Offshore Ornithology cumulative effect assessment.

Project	Status	Distance to the Project array area (km)	Distance to the Project offshore ECC (km)	Tier	Reason for inclusion
Beatrice	Operational	566.4	579.6	1a	Potential temporal overlap of operation with the Project
Blyth Demonstration Site (Phase 1)	Operational	232.8	233.0	1a	Limited potential temporal overlap of operation with the Project as decommissioning planned for 2024-27, before the Project construction phase scheduled to be completed.
Dudgeon	Operational	19.9	11.1	1a	Potential temporal overlap of operation with the Project
East Anglia One	Operational	149.1	144.4	1a	Potential temporal overlap of operation with the Project
European Offshore Wind Development Centre	Operational	444.9	458.8	1a	Potential temporal overlap of operation with the Project
Forthwind Demonstration Project (Methil)	Operational	387.7	387.3	1a	Potential temporal overlap of operation with the Project
Galloper	Operational	172.6	158.4	1a	Potential temporal overlap of operation with the Project
Greater Gabbard	Operational	173.9	159.3	1a	Potential temporal overlap of operation with the Project
Gunfleet Sands	Operational	195.9	177.5	1a	Potential temporal overlap of operation with the Project

Project	Status	Distance to the Project array area (km)	Distance to the Project offshore ECC (km)	Tier	Reason for inclusion
Hornsea Project One	Operational	21.4	38.2	1a	Potential temporal overlap of operation with the Project
Hornsea Project Two	Operational	17.7	35.5	1a	Potential temporal overlap of operation with the Project
Humber Gateway	Operational	45.5	33.1	1a	Potential temporal overlap of operation with the Project
Hywind Scotland	Operational	455.7	472.5	1a	Potential temporal overlap of operation with the Project
Kentish Flats	Operational	222.6	201.6	1a	Potential temporal overlap of operation with the Project
Kentish Flats Extension	Operational	223.3	201.6	1a	Potential temporal overlap of operation with the Project
Kincardine	Operational	418.1	431.6	1a	Potential temporal overlap of operation with the Project
Lincolnshire Node	Operational	45.2	0.2	1a	Potential temporal overlap of operation with the Project
Lynn	Operational	53.6	10.6	1a	Potential temporal overlap of operation with the Project
Inner Dowsing	Operational	50.3	3.3	1a	Potential temporal overlap of operation with the Project
London Array	Operational	198.3	182.1	1a	Potential temporal overlap of operation with the Project
Methil (Samsung) Demo	Operational	389.1	388.9	1a	Potential temporal overlap of operation with the Project

Project	Status	Distance to the Project array area (km)	Distance to the Project offshore ECC (km)	Tier	Reason for inclusion
Moray East	Operational	553.2	568.0	1a	Potential temporal overlap of operation with the Project
Race Bank	Operational	22.8	0.0	1a	Potential temporal overlap of operation with the Project
Rampion	Operational	321.5	284.8	1a	Potential temporal overlap of operation with the Project
Scroby Sands	Operational	97.6	85.3	1a	Potential temporal overlap of operation with the Project
Sheringham Shoal	Operational	34.0	16.7	1a	Potential temporal overlap of operation with the Project
Teesside	Operational	182.2	177.8	1a	Potential temporal overlap of operation with the Project
Thanet	Operational	225.8	209.7	1a	Potential temporal overlap of operation with the Project
Triton Knoll	Operational	7.7	5.5	1a	Potential temporal overlap of operation with the Project
Westermost Rough	Operational	59.5	53.9	1a	Potential temporal overlap of operation with the Project
Neart na Gaoithe	Under construction	357.0	363.0	1b	Potential temporal overlap of operation with the Project
SeaGreen offshore windfarm	Under construction	375.5	385.8	1b	Potential temporal overlap of operation with the Project
Dogger Bank A	Under construction	114.4	132.1	1c	Potential temporal overlap of operation with the Project

Project	Status	Distance to the Project array area (km)	Distance to the Project offshore ECC (km)	Tier	Reason for inclusion
Dogger Bank B	Under construction	132.8	150.7	1c	Potential temporal overlap of operation with the Project
Dogger Bank C (formerly Dogger Bank Teesside A)	Consented - construction expected 2023-2026	160.1	177.1	1c	Potential temporal overlap of operation with the Project
East Anglia Three	Consented - construction expected 2023-2026	118.9	122.4	1c	Potential temporal overlap of operation with the Project
Hornsea Three	Consented – construction expected 2024-2030	59.4	70.9	1c	Potential temporal overlap of operation with the Project
Inch Cape	Under construction	374.5	382.8	1c	Potential temporal overlap of operation with the Project
Moray West	Consented – construction expected 2022-2025	555.8	568.7	1c	Potential temporal overlap of operation with the Project
Sofia (formerly Dogger Bank Teesside B)	Under construction	139.4	156.8	1c	Potential temporal overlap of operation with the Project
East Anglia One North	Consented - construction expected 2023 – 2026	133.1	127.1	1c	Potential temporal overlap of operation with the Project
East Anglia Two	Consented - construction expected 2023 – 2026	141.0	131.0	1c	Potential temporal overlap of operation with the Project

Project	Status	Distance to the Project array area (km)	Distance to the Project offshore ECC (km)	Tier	Reason for inclusion
Norfolk Boreas	Consented - construction expected 2023 – 2026	94.9	100.5	1c	Potential temporal overlap of operation with the Project
Norfolk Vanguard	Consented – construction expected 2023 – 2025	83.8	86.7	1c	Potential temporal overlap of operation with the Project
Sheringham Shoal Extension Project	In determination	26.1	8.8	1d	Potential temporal overlap of operation with the Project
Dudgeon Extension Project	In determination	13.5	0.0	1d	Potential temporal overlap of operation with the Project
Rampion 2	Application Submitted 2023	321.6	285.2	2	Potential temporal overlap of operation with the Project
Five Estuaries (Galloper Extension)*	In planning	175.5	162.5	2	Potential temporal overlap of operation with the Project
North Falls (Greater Gabbard Extension)*	In planning	169.9	155.1	2	Potential temporal overlap of operation with the Project
Dogger Bank South (East)	Pre-planning	81.2	98.7	2	Potential temporal overlap of operation with the Project
Dogger Bank South (West)	Pre-planning	94.6	112.5	2	Potential temporal overlap of operation with the Project
Dogger Bank D	Pre-planning	117.7	190.1	2	Potential temporal overlap of operation with the Project

Project	Status	Distance to the Project array area (km)	Distance to the Project offshore ECC (km)	Tier	Reason for inclusion
ScotWind Projects (multiple)[2]	Pre-planning	Multiple	Multiple	1d to 3a	Potential temporal overlap of operation with the Project

[2] Projects at varying stages of consent. Those with submitted applications have had impacts included for relevant species.

355. The cumulative MDS for the Project is outlined in Table 12.47, based on the impacts having the potential to result in the greatest cumulative effect on an identified receptor group. The cumulative impact MDS has been selected based on details presented in the project specific MDS (Table 12.10), alongside publicly available information on other projects and plans.

Table 12.47 Maximum Design Scenario for Cumulative Assessment

Impact	Maximum Design Scenario	Justification
Construction		
Impact 1: Disturbance and displacement: Offshore ECC.	MDS for the Project, plus the cumulative full development of the following projects within the UK North Sea and English Channel: Tier 1: - Permitted OWFs not yet implemented; and - OWFs with submitted applications not yet determined. Tier 2: - Tier 2 project identified	Maximum potential for interactive effects from construction activities associated with the construction of the OWFs considered within the UK North Sea and English Channel BDMPS region (where appropriate). This region was chosen as seabirds associated with the Project 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.
O&M phase		
Impact 2: Disturbance and displacement: Array Area. Gannet and auk species (guillemot, razorbill and puffin)	MDS for the Project, plus the cumulative full development of the following projects within the UK North Sea and English Channel: Tier 1: - Operational OWFs in the North Sea and English Channel (where applicable); - OWFs under construction in the North Sea and English Channel (where applicable); - Permitted OWFs not yet implemented; and - OWFs with submitted applications not yet determined. Tier 2: - Tier 2 project identified Tier 3; and - Tier 3 projects identified.	Maximum potential for interactive effects from operational and maintenance activities associated with the OWFs considered within the UK North Sea and English Channel (where appropriate). This region was chosen as seabirds associated with the Project 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.

Impact	Maximum Design Scenario	Justification
Impact 3: Collision risk: Array area. Gannet, kittiwake, great black-backed gull, herring gull, lesser black-backed gull, and Sandwich tern.	MDS for the Project, plus the cumulative full development of the following projects within the UK North Sea and English Channel: Tier 1: - Operational OWFs in the North Sea and English Channel (where applicable); - OWFs under construction in the North Sea and English Channel (where applicable); - Permitted OWFs not yet implemented; and - OWFs with submitted applications not yet determined. Tier 2: - 1 Tier 2 project identified, with quantitative data not yet publicly available. Tier 3: - 2 tier 3 projects identified, with quantitative data not yet publicly available.	Maximum potential for interactive effects from operational and maintenance activities associated with the OWFs considered within the UK North Sea and English Channel (where appropriate). This region was chosen as seabirds associated with the Project 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.

12.10.2 Cumulative Impact Assessment: Disturbance and Displacement (Construction Phase)

356. There is potential for cumulative disturbance and displacement impacts to occur when the construction of the Project temporally overlaps with that of one or more other consented and/or application-stage projects. As outlined in Table 12.48, this section only considers cumulative effects on red-throated divers during the construction of the Offshore ECC on a precautionary basis.

357. All other species/impacts relating to disturbance and displacement have been screened out of the cumulative assessment. For common scoter, the worst-case scenario impact from the Project is less than one (0.1) mortality per annum and therefore, there is no potential for the Project to contribute materially to any cumulative impact. For auk species and gannet, the impact is also not considered to be relevant at the cumulative level. Impacts during the construction phase are temporary, reversible and spatially limited. In addition, impacts during the construction phase are considered to be at least half compared with the operational phase. Cumulative impacts for the operational phase are considered below (Section 12.10) for these species.

Red-throated diver

358. During the construction phase, there is potential for cumulative construction-related disturbance and displacement impacts arising within project ECCs from a number of Tier 1 and Tier 2 projects, as outlined in Table 12.48below. The impact assessments for those projects included were largely carried out using a consistent methodology and in common with the methodology used for the Project alone assessment, with an area of 2km around cable-laying vessels being assumed to be subject to displacement. A mortality range of 1% to 10% was mainly considered, but where this was not the case, values have been converted for consistency. Values in the table are those of predicted displacement/disturbance impacts at the construction phase of each relevant project. ECC impacts through displacement and subsequent mortality are considered to be lower than those from the array as the area affected at any one time is small (i.e. a 2 km buffer around the cable laying vessel). As such, no substantial difference to bird distribution arises, and the presence of displacement pressure at any given location is very short-lived.

Table 12.48 Projects and parameters used in the cumulative assessment of red-throated diver.

Project	Predicted mortality range (individuals)	Mortality rate assumptions in ES	Tier
East Anglia THREE	0 - 2	1-10% mortality	1c
Norfolk Vanguard	0 - 9	2 - 4 at 5% mortality, converted to 1-10% mortality	1c
Norfolk Boreas	0 – 9	1-10% mortality	1c
East Anglia ONE North	0 - 10	1-10% mortality	1c
East Anglia TWO	0 - 10	1-10% mortality	1c

Project	Predicted mortality range (individuals)	Mortality rate assumptions in ES	Tier
Hornsea Project 4	0 - 0	No losses even with 100% displacement	1d
Dudgeon Offshore Extension Project	0 - 0	1-10% mortality	1d
Sheringham Shoal Extension Project	0 - 3	1-10% mortality	1d
Rampion 2	0 – 0	Species not assessed	2
ForthWind Offshore Wind Demonstration Project – Phase 1	0 - 0	Species not assessed	-
West of Orkney	0 - 0	Species not assessed	-
Dogger Bank South	0 - 0	Species not assessed	-
North Falls	1 - 18	Species not assessed	-
Total (other projects)	**1 - 61**	**-**	**-**
The Project	0 - 3	1-10% mortality	-
Total (all projects)	**1 - 64**	**-**	-

359. In total, up to 61 red-throated divers are currently predicted to be at risk of cumulative displacement-consequent mortality during the construction phase of these OWFs, rising to 64 when including the worst-case scenario from the Project (based on 100% displacement, and 10% mortality).

360. Considering the largest Southwest North Sea BDMPS population of 13,277 individuals, and a baseline mortality of 3,120 individuals per annum, the addition of 64 individuals would represent a 2.051% increase in baseline mortality. Considering the biogeographic population of 27,000 individuals and a baseline mortality of 6,345 individuals, the addition of 64 individuals would represent a 1.009% increase in baseline mortality.

361. It is noted that the cumulative assessment for red-throated diver is considered to be over-precautionary due to several reasons, including:

- The temporary nature of the are affected, with vessel activity only impacting a small number of individuals for a limited period of time, therefore having no expected material differences on seabird densities;
- A review undertaken by Norfolk Vanguard Ltd (2019) found that the top range of 100% and 10% recommended by SNCBs is over precautionary, and that the lower range of 90% displacement and 1% mortality is more appropriate, while still being precautionary. They also recommend that displacement mortality may in reality be less than 1% and as low as zero;
- There is an unknown level of double counting, since some birds will be present within more than one bio-season and could also move between sites;

- The majority of the predicted annual mortality occurs during the autumn and spring migration periods, where the potential consequences of displacement are expected to be much lower in reality, since birds will be present within the area for only a brief duration; and
- It is probable that the South-west North Sea BDMPS for spring and autumn migration (13,277) is an underestimate. Based on the most recent population count, the Greater Wash SPA hosts 22,280 individuals. If this value were used as a minimum estimate for the BDMPS assessment, then the predicted annual cumulative mortality of 1 to 46 individuals would represent a 0.032% to 1.474% increase in baseline mortality.

362. On this basis, it is considered more realistic (and still precautionary) to base the assessment on a displacement rate of 100% and a mortality rate of 1%. This, combined with the additional sources of precaution listed above, would result in a large reduction in the cumulative displacement totals presented as the worst-case scenario to six (6.4) individuals, resulting in an increase in baseline mortality 0.205% at the South-west North Sea BDMPS scale, and a 0.101% increase in baseline mortality at the biogeographic scale.

363. Based on this, the magnitude of the impact is assessed as negligible at the BDMPS and biogeographic scales. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of high, the significance of the cumulative effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

364. Confidence in the conclusions of this assessment is high due to the precautionary displacement and mortality rates used, and the temporary nature of the impact.

12.10.3 Cumulative impact assessment: Disturbance and displacement (O&M phase)

365. As a result of the operational and maintenance activities associated with the Project and other projects (Table 12.47), there is potential for cumulative displacement. For this cumulative impact assessment, only projects which were defined as being within Tier 1 (sub-tiers 1a to 1d) and Tier 2 were considered because they are the only projects with publicly available ornithological impact estimates. This approach is in line with Planning Inspectorate guidance note 17.

366. The presence of WTGs and other infrastructure or O&M activity 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).

367. Following the screening process, five seabird species of interest (guillemot, razorbill, puffin, red-throated diver and gannet) were assessed for cumulative displacement.

Red-throated diver

368. As outlined in Section 12.8, red-throated divers show a high level of sensitivity to maintenance activities from, for example, ship and helicopter traffic as well as to the presence of operational WTGs.

369. For red-throated diver, there are a limited number of OWFs in the southern North Sea which have quantitatively assessed the impacts of displacement on this species during the O&M phase. A review of impact assessments for OWFs in the south-west North Sea BDMPS is presented in Norfolk Vanguard Ltd (2019). Within this review, four categories of impact assessments were identified:

- OWFs with no population estimates presented (Dogger Bank A, B, C and Sofia, and Blyth demonstrator);
- Coastal windfarms with low numbers of over-wintering birds reported (Teesside, Humber Gateway and Westernmost Rough);
- OWFs with sightings made during months considered to belong to the breeding season (Hornsea projects); and
- OWFs with quantitative numbers of over wintering birds by season (Norfolk Vanguard, Norfolk Boreas).

370. Mortality estimates from the above projects, as provided for Sheringham Shoal and Dudgeon Offshore Windfarm Extension Projects (Royal HaskoningDHV, 2022b) are presented in Table 12.49 below for the full range of displacement scenarios (90% displacement and 1% mortality, to 100% displacement and 10% mortality), with the addition of Rampion 2, ForthWind Offshore Wind Demonstration Project, West of Orkney, Dogger Bank South, North Falls and Five Estuaries for which data has become available since this document.

Table 12.49 Cumulative displacement mortality estimates for red-throated diver from Tier 1 and 2 projects.

Project	Post-breeding migration	Migration-free winter	Return migration	Breeding	Non-breeding	Annual total	Tier
Wider region (Royal HaskoningDHV, 2022b)	N/A	N/A	N/A	-	-	6 – 56	1a
East Anglia ONE	0.4 – 5	1 – 10	1.4 – 15	-	-	2.8 – 30	1a
East Anglia THREE	0.4 – 5	0.2 – 2	2 – 20	-	-	2.6 – 27	1c

Project	Post-breeding migration	Migration-free winter	Return migration	Breeding	Non-breeding	Annual total	Tier
Norfolk Vanguard East	0.4 – 5	0.2 – 3	1 – 12	-	-	1.6 – 20	1c
Norfolk Vanguard West	0 – 3	3 – 36	2 – 20	-	-	5 – 59	1c
Norfolk Boreas	0 – 1	1 – 15	5 – 62	-	-	6 – 78	1c
East Anglia ONE North	0 – 1	1 – 3	3 – 17	-	-	4 – 42	1c
East Anglia TWO	0	0 – 2	2 – 25	-	-	3 – 28	1c
Hornsea Project 4	0	0	0	-	-	0	1d
Dudgeon Offshore Extension Project	1 – 6	0 – 1	1 – 5	-	-	1 – 13	1d
Sheringham Shoal Extension Project	1 – 8	0 – 1	2 – 18	-	-	3 – 26	1d
Rampion 2	0	0	0	0	0	0	2
ForthWind Offshore Wind Demonstration Project – Phase 1	0	0	0	0	0	0	2
West of Orkney	0	0	0	0	0	0	2
Dogger Bank South	0	0	0	0	0	0	2
North Falls	0 – 1	1 - 6	5 - 49	-	-	6 - 56	2
Five Estuaries	0 – 0	0 – 2	0 - 3	-	-	0 - 5	2
Total (other projects)	**3.2 – 35**	**7.4 – 81**	**24.4 – 246**	**0.0 – 0.0**	**0.0 – 0.0**	**41.0 – 440.0**	**-**
The Project	-	-	-	0.1 – 1.5	1.7 - 18.8	1.8 - 20.3	-
Total (all projects)	-	-	-	-	-	**42.8 – 460.3**	**-**

371. The potential overall magnitude of impact is estimated by calculating the increase in baseline mortality when compared against the largest UK Southwest North Sea BDMPS and biogeographic population. The largest red-throated diver BDMPS is 13,277 individuals whilst the wider bio-geographic population is 27,000 individuals. Using the average mortality rate of 0.228 (Table 12.9), the background mortality for these population scales are 3,027 and 6,156 individuals per annum, respectively.

372. The predicted cumulative displacement mortality for red-throated divers based on 90% to 100% displacement, and 1% to 10% mortality, is estimated as 43 (42.8) – 460 (460.3) individuals.

373. At the UK Southwest North Sea BDMPS scale, the potential cumulative loss of 43 to 460 individuals represents a 1.414% to 15.206% increase in baseline mortality. At the biogeographic scale, this addition of 43 to 460 individuals represents a 0.695% to 7.477% increase in baseline mortality. As the population in the south-west North Sea may be increasing (for example the population of the Outer Thames SPA has increased from 6,446 individuals during the period 1989 – 2006/7 to 21,997 (Irwin *et al.*, 2019)) it is likely that the impacts predicted here represent a lower increase in baseline mortality than those calculated above.

374. A more realistic scenario is considered to be the use of 100% displacement, and 1% mortality, which would result in an annual total of 44 (43.9) predicted displacement consequent mortalities. This would result in a 1.450% and 0.713% increase in baseline mortality at the BDMPS and biogeographic populations respectively.

375. However, it is noted that the cumulative assessment for red-throated diver is considered to be over-precautionary due to several reasons laid out below:

- Assessments for OWFs have assumed that displacement occurs to the same extent across the entire OWF and 4km buffer, whereas in reality it is expected that the degree of displacement will decline with distance from windfarm boundaries, and may be as low as zero by 2km;
- The inclusion of total displacement within the 4km buffers from both Norfolk Vanguard East and Norfolk Vanguard West is highly precautionary since no allowance is made for the division of WTGs across the two windfarm sites and the consequent reduction in developed area or increase in WTG spacing;
- The majority of the predicted annual mortality occurs during the autumn and spring migration periods, where the potential consequences of displacement are expected to be much lower in reality, since birds will be present within the area for only a brief duration;
- It is probable that the South-west North Sea BDMPS for spring and autumn migration (13,277) is an underestimate. Based on the most recent population count, the Greater Wash SPA hosts 22,280 individuals. If this value were used as a minimum estimate for the BDMPS assessment, then the predicted annual cumulative mortality of 1 to 460 individuals would represent a 0.032% to 1.474% increase in baseline mortality;
- There is an unknown level of double counting, since some birds will be present within more than one bio-season and could also move between sites;

- There is an overlap of the Norfolk Boreas, Norfolk Vanguard East and East Anglia THREE 4km buffers, resulting in an unaccounted-for level of double counting of birds (approximately 15%); and

376. Based on these elements of precaution, it is considered that the realistic scenario of 100% displacement and 1% mortality, combined with the elements of precaution outlined above, would result in the magnitude of impact at the South-west North Sea BDMPS scale and biogeographic scale being negligible, representing no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of high, the significance of the effect is therefor considered to be **minor adverse, which is not significant in EIA terms** based on the matrix approach defined in Table 12.15.

Gannet

377. As outlined in Section 12.8, gannets show a low level of sensitivity to maintenance activities from ship and helicopter traffic as well as to operational WTGs. Additionally, gannets are highly flexible in their foraging requirements, and therefore is it unlikely that the Project will contribute to any significant impacts at the cumulative level. A cumulative assessment has been carried out on this species to demonstrate this.

378. Table 12.50below presents the bio-season and annual abundance estimates for relevant OWFs in the UK North Sea and Channel BDMPS. This approach has considered birds within the array area and 2km buffer for all projects. Abundances were taken from the Sheringham Shoal and Dudgeon Offshore Windfarm Extension Projects Gannet and Auk cumulative Displacement Updates Technical Note (Royal HaskoningDHV, 2023). The following amendments were made to these values:

- Inclusion of values from the ForthWind Offshore Wind Demonstration Project, Berwick Bank, North Falls and Five Estuaries;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time the Project is predicted to be operational; and
- Inclusion of values from the Project.

Table 12.50 Cumulative bio-season and total abundance estimates for gannet from all Tier 1 and 2 projects.

Project	Breeding	Post-breeding migration	Return migration	Annual total	Tier
Beatrice	151	0	0	151	1a
Blyth Demonstration Site	-	-	-	0	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

Project	Breeding	Post-breeding migration	Return migration	Annual total	Tier
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	-	-	-	0	1a
Hywind 2 Demonstration	10	0	4	14	1a
Kentish Flats	-	-	-	0	1a
Kentish Flats Extension	0	13	0	13	1a
Kincardine	120	0	0	120	1a
Lincolnshire Node	-	-	-	0	1a
London Array	-	-	-	0	1a
Methil	23	0	0	23	1a
Race Bank	92	32	29	153	1a
Rampion	0	590	0	590	1a
Scroby Sands	-	-	-	0	1a
Sheringham Shoal	47	31	2	80	1a
Teesside	1	0	0	1	1a
Thanet	-	-	-	0	1a
Westermost Rough	-	-	-	0	1a
Hornsea Project Two	457	1,140	124	1,721	1b
Moray Firth EDA	564	292	27	883	1b
Neart na Gaoithe	1,987	552	281	2,820	1b
Triton Knoll	211	15	24	250	1b
Firth of Forth Alpha and Bravo	2,956	664	332	3,952	1b
Dogger Bank Creyke Beck Projects A & B	1,155	2,048	394	3,597	1c
Dogger Bank Teeside Projects A and B	2,250	887	464	3,601	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
Norfolk Vanguard	271	2,453	437	3,161	1c
Norfolk Boreas	1,229	1,723	526	3,478	1c
East Anglia ONE North	149	468	44	661	1c
East Anglia TWO	192	891	192	1,275	1c
Hornsea Four	976	790	401	2,167	1c
ForthWind Offshore Wind Demonstration Project - phase 1	64	26	44	134	1c
Sheringham Shoal Extension	23	295	11	329	1d

Project	Breeding	Post-breeding migration	Return migration	Annual total	Tier
Dudgeon Extension	417	343	47	807	1d
Berwick Bank	4,735	1,500	269	6,504	1d
Green Volt	120	16	49	185	1d
Rampion 2 (PEIR)	111	102	123	336	2
North Falls (PEIR)	68	453	245	766	2
Five Estuaries	233	640	67	940	2
Total All Projects (without the Project)	26,963	24,709	6,267	57,939	-
the Project	5.45	3.86	0.67	9.98	-
Total (with the Project)	26,968	24,713	6,268	57,949	-

Potential magnitude of impact

379. The potential overall 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 0.191 (Table 12.9), the background mortality for these population scales are 87,151 and 225,380 individuals per annum, respectively.

380. The predicted cumulative mortality from displacement is estimated based on a displacement rate of 70% and a mortality rate of 1%, though a range of 60% to 80% displacement is also presented in Table 12.51in line with SNCB guidance (MIG-Birds, 2022). The cumulative annual displacement matrix is presented in Table 12.52.

Table 12.51 Cumulative seasonal and annual displacement impacts on gannet (O&M phase).

Bio-season (months)	Cumulative **Seasonal abundance (array area plus 2km buffer)**	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated cumulative mortality level during O&M phase.		Increase in baseline mortality (%) during O&M phase	
		Population	Baseline mortality	70% displacement, 1% mortality	60-80% displacement, 1% mortality	70% displacement, 1% mortality	60-80% displacement, 1% mortality
Return migration (Dec-Mar)	6,268	248,385	47,442	43.9	37.6 – 50.1	0.092	0.081 – 0.107
Migration-free breeding (Apr-Aug)	26,968	299,492	76,462	188.8	161.8 – 215.7	0.246	0.21 – 0.385
Post-breeding migration (Sep-Nov)	24,713	456,298	87,151	172.9	148.3 - 197.7	0.198	0.170 – 0.232
Annual (BDMPS)	57,949	456,298	87,151	405.6	347.6 – 463.6	0.536	0.459 – 0.612
Annual (biogeographic)	57,949	1,180,000	225,380	405.6	3.647 – 463.6	0.536	0.459 – 0.612

Table 12.52 Cumulative annual displacement matrix for gannet within the array area and 2km buffer, values in light blue represent the range-based values advocated by SNCBs and the darker shade of blue representing the Applicant's approach value.

Annual (2km Buffer)	Mortality Rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	58	116	290	579	1,159	1,738	2,318	2,897	3,477	4,056	4,636	5,215	5,795
20	116	232	579	1,159	2,318	3,477	4,636	5,795	6,954	8,113	9,272	10,431	11,590
30	174	348	869	1,738	3,477	5,215	6,954	8,692	10,431	12,169	13,908	15,646	17,385
40	232	464	1,159	2,318	4,636	6,954	9,272	11,590	13,908	16,226	18,544	20,862	23,180
50	290	579	1,449	2,897	5,795	8,692	11,590	14,487	17,385	20,282	23,180	26,077	28,975
60	348	695	1,738	3,477	6,954	10,431	13,908	17,385	20,862	24,339	27,816	31,292	34,769
70	406	811	2,028	4,056	8,113	12,169	16,226	20,282	24,339	28,395	32,451	36,508	40,564
80	464	927	2,318	4,636	9,272	13,908	18,544	23,180	27,816	32,451	37,087	41,723	46,359
90	522	1,043	2,608	5,215	10,431	15,646	20,862	26,077	31,292	36,508	41,723	46,939	52,154
100	579	1,159	2,897	5,795	11,590	17,385	23,180	28,975	34,769	40,564	46,359	52,154	57,949

381. Across all OWF projects presented in Table 12.50, the annual cumulative total of gannets at risk of displacement is calculated to be 57,949. When applying a 70% displacement rate and a 1% mortality rate, the annual cumulative loss is estimated as 406 (405.5) individuals.

382. At the UK North Sea and English Channel BDMPS scale, the potential cumulative loss of 406 gannets represents a 0.465% increase in baseline mortality. At the biogeographic scale, this additional mortality would increase baseline mortality by 0.179%.

383. Over the range of displacement and mortality scenarios assessed, the addition to baseline mortality remains well below 1% and can, therefore, be considered to make no material difference to the baseline mortality of the species.

384. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of minor to moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

Guillemot

385. As outlined in Section 12.8, guillemots show a medium level of sensitivity to maintenance activities from, for example, ship and helicopter traffic as well as to operational WTGs.

386. Table 12.53below presents the bio-season and annual abundance estimates for relevant OWFs in the UK North Sea and Channel BDMPS. This approach has considered birds within the array area and 2km buffer for all projects. Abundances were taken from the Sheringham Shoal and Dudgeon Offshore Windfarm Extension Projects Gannet and Auk cumulative Displacement Updates Technical Note (Royal HaskoningDHV, 2023). The following amendments were made to these values:

- Inclusion of values from the ForthWind Offshore Wind Demonstration Project, Berwick Bank, North Falls and Five Estuaries;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time the Project is predicted to be operational; and
- Inclusion of values from the Project.

387. It should be noted that the total number of birds estimated within the collective array area and 2km buffers is likely to be an overestimate due to each individual assessment considering the mean peak for each bio-season. Consequently, the total abundance presented in Table 12.53 represents ~28% of the entire North Sea and English Channel BDMPS population, whilst the area covered by the combined array area and 2km buffers of all of the OWFs considered within this cumulative displacement assessment would be well under 5% of the corresponding area. The approach undertaken to assess cumulative displacement is therefore considered highly precautionary.

Table 12.53 Cumulative bio-season and total abundance estimates for guillemot from all Tier 1 and 2 projects.

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
European Offshore Wind Development Centre (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
Kincardine	632	0	632	1a
Lincolnshire Node & LID	582	814	1,396	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	-	-	0	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 Firth EDA	9,820	547	10,367	1b
Neart na Gaoithe	1,755	3,761	5,516	1b
Triton Knoll	425	746	1,171	1b
Dogger Band Teeside A	3,283	2,268	5,551	1b
Dogger Bank Teeside B	5,211	3,701	8,912	1b
Firth of Forth Alpha	13,606	4,688	18,294	
Firth of Forth Bravo	11,118	4,112	15,230	
Dogger Bank Creyke Beck Project A	5,407	6,142	11,549	1c
Dogger Bank Creyke Beck Project B	9,479	10,621	20,100	
East Anglia Three	1,744	2,859	4,603	1c
Hornsea Three	13,374	17,772	31,146	1c
Inch Cape	4,371	3,177	7,548	1c

Project	Breeding	Non-breeding	Annual total	Tier
Moray West	24,426	38,174	62,600	1c
Norfolk Vanguard	4,320	4,776	9,096	1c
Norfolk Boreas	7,767	13,777	21,544	1c
East Anglia ONE North	4,183	1,888	6,071	1c
East Anglia TWO	2,077	1,675	3,752	1c
Hornsea Four (NE approach)	9,382	36,965	46,347	1c
ForthWind Offshore Wind Demonstration Project - phase 1	417	401	818	1c
Pentland Floating	1,146	650	1,796	1c
Sheringham Shoal Extension	1,085	1,095	2,180	1d
Dudgeon Extension	3,839	14,887	18,726	1d
Berwick Bank	74,154	44,171	118,325	1d
Green Volt	4,429	16,105	20,534	1d
Rampion 2 (PEIR)	185	13,020	13,205	2
North Falls (PEIR)	1,103	4,497	5,600	2
Five Estuaries	1,201	3,698	4,899	2
Total All Projects (without the Project)	267,562	306,363	573,925	
The Project	82	56	138	
Total (with the Project)	267,644	306,419	574,063	

Potential magnitude of impact

388. The potential overall 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 guillemot BDMPS for the UK North Sea and English Channel is 2,045,078 individuals, whilst the wider bio-geographic population is 4,125,000 individuals. Using the average mortality rate of 0.138 (Table 12.9), the background mortality for these population scales are 282,220 and 569,250 individuals per annum, respectively.

389. The predicted cumulative mortality as a result of displacement is estimated based on a displacement rate of 50% and a mortality rate of 1%, though a displacement rate range of 30% to 70% and a mortality rate range of 1% to 10% is also presented in Table 12.54in line with SNCB guidance (MIG-Birds, 2022). Results are also presented in a displacement matrix in Table 12.55.

Table 12.54 Cumulative seasonal and annual displacement impacts on guillemot (O&M phase).

Bio-season (months)	Cumulative Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated cumulative mortality level during O&M phase.		Increase in baseline mortality (%) during O&M phase.	
		Population	Baseline mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality
Breeding (Mar - Jul)	267,644	2,045,078	286,311	1,338.2	802.9 – 18,734.0	0.467	0.280 – 6.654
Non-breeding (Aug - Feb)	306,419	1,617,306	226,422	1,532.1	919.3 – 21,449.4	0.677	0.406 – 9.473
Annual (BDMPS)	574,063	2,045,078	286,311	2,870.3	1,772.8 - 40,184.2	1.003	0.602 – 14.035
Annual (biogeographic)	574,063	4,125,000	577,500	2,870.3	1,772.8 – 40,184.2	0.504	0.303 – 7.059

Table 12.55 Cumulative annual displacement matrix for guillemot within the array area and 2km buffer, values in light blue represent the range-based values advocated by SNCBs and the darker shade of blue representing the Applicant's approach value.

Annual (2km Buffer)	Mortality Rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	574	1,148	2,870	5,741	11,481	17,222	22,963	28,703	34,444	40,184	45,925	51,666	57,406
20	1,148	2,296	5,741	11,481	22,963	34,444	45,925	57,406	68,888	80,369	91,850	103,331	114,813
30	1,722	3,444	8,611	17,222	34,444	51,666	68,888	86,109	103,331	120,553	137,775	154,997	172,219
40	574	1,148	2,870	5,741	11,481	17,222	22,963	28,703	34,444	40,184	45,925	51,666	57,406
50	2,870	5,741	14,352	28,703	57,406	86,109	114,813	143,516	172,219	200,922	229,625	258,328	287,032
60	3,444	6,889	17,222	34,444	68,888	103,331	137,775	172,219	206,663	241,106	275,550	309,994	344,438
70	4,018	8,037	20,092	40,184	80,369	120,553	160,738	200,922	241,106	281,291	321,475	361,660	401,844
80	4,593	9,185	22,963	45,925	91,850	137,775	183,700	229,625	275,550	321,475	367,400	413,325	459,250
90	5,167	10,333	25,833	51,666	103,331	154,997	206,663	258,328	309,994	361,660	413,325	464,991	516,657
100	5,741	11,481	28,703	57,406	114,813	172,219	229,625	287,032	344,438	401,844	459,250	516,657	574,063

390. Across all OWF projects presented in Table 12.47, the annual cumulative total of guillemots at risk of displacement is calculated to be 574,063. When applying a 50% displacement rate and a 1% mortality rate, the annual cumulative loss is estimated as 2,870 (2,870.3) individuals.

391. At the UK North Sea and English Channel BDMPS scale, the potential cumulative loss of 2,870 guillemots represents a 1.003% increase in baseline mortality. At the biogeographic scale, this additional mortality would increase baseline mortality by 0.504%. As the predicted impact exceeds a 1% increase in baseline mortality at the BDMPS scale, further consideration is given below in the form of Population Viability Analysis (PVA).

392. PVA was undertaken on a range of scenarios for both the Project alone and cumulatively with other projects (as presented in Appendix 12.4: Population Viability Analysis [document reference: 6.3.12.4]). For each scenario, counterfactual of population growth (CGR) and counterfactual of population size (CPS) have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 35 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis. PVA results are shown in Table 12.56.

393. The worst-case scenario of 70% displacement and 10% mortality would result in an annual reduction in BDMPS population growth rate of 2.2% and a 1.1% reduction in biogeographic population growth rate. Notably, this scenario is considered highly precautionary, and not representative of actual impacts expected as a result of the Project when combined with other projects. A realistic worst-case scenario is considered to be 70% displacement and 2% mortality, which aligns with recent Natural England preferred approach (e.g., SEP & DEP, Natural England, 2023), results in a reduction in population growth rate of 0.4% and 0.2% at the BDMPS and biogeographic population scales, respectively. These impacts are further reduced to 0.2% and 0.08% respectively when considering the applicant’s approach of 50% displacement and 1% mortality.

394. Based on this PVA analysis, even considering the realistic worst-case scenario of 70% displacement and 2% mortality, the resulting reduction in annual population growth rate at both the BDMPS and biogeographic population scales is expected to be indistinguishable from natural fluctuations in the population. Additionally, it should be noted that the displacement assessment undertaken is based on several elements that incorporate a high level of precaution, including:

- The use of mean peak estimates in the displacement assessment results in the unrealistically high estimates of seasonal abundance;
- PVA does not incorporate density dependence, resulting in over-precautionary model outputs; and

- The guillemot population is modelled as a closed population, with no emigration or immigration.

395. Within the context of wider UK guillemot population changes (for example, a national decline of 11% between Seabird 2000 and Seabirds Count (a period of approximately 20 years), and an increase of 106% in England and a decrease of 31% in Scotland (Burnell *et al.,* 2023), the changes in populations modelled by PVA from cumulative impacts are considered to be small compared to the natural fluctuations within the population, or changes brought about by other pressures.

396. Density dependence regulates population size by adjusting demographic rates to maintain a population around a carrying capacity. If impacts from OWFs decrease survival rates, the resulting decrease in competition for resources might lead to increased survival and/or productivity in the remaining population, consequently boosting population growth. The importance of density dependence is evident in natural ecosystems, where without it, populations would exhibit exponential growth. However, the mechanisms as to how this operates in seabirds are largely uncertain. Misinterpretation of density dependence in population assessments can result in unreliable predictions. As such, PVA models used in this assessment were density independent, despite ecological evidence suggesting the presence of density dependence in large populations (Horswill et al., 2017). While density-independent models lack the capacity for population recovery once it falls below a certain threshold, they are preferred for impact assessments due to their precautionary nature (Ridge et al. 2019). Please see the PVA Appendix 12.4 for further justification.

Table 12.56 PVA results for guillemot impacts on the North Sea BDMPS

PVA Scenario	Annual mortality	Impact on survival	Median CGR	Median CPS
Project alone				
30% displacement, 1% mortality (BDMPS)	83.0	<0.001	1.000	0.998
50% displacement, 1% mortality (BDMPS)	138.3	<0.001	1.000	0.997
70% displacement, 2% mortality (BDMPS)	387.1	<0.001	1.000	0.992
70% displacement,	1,935.7	0.001	0.999	0.962

PVA Scenario	Annual mortality	Impact on survival	Median CGR	Median CPS
10% mortality (BDMPS)				
30% displacement, 1% mortality (biogeographic)	83.0	<0.001	1.000	0.983
50% displacement, 1% mortality (biogeographic)	138.3	<0.001	0.999	0.972
70% displacement, 2% mortality (biogeographic)	8,036.9	<0.001	0.998	0.924
70% displacement, 10% mortality (biogeographic)	1,935.7	<0.001	0.989	0.674
Project cumulatively				
30% displacement, 1% mortality (BDMPS)	83.0	0.001	0.999	0.965
50% displacement, 1% mortality (BDMPS)	138.3	0.001	0.998	0.945
70% displacement, 2% mortality (BDMPS)	387.1	0.004	0.996	0.853
70% displacement, 10% mortality (BDMPS)	1935.7	0.020	0.978	0.447
30% displacement, 1% mortality (biogeographic)	83.0	<0.001	1.000	0.983
50% displacement,	138.3	0.001	0.999	0.972

PVA Scenario	Annual mortality	Impact on survival	Median CGR	Median CPS
1% mortality (biogeographic)				
70% displacement, 2% mortality (biogeographic)	387.1	0.002	0.998	0.924
70% displacement, 10% mortality (biogeographic)	1935.7	0.020	0.989	0.674

397. This level of change is considered to be of minor magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall as it represents no discernible change to baseline mortality. Given a magnitude change of minor, and a sensitivity to disturbance and displacement of moderate, the significance of effect is therefore concluded to be **minor, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

Razorbill

398. As outlined in Section 12.8, razorbill show a medium level of sensitivity to maintenance activities from, for example, ship and helicopter traffic as well as to operational WTGs.

399. Table 12.57 below presents the bio-season and annual abundance estimates for relevant OWFs in the UK North Sea and Channel BDMPS. This approach has considered birds within the array area and 2km buffer for all projects. Abundances were taken from the Sheringham Shoal and Dudgeon Offshore Windfarm Extension Projects Gannet and Auk cumulative Displacement Updates Technical Note (Royal HaskoningDHV, 2023). The following amendments were made to these values:

- Inclusion of values from the ForthWind Offshore Wind Demonstration Project, Berwick Bank, North Falls and Five Estuaries;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time the Project is predicted to be operational; and
- Inclusion of values from the Project.

400. For the cumulative assessment, the collective total number of birds estimated within the array area and 2km buffers is considered to be highly over-inflated due to each individual assessment considering the mean peak for each bio-season. Consequently, the total abundance presented in Table 12.57represents approximately 26% of the entire North Sea and English Channel BDMPS population. However, the area covered by the combined array area and 2km buffers of all of the OWFs included within this cumulative displacement assessment would be well under 5% of the corresponding area. The approach undertaken to assess cumulative displacement is therefore considered highly precautionary.

401. Based on the justification provided in Section 12.8, a precautionary displacement rate of 50% and mortality rate of 1% is used for assessment.

Table 12.57 Cumulative bio-season and total abundance estimates for razorbill from all Tier 1 & 2 projects.

Project	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
European Offshore Wind Development Centre (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
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 and extension	-	-	-	-	0	1a
Kincardine	22				22	1a
Lincolnshire Node & LID	45	34	22	34	135	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	1244	3327	5267	1a
Scroby Sands	-	-	-	-	0	1a
Sheringham Shoal	106	1343	211	30	1690	1a

Project	Breeding	Post-breeding migration	Non-migratory wintering	Return migration	Annual total	Tier
Teesside	16	61	2	20	99	1a
Thanet	3	0	14	21	38	1a
Westermost Rough	91	121	152	91	455	1a
Hornsea Project Two	2511	4221	720	1668	9120	1b
Moray Firth EDA	2,423	1,103	30	168	3,724	1b
Neart na Gaoithe	331	5,492	508		6,331	1b
Triton Knoll	40	254	855	117	1,266	1b
Dogger Bank A	1,250	1,576	1,728	4,149	8,703	1b
Dogger Bank B	1,538	2,097	2,143	5,119	10,897	1b
Firth of Forth Alpha	5876	-	1103	-	6,979	1c
Firth of Forth Bravo	3,698	-	1,272	-	4,970	1c
East Anglia Three	1807	1,122	1,499	1,524	5,952	1c
Hornsea Three	630	2,020	3649	2105	8,404	1c
Inch Cape	1,436	2,870	651		4,957	1c
Moray West	2808	3,544	184	3585	10,121	1c
Norfolk Vanguard	879	866	839	924	3,508	1c
Norfolk Boreas	630	263	1,065	345	2,303	1c
Sofia	834	310	959	1,919	4,022	1c
Dogger Bank C	1153	592	1426	2953	6124	
East Anglia ONE North	403	85	54	207	749	1c
East Anglia TWO	281	44	136	230	691	1c
ForthWind Offshore Wind Demonstration Project - phase 1	57	81	58	81	277	1d
Hornsea Four	386	4,311	455	449	5,601	1d
Pentland Floating	134	16	17	14	181	
Sheringham Shoal Extension	316	759	686	144	1,905	1d
Dudgeon Extension	923	3741	845	320	5829	1d
Berwick Bank	4040	8849	1399	7,480	21,768	1d
Green Volt	-	-	-	-	515	1d
Rampion 2 (PEIR)	44	18	22	2130	2,214	2
North Falls (PEIR)	168	266	2,565	1,860	4,859	2
Five Estuaries	90	284	1,046	756	2,176	2
Total All Projects (without the Project)	38,282	53,425	31,188	45,765	169,175	-
the Project	18	12	9.8	31.1	70.8	-
Total (with the Project)	38,300	53,437	31,198	45,796	169,246	-

Potential magnitude of impact

402. 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 razorbill BDMPS for the UK North Sea and English Channel is 591,232 individuals, whilst the wider bio-geographic population is 1,707,000 individuals. Using the average mortality rate of 0.174 (Table 12.9), the background mortality for these population scales are 102,986 and 297,018 individuals per annum, respectively.

403. The predicted cumulative mortality as a result of displacement is estimated based on a displacement rate of 50% and a mortality rate of 1%, though a range of 30% to 70% displacement is also presented in Table 12.58 in line with SNCB guidance (MIG-Birds, 2022). Results are also presented in a displacement matrix in Table 12.59.

Table 12.58 Cumulative seasonal and annual displacement impacts on razorbill (O&M phase).

Bio-season (months)	Cumulative Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated cumulative mortality level during O&M phase.		Increase in baseline mortality (%) during O&M phase.	
		Population	Baseline mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality
Return migration (Jan - Mar)	45,796	591,874	102,986	228.9	137.3 – 2,289.0	0.222	0.120 – 2.800
Migration-free breeding (Apr - Jul)	38,300	158,662	27,607,	191.5	114.9 – 1915.0	0.693	0.211 – 4.914
Post-breeding migration (Aug - Oct)	53,437	591,874	102,986	267.2	160.3 – 2672.0	0.259	0.139 – 3.262
Migration-free winter (Nov - Dec)	31,198	218,622	38,047194	155.9	93.54 – 1559.0	0.409	0.221 – 5.166
Annual (BDMPS)	169,246	591,874	102,986	846.2	507.7 – 8462.0	0.812	0.422 – 9.856
Annual (biogeographic)	169,246	1,707,000	297,018	846.2	507.7 – 8462.0	0.284	0.154 – 3.584

Table 12.59 Cumulative annual displacement matrix for razorbill within the array area and 2km buffer, values in light blue represent the range-based values advocated by SNCBs and the darker shade of blue representing the Applicant's approach value.

Annual (2km Buffer)	Mortality Rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	169	338	846	1,692	3,385	5,077	6,770	8,462	10,155	11,847	13,540	15,232	16,925
20	338	677	1,692	3,385	6,770	10,155	13,540	16,925	20,310	23,694	27,079	30,464	33,849
30	508	1,015	2,539	5,077	10,155	15,232	20,310	25,387	30,464	35,542	40,619	45,696	50,774
40	677	1,354	3,385	6,770	13,540	20,310	27,079	33,849	40,619	47,389	54,159	60,929	67,698
50	846	1,692	4,231	8,462	16,925	25,387	33,849	42,312	50,774	59,236	67,698	76,161	84,623
60	1,015	2,031	5,077	10,155	20,310	30,464	40,619	50,774	60,929	71,083	81,238	91,393	101,548
70	1,185	2,369	5,924	11,847	23,694	35,542	47,389	59,236	71,083	82,931	94,778	106,625	118,472
80	1,354	2,708	6,770	13,540	27,079	40,619	54,159	67,698	81,238	94,778	108,317	121,857	135,397
90	1,523	3,046	7,616	15,232	30,464	45,696	60,929	76,161	91,393	106,625	121,857	137,089	152,321
100	1,692	3,385	8,462	16,925	33,849	50,774	67,698	84,623	101,548	118,472	135,397	152,321	169,246

404. Across all OWF projects presented in Table 12.57, the annual cumulative total of razorbills at risk of displacement is calculated to be 169,246. When applying a displacement rate of 50% and a 1% mortality rate, the annual cumulative loss is estimated as 846 (846.2) individuals.

405. At the UK North Sea and English Channel BDMPS scale, the potential cumulative loss of 774 razorbills represents a 0.812% increase in baseline mortality. At the biogeographic scale, this additional mortality would increase baseline mortality by 0.284%. As the predicted impact exceeds a 1% increase in baseline mortality at the BDMPS scale at the more precautionary higher displacement and mortality ratios, further consideration is given below in the form of PVA analysis.

406. PVA was undertaken on a range of scenarios for both the Project alone and cumulative with other projects (as presented in Appendix 12.4) For each scenario, CGR and CPS have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 35 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis.

407. The worst-case scenario of 70% displacement and 10% mortality would result in an annual reduction in population growth rate of 2.4% at the BDMPS population scale, and 0.8% based on the biogeographic population scale. Notably, this scenario is considered highly precautionary, and not representative of actual impacts expected as a result of the Project in-combination with other projects. A more realistic worst-case scenario is considered to be 70% displacement and 2% mortality which results in a reduction in population growth rate of 0.03% and 0.2% at the BDMPS and biogeographic population scales respectively. These impacts are further reduced to 0.02% and 0.04% respectively when considering the applicant’s approach of 50% displacement and 1% mortality. Results of the PVA are presented in Table 12.60.

408. Based on this PVA analysis, even considering the realistic worst-case scenario of 70% displacement and 2% mortality, the resulting reduction in annual population growth rate at both the BDMPS and biogeographic population scales is expected to be indistinguishable from natural fluctuations in the population. Additionally, it should be noted that the displacement assessment undertaken is based on several elements that incorporate a high level of precaution, including:

- The use of mean peak estimates in the displacement assessment results in the unrealistically high estimates of seasonal abundance;
- PVA does not incorporate density dependence, resulting in over-precautionary model outputs; and
- The razorbill population is modelled as a closed population, with no emigration or immigration.

409. Within the context of wider UK razorbill population changes (for example, a national increase of 18% between Seabird 2000 and Seabirds Count (a period of approximately 20 years), and an increase of 240% in England and a decrease of 2% in Scotland (Burnell *et al* 2023), the changes in populations modelled by PVA from cumulative impacts are considered to be small compared to the natural fluctuations within the population, or changes brought about by other pressures.

410. Density dependence regulates population size by adjusting demographic rates to maintain a population around a carrying capacity. If impacts from OWFs decrease survival rates, the resulting decrease in competition for resources might lead to increased survival and/or productivity in the remaining population, consequently boosting population growth. The importance of density dependence is evident in natural ecosystems, where without it, populations would exhibit exponential growth. However, the mechanisms as to how this operates in seabirds are largely uncertain. Misinterpretation of density dependence in population assessments can result in unreliable predictions. As such, PVA models used in this assessment were density independent, despite ecological evidence suggesting the presence of density dependence in large populations (Horswill et al., 2017). While density-independent models lack the capacity for population recovery once it falls below a certain threshold, they are preferred for impact assessments due to their precautionary nature (Ridge et al. 2019). Please see Appendix 12.4 for further justification.

Table 12.60 PVA results for razorbill impacts on the North Sea BDMPS

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
Project alone				
30% displacement, 1% mortality (BDMPS)	42.5	<0.001	1.000	0.997
50% displacement, 1% mortality (BDMPS)	80.8	<0.001	1.000	0.994
70% displacement, 2% mortality (BDMPS)	198.1	<0.001	1.000	0.986
70% displacement, 10% mortality (BDMPS)	990.7	0.002	0.998	0.931
30% displacement,	42.5	<0.001	1.000	0.999

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
1% mortality (biogeographic)				
50% displacement, 1% mortality (biogeographic)	80.8	<0.001	1.000	0.998
70% displacement, 2% mortality (biogeographic)	198.1	<0.001	1.000	0.995
70% displacement, 10% mortality (biogeographic)	990.7	0.001	0.999	0.976
Project cumulatively				
30% displacement, 1% mortality	506.2	0.001	0.999	0.964
50% displacement, 1% mortality	843.7	0.001	0.998	0.941
70% displacement, 2% mortality	2,362.3	0.004	0.995	0.844
70% displacement, 10% mortality	11,811.6	0.020	0.976	0.424
30% displacement, 1% mortality	506.2	<0.001	1.000	0.987
50% displacement, 1% mortality	843.7	<0.001	0.999	0.979
70% displacement, 2% mortality	2,362.3	0.001	0.998	0.943
70% displacement, 10% mortality	11,811.6	0.007	0.992	0.745

411. This level of change is considered to be of minor magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of minor, and a sensitivity to disturbance and displacement of moderate, the significance of effect is therefore concluded to be **minor, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.Puffin

412. As outlined in Section 12.8, puffin show a medium level of sensitivity to maintenance activities from, for example, ship and helicopter traffic as well as to operational WTGs.

413. Table 12.61 below presents the bio-season and annual abundance estimates for relevant OWFs in the UK North Sea and Channel BDMPS. This approach has considered birds within the array area and 2km buffer for all projects. Abundances were taken from the Hornsea Project Four Ornithology EIA & HRA Annex (APEM Ltd and GoBe Consultants 2022). The following amendments were made to these values:

- Inclusion of values from the Pentland Floating Windfarm, Berwick Bank and Green Volt;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time the Project is predicted to be operational; and
- Inclusion of values from the Project.

414. For the cumulative assessment, a highly unlikely total number of birds is estimated within the collective array area and 2km buffers, due to each individual assessment considering the mean peak for each bio-season. Consequently, the total abundance presented in Table 12.61represents ~18% of the entire North Sea and English Channel BDMPS population, whilst the area covered by the combined array area and 2km buffers of all of the OWFs considered within this cumulative displacement assessment would be well under 5% of the corresponding area. The approach undertaken to assess cumulative displacement is therefore considered highly precautionary.

Table 12.61 Cumulative bio-season and total abundance estimates for puffin from all Tier 1 and 2 projects.

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
EOWDC	42	82	124	1a
Galloper	0	1	1	1a
Greater Gabbard	0	1	1	1a
Gunfleet Sands	-	-	-	1a
Humber Gateway	15	10	25	1a
Hywind 2 Demonstration	119	85	204	1a
Kentish Flats	-	-	-	1a

Project	Breeding	Non-breeding	Annual total	Tier
Kentish Flats Extension	3	6	9	1a
Lincolnshire Node, 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
East Anglia One	16	32	48	1b
Hornsea Project One	1,070	1,257	2,327	1b
Hornsea Project Two	468	2,039	2,507	1b
Moray East	2,795	656	3,451	1b
Triton Knoll	23	71	94	1b
Kincardine	19	0	19	1b
Dogger Bank Creyke Beck A	37	295	332	1c
Dogger Bank Creyke Beck B	102	743	845	1c
Dogger Bank Teesside A	34	273	307	1c
East Anglia Three	181	307	488	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
Hornsea Three	253	67	320	1c
Norfolk Boreas	0	23	23	1c
Norfolk Vanguard	67	112	179	1c
East Anglia One North	-	-	-	1c
East Anglia Two	15	0	15	1c
Hornsea Four	203	442	644	1c
Pentland Floating	1,211	2	1,213	1c
Berwick Bank	-	-	4,513	1d
Green Volt	250	41	291	1d
Dudgeon Extension Project	0	17	17	1d
Sheringham Shoal Extension Project	0	11	11	1d
Rampion 2	6	0	6	2
North Falls	-	-	-	2
Five Estuaries	-	-	-	2

Project	Breeding	Non-breeding	Annual total	Tier
Total All Projects (without the Project)	22,964	23,705	46,669	
the Project	3.8	3.2	7	
Total (with the Project)	22,968	23,708	46,676	

Potential magnitude of impact

415. 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 individuals, whilst the wider bio-geographic population is 11,840,000 individuals. Using the average mortality rate of 0.167 (Table 12.9), the background mortality for these population scales are 145,071 and 1,977,280 individuals per annum, respectively.

416. The predicted cumulative mortality as a result of displacement is estimated based on a displacement rate of 50% and a mortality rate of 1%, though a range of 30% to 70% displacement is also presented in Table 12.62 in line with SNCB guidance (MIG-Birds, 2022). Results are also presented in a displacement matrix in Table 12.63.

Table 12.62 Cumulative seasonal and annual displacement impacts on puffin (O&M phase).

Bio-season (months)	Cumulative Seasonal abundance (array area plus 2km buffer)	Regional baseline populations and baseline mortality rates (individuals per annum)		Estimated cumulative mortality level during O&M phase.		Increase in baseline mortality (%) during O&M phase.	
		Population	Baseline mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality	50% displacement, 1% mortality	30-70% displacement, 1-10% mortality
Breeding (Mar - Jul)	22,968	868,689	145,071	114.8	68.9 – 1,607.2	0.079	0.363 – 8.484
Non-breeding (Aug - Feb)	23,708	231,957	35,730	118.5	71.1 – 1,659.0	0.331	0.174 – 4.074
Annual (BDMPS)	46,676	231,957	35,730	233.4	140.0 – 3,267.6	0.653	0.344 – 8.036
Annual (biogeographic)	46,676	11,840,000	1,977,280	233.4	140.0 – 3,267.6	0.011	0.007 – 0.154

417.

Table 12.63 Cumulative annual displacement matrix for puffin within the array area and 2km buffer, values in light blue represent the range-based values advocated by SNCBs and the darker shade of blue representing the Applicant's approach value.

Annual (2km Buffer)	Mortality Rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	47	93	233	467	934	1,400	1,867	2,334	2,801	3,267	3,734	4,201	4,668
20	93	187	467	934	1,867	2,801	3,734	4,668	5,601	6,535	7,468	8,402	9,335

30	140	280	700	1,400	2,801	4,201	5,601	7,001	8,402	9,802	11,202	12,603	14,003
40	187	373	934	1,867	3,734	5,601	7,468	9,335	11,202	13,069	14,936	16,803	18,670
50	233	467	1,167	2,334	4,668	7,001	9,335	11,669	14,003	16,337	18,670	21,004	23,338
60	280	560	1,400	2,801	5,601	8,402	11,202	14,003	16,803	19,604	22,404	25,205	28,006
70	327	653	1,634	3,267	6,535	9,802	13,069	16,337	19,604	22,871	26,139	29,406	32,673
80	373	747	1,867	3,734	7,468	11,202	14,936	18,670	22,404	26,139	29,873	33,607	37,341
90	420	840	2,100	4,201	8,402	12,603	16,803	21,004	25,205	29,406	33,607	37,808	42,008
100	467	934	2,334	4,668	9,335	14,003	18,670	23,338	28,006	32,673	37,341	42,008	46,676

418. Across all OWF projects presented in Table 12.47, the annual cumulative total of puffins at risk of displacement is calculated to be 46,676. When applying a displacement rate of 50% and a 1% mortality rate, the annual cumulative loss is estimated as 233 (233.4) individuals.

419. At the UK North Sea and English Channel BDMPS scale, the potential cumulative loss of 236 puffins represents a 0.653% increase in baseline mortality. At the biogeographic scale, this additional mortality would increase baseline mortality by 0.011%. Though predicted impacts do not exceed a 1% increase in baseline mortality based on the Applicant's approach, PVA has been carried out as a precautionary approach.

420. PVA was undertaken on a range of scenarios for both the Project alone and cumulatively with other projects (as presented in Appendix 12.4) For each scenario, CGR and CPS values have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 35 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis. PVA results are presented in Table 12.64.

421. Based on the BDMPS population, the predicted cumulative impacts would result in a 0.5% reduction in population growth rate when using the worst-case scenario of 70% displacement and 10% mortality, and a 0.04% reduction considering the biogeographic population. This impact is further reduced considering the Applicants approach, with a 0.03% and 0.003% reduction in population growth at the BDMPS and biogeographic population scales respectively.

422. Even considering the worst-case scenario (70% displacement and 10% mortality) which is not considered ecologically realistic based on available evidence, predicted impacts would be indistinguishable from natural fluctuations in the population.

423. Within the context of wider UK puffin population changes (for example, a national decline of 23% between Seabird 2000 and Seabirds Count (a period of approximately 20 years), and an increase of 50% in England and a decrease of 32% in Scotland (Burnell *et al* 2023), the changes in populations modelled by PVA from cumulative impacts are considered to be small compared to the natural fluctuations within the population, or changes brought about by other pressures.

424. Density dependence regulates population size by adjusting demographic rates to maintain a population around a carrying capacity. If impacts from OWFs decrease survival rates, the resulting decrease in competition for resources might lead to increased survival and/or productivity in the remaining population, consequently boosting population growth. The importance of density dependence is evident in natural ecosystems, where without it, populations would exhibit exponential growth. However, the mechanisms as to how this operates in seabirds are largely uncertain. Misinterpretation of density dependence in population assessments can result in unreliable predictions. As such, PVA models used in this assessment were density independent, despite ecological evidence suggesting the presence of density dependence in large populations (Horswill et al., 2017). While density-independent models lack the capacity for population recovery once it falls below a certain threshold, they are preferred for impact assessments due to their precautionary nature (Ridge et al. 2019). Please see Appendix 12.4 for further justification.

Table 12.64 PVA results for puffin impacts on the North Sea BDMPS

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
Project alone				
30% displacement, 1% mortality (BDMPS)	4.2	<0.001	1.000	1.000
50% displacement, 1% mortality (BDMPS)	7.0	<0.001	1.000	1.000
70% displacement, 10% mortality (BDMPS)	97.8	<0.001	1.000	0.995
30% displacement, 1% mortality (biogeographic)	4.2	<0.001	1.000	1.000
50% displacement, 1% mortality (biogeographic)	7.0	<0.001	1.000	1.000
70% displacement, 10% mortality (biogeographic)	97.8	<0.001	1.000	1.000

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
Project cumulatively				
30% displacement, 1% mortality (BDMPS)	153.6	<0.001	1.000	0.993
50% displacement, 1% mortality (BDMPS)	255.9	<0.001	1.000	0.988
70% displacement, 10% mortality (BDMPS)	3582.7	0.004	0.995	0.839
30% displacement, 1% mortality (biogeographic)	153.6	<0.001	1.000	0.999
50% displacement, 1% mortality (biogeographic)	255.9	<0.001	1.000	0.999
70% displacement, 10% mortality (biogeographic)	3582.7	<0.001	1.000	0.987

425. This level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

12.10.4Cumulative Impact Assessment: Collision (O&M phase)

426. As a result of the operational activities associated with the Project and other projects Table 12.47), there is potential for cumulative collision risk to birds through collision with WTGs and associated infrastructure, resulting in injury or fatality. Collision may occur when birds fly through OWFs during foraging trips, migration, and/or commuting trips between breeding sites and foraging areas.

427. Within this cumulative impact assessment, only projects identified in Table 12.50 as being Tier 1 (sub-tiers 1a to 1d) and Tier 2 are considered. 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 those in Tier 2 for which publicly available quantitative information is available (for example, projects that have made data available at PEIR).

428. CRM has been carried out for the Project (Section 12.8) for six species of interest which were identified as potentially at risk and of interest for impact assessment (gannet, kittiwake, Sandwich tern, herring gull, great black-backed gull and lesser black-backed gull). Following the screening process for potential cumulative effects presented in Section 12.8, all species assessed for project alone impacts due to collision were assessed for cumulative impacts.

429. It is noted that the following cumulative collision risk assessments are considered to be highly over precautionary, with an overestimation of predicted collisions driven by a range of factors, including:

- Collision risk estimates are calculated based on consented designs. However, OWFs are rarely constructed as consented, typically comprising a reduced number of larger WTGs (equating to a smaller swept area);
- The CRMs are inherently over-precautionary. Actual collision rates of birds are likely to be significantly lower than predicted based on precaution being applied to each input parameter (evidence presented in Section 12.8); and
- Finally, it must be appreciated that many of the projects within this cumulative impact assessment are likely to be decommissioned during the operational lifetime of the Project, so consideration of their impacts is 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 which can be reasonably expected to lead to a reduction in collisions.

Kittiwake

430. As outlined in Section 12.8, kittiwakes show a medium level of sensitivity to collision with WTGs.

431. Table 12.65 below presents the bio-season and annual collision mortality estimates for relevant OWFs in the UK North Sea and Channel BDMPS. Collision estimates were taken from the Sheringham Shoal and Dudgeon Offshore Windfarm Extension Projects Collision Risk Modelling (CRM) Updates Technical Note (Royal HaskoningDHV, 2023b), as agreed with Natural England (Offshore Ornithology and Derogation and Compensation Workshop; Table 12.3). Updates to these values have utilised up-to-date avoidance rates to re-calculate impacts for previously submitted projects. As such, the impacts from these projects presented here may differ from those presented at submission. Projects for which impacts have been / are being compensated for due to a conclusion of Adverse Effect on the Integrity of a SPA in the secretary of state's Appropriate Assessment are also included, ensuring that the approach delivers a precautionary assessment of cumulative impact. Updates include:

- Inclusion of revised design collision estimates from Neart na Gaoithe and Inch Cape, and addition of values from Pentland Floating Windfarm, ForthWind Offshore Wind Demonstration Project, Berwick Bank, Green Volt, North Falls, and Five Estuaries;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time the Project is predicted to be operational; and
- Inclusion of values from the Project.

Table 12.65 Cumulative bio-season and annual collision mortality estimates for kittiwake from all Tier 1 and 2 projects.

Project	Breeding	Post-breeding migration	Return migration	Annual total	Tier
Beatrice	68.9	7.8	28.9	105.6	1a
Blyth Demonstration Site	1.2	1.7	1.0	3.9	1a
Dudgeon	-	-	-	0.0	1a
East Anglia One	1.3	116.7	34.0	152.0	1a
European Offshore Wind Development Centre (EOWDC)	8.6	4.2	0.8	13.6	1a
Galloper	4.6	20.2	23.1	47.9	1a
Greater Gabbard	0.8	10.9	8.3	20.0	1a
Gunfleet Sands	-	-	-	0.0	1a
Hornsea Project One	32.0	40.7	15.2	87.9	1a
Humber Gateway	1.4	2.3	1.4	5.1	1a
Hywind 2 Demonstration	12.1	0.7	0.7	13.5	1a
Kentish Flats	0.0	0.7	0.5	1.2	1a
Kentish Flats Extension	0.0	0.0	2.7	2.7	1a

Project	Breeding	Post-breeding migration	Return migration	Annual total	Tier
Kincardine	16.0	6.5	0.7	23.2	1a
Lincolnshire Node	0.5	0.9	0.5	1.9	1a
London Array	1.0	1.7	1.3	4.0	1a
Lynn and Inner Dowsing	-	-	-	0.0	1a
Methil	0.4	0.0	0.0	0.4	1a
Race Bank	1.4	17.4	4.1	22.9	1a
Rampion	39.6	27.2	21.6	88.4	1a
Scroby Sands	-	-	-	0.0	1a
Sheringham Shoal	-	-	-	0.0	1a
Teesside	27.9	17.5	1.8	47.2	1a
Thanet	0.1	0.4	0.3	0.8	1a
Westermost Rough	0.1	0.1	0.1	0.3	1a
Hornsea Project Two	11.6	6.5	2.2	20.3	1b
Moray East	31.7	1.5	14.0	47.2	1b
Neart na Gaoithe	10.8	5.1	1.3	17.2	1b
Triton Knoll	17.9	101.1	33.0	152.0	1b
Dogger Bank A & B	209.9	98.2	214.8	522.9	1b
Dogger Bank C & Sofia	99.6	66.0	157.7	323.3	1b
Seagreen Alpha and Bravo	70.9	94.9	55.0	220.8	1c
East Anglia Three	4.4	50.2	27.3	81.9	1c
Hornsea Three	56.0	27.6	5.8	89.4	1c
Inch Cape	25.5	16.5	3.8	45.8	1c
Moray West	57.5	17.5	5.1	80.1	1c
Norfolk Vanguard	15.9	11.9	14.0	41.8	1c
Norfolk Boreas	9.7	23.4	8.7	41.8	1c
East Anglia ONE North	29.4	5.9	2.5	37.8	1c
East Anglia TWO	21.5	3.9	5.4	30.8	1c
Hornsea Four	54.2	10.1	3.3	67.6	1c
Pentland floating	4.5	0.6	0.0	5.1	1c
ForthWind Offshore Wind Demonstration Project - phase 1	0.0	0.0	0.0	0.0	1c
SEP & DEP	7.2	4.3	0.9	12.4	1d
Berwick Bank	392.6	120.9	113.9	627.5	1d
Green Volt	4.8	4.5	2.8	12.1	1d
Rampion 2	1.3	1.2	5.3	7.8	2
North Falls (PEIR)	13.4	7.6	12.1	33.1	2
Five Estuaries	9.4	6.6	4.6	20.5	2

Project	Breeding	Post-breeding migration	Return migration	Annual total	Tier
Total All Projects (without the Project)	1,377.5	963.7	840.4	3,181.6	
the Project	25.5	2.8	2.6	30.9	
Total (with the Project)	1,403	966.5	843.0	3,212.5	

Potential magnitude of impact

432. 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 kittiwake BDMPS for the North Sea and English Channel is 829,937 individuals, whilst the wider bio-geographic population is 5,100,000 individuals. When considering the average mortality rate of 0.156 (Table 12.9) the background mortality for these two population scales is 129,470 and 795,600 individuals per annum, respectively.

433. The potential cumulative loss of 4,219 (4,219.6) kittiwakes would represent an increase of 3.259% 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 0.530%. As the predicted impact exceeds a 1% increase in baseline mortality at the BDMPS scale, further consideration is given below in the form of PVA analysis.

434. PVA was undertaken on a range of scenarios for both the Project alone and cumulatively with other projects (as presented in Appendix 12.4). For each scenario, CGR and CPS values have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 35 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis. PVA results are presented in Table 12.66.

435. At the BDMPS population scale, the cumulative mortalities predicted would result in a reduction in population growth of 0.5%, and a 0.08% reduction at the biogeographic population scale. These changes are considered to be sufficiently small that they would be indistinguishable against natural fluctuations in the populations. Additionally, the assessment is considered to be over-precautionary in nature, such that the predicted impacts are expected to be even less in reality.

436. A key aspect of precaution in the CRM assessment is the use of over-precautionary nocturnal activity rates. A review of nocturnal activity in kittiwakes (Furness *et al*., in prep.) has found that the previously used value of 50% is a considerable overestimate, and instead identifies evidence-based rates of 20% during the breeding season and 17% during the non-breeding season. Natural England have acknowledged this element of precaution and have recently advised the use of 37.5% nocturnal activity alongside a SD that incorporates variation from 25% - 50% nocturnal activity. Applying the use of a 37.5% (or 25% in the basic Band model) nocturnal activity factor to other projects presented in Table 12.50 would result in a considerable reduction in the annual cumulative collision estimate though the magnitude of reduction will vary depending on the time of year and windfarm latitude owing to variation in day and night length.

437. Within the context of wider UK kittiwake population changes (for example, a national decline of 43% between Seabird 2000 and Seabirds Count (a period of approximately 20 years) and decreases of 4% in England and 57% in Scotland (Burnell *et al* 2023)), the changes in populations modelled by PVA from cumulative impacts are considered to be small compared to the natural fluctuations within the population, or changes brought about by other pressures.

438. Density dependence regulates population size by adjusting demographic rates to maintain a population around a carrying capacity. If impacts from OWFs decrease survival rates, the resulting decrease in competition for resources might lead to increased survival and/or productivity in the remaining population, consequently boosting population growth. The importance of density dependence is evident in natural ecosystems, where without it, populations would exhibit exponential growth. However, the mechanisms as to how this operates in seabirds are largely uncertain. Misinterpretation of density dependence in population assessments can result in unreliable predictions. As such, PVA models used in this assessment were density independent, despite ecological evidence suggesting the presence of density dependence in large populations (Horswill et al., 2017). While density-independent models lack the capacity for population recovery once it falls below a certain threshold, they are preferred for impact assessments due to their precautionary nature (Ridge et al. 2019). Please see Appendix 12.4 for further justification.

Table 12.66. PVA results for kittiwake impacts on the North Sea BDMPS

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
Project alone				
BDMPS	30.9	<0.001	1.000	1.000
Biogeographic	30.9	<0.001	1.000	1.000
Project cumulatively				
BDMPS	3,212.6	0.004	0.995	0.891
Biogeographic	3,212.6	0.001	0.999	0.973

439. The potential cumulative impact resulting from collision risk to the wider BDMPS population is therefore considered to be of minor magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall. Given a magnitude change of minor, and a sensitivity to collision of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

Great black-backed gull

440. As outlined in Section 12.8, great black-backed gulls show a medium level of sensitivity to collision with WTGs.

441. Table 12.67 below presents the bio-season and annual collision mortality estimates for relevant OWFs in the UK North Sea and Channel BDMPS. Collision estimates were taken from the Sheringham Shoal and Dudgeon Offshore Windfarm Extension Projects Collision Risk Modelling (CRM) Updates Technical Note (Royal HaskoningDHV, 2023b). Updates to these values included:

- Inclusion of values from Pentland Floating Windfarm, ForthWind Offshore Wind Demonstration Project, Berwick Bank, Green Volt, North Falls, and Five Estuaries;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time the Project is predicted to be operational; and
- Inclusion of values from the Project.

Table 12.67 Cumulative bio-season and annual collision mortality estimates for great black-backed gull from all Tier 1 and 2 projects.

Project	Breeding	Non-breeding	Annual total	Tier
Beatrice	36.2	145.0	181.2	1a
Blyth Demonstration Site	1.6	6.1	7.7	1a
Dudgeon	0.0	0.0	0.0	1a
East Anglia One	0.0	55.2	55.2	1a
European Offshore Wind Development Centre (EOWDC)	0.7	2.9	3.6	1a
Galloper.	5.4	21.6	27.0	1a
Greater Gabbard	50.0	200.0	250.0	1a
Gunfleet Sands	-	-	0.0	1a
Hornsea Project One	20.6	82.3	102.9	1a
Humber Gateway	1.6	6.1	7.7	1a
Hywind 2 Demonstration	0.4	5.4	5.8	1a
Kentish Flats	-	-	0.0	1a
Kentish Flats Extension	0.1	0.2	0.3	1a
Kincardine	0.0	0.0	0.0	1a

Project	Breeding	Non-breeding	Annual total	Tier
Lincolnshire Node	0.0	0.0	0.0	1a
London Array	-	-	0.0	1a
Lynn and Inner Dowsing	0.0	0.0	0.0	1a
Methil	0.8	0.8	1.6	1a
Race Bank	0.0	0.0	0.0	1a
Rampion	6.2	25.0	31.2	1a
Scroby Sands	-	-	0.0	1a
Sheringham Shoal	0.0	0.0	0.0	1a
Teesside	10.4	41.8	52.2	1a
Thanet	0.1	0.5	0.8	1a
Westermost Rough	0.0	0.0	0.1	1a
Hornsea Project Two	3.6	24.0	27.6	1b
Moray Firth EDA	11.4	30.6	42.0	1b
Neart na Gaoithe	1.1	4.3	5.4	1b
Triton Knoll	29.3	117.1	146.4	1b
Dogger Bank A & B	7.0	28.0	35.0	1b
Dogger Bank C & Sofia	7.7	30.6	38.3	1b
Seagreen Alpha and Bravo	16.1	64.1	80.2	1c
East Anglia Three	5.5	41.3	46.8	1c
Hornsea Three	9.6	33.6	43.2	1c
Inch Cape	0.0	44.2	219.2	1c
Moray West	4.8	6.0	10.8	1c
Norfolk Vanguard	5.4	25.8	31.2	1c
Norfolk Boreas	8.3	34.4	42.7	1c
East Anglia ONE North	4.4	1.4	5.8	1c
East Anglia TWO	4.2	4.1	8.3	1c
Hornsea Four	1.0	10.6	11.6	1c
ForthWind Offshore Wind Demonstration Project - phase 1	-	-	0.0	1c
Pentland Floating	0.0	0.0	0.0	
SEP & DEP	5.7	0.3	6.0	1d
Berwick Bank	-	-	0.0	1d
Green Volt	0.0	5.2	5.2	1d
Rampion 2	1.1	3.7	4.8	2
North Falls (PEIR)	0.0	6.0	6.0	2
Five Estuaries			0.0	2
Total All Projects (without the Project)	260.3	1,108.2	1,543.8	
the Project	0.39	2.59	2.98	
Total (with the Project)	260.7	1,110.8	1,371.4	

Potential magnitude of impact

442. 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 great black-backed gull BDMPS for the North Sea and English Channel is 59,329 individuals, whilst the wider bio-geographic population is 235,000 individuals. When considering the average mortality rate of 0.144 (Table 12.9) the background mortality for these two population scales are 8,543 and 33,840 individuals per annum, respectively.

443. The potential cumulative loss of 1,371 (1,371.4) great black-backed gulls would represent an increase of 16.04% 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 4.0513%. As the predicted impact exceeds a 1% increase in baseline mortality at the BDMPS scale, further consideration is given below in the form of PVA analysis.

444. PVA was undertaken on a range of scenarios for both the Project alone and cumulatively with other projects (as presented in Appendix 12.4). For each scenario, CGR and CPS values have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 35 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis. PVA results are presented in Table 12.68.

445. At the BDMPS population scale, the predicted cumulative impacts would result in a 1.6% reduction in population growth, and a 0.6% reduction based on the biogeographic population. Though the CGR value is lower than 0.995 at both the BDMPS and biogeographic population scales, the resulting impact is not considered significant when accounting for the over-precautionary nature of the assessment.

446. For many of the OWFs included within the cumulative assessment, collisions are based on consented designs which have higher numbers of WTGs (and total rotor swept areas) than have actually been installed (or are planned to be installed), which will considerably reduce the predicted cumulative collisions. Additionally, several of the older operational projects listed are considered to be part of the baseline environment and so should theoretically be excluded from the assessment, though are kept in to represent a precautionary approach.

447. Considering input parameters, as with kittiwake, the nocturnal activity rate used is also highly precautionary, with the use of 25% considered more appropriate than the currently used 0.375, and previously recommended 50% based on a review (EATL, 2015). Meanwhile many of the projects in the cumulative assessment have used a higher value of 50%. Reducing the cumulative collisions to reflect this lower nocturnal activity rate would similarly result in a significant reduction in predicted cumulative collisions.

448. Furthermore, the contribution of the Project to cumulative mortalities is low, with the predicted three (3.0) mortalities representing just 0.2% of the total predicted cumulative mortalities.

449. Within the context of wider UK great black-backed gull population changes (for example, a national decline of 52% between Seabird 2000 and Seabirds Count (a period of approximately 20 years), and decreases of 3% in England and 63% in Scotland (where the majority of the UK's population breeds) (Burnell *et al* 2023), the changes in populations modelled by PVA from cumulative impacts are considered to be small compared to the natural fluctuations within the population, or changes brought about by other pressures.

450. Density dependence regulates population size by adjusting demographic rates to maintain a population around a carrying capacity. If impacts from OWFs decrease survival rates, the resulting decrease in competition for resources might lead to increased survival and/or productivity in the remaining population, consequently boosting population growth. The importance of density dependence is evident in natural ecosystems, where without it, populations would exhibit exponential growth. However, the mechanisms as to how this operates in seabirds are largely uncertain. Misinterpretation of density dependence in population assessments can result in unreliable predictions. As such, PVA models used in this assessment were density independent, despite ecological evidence suggesting the presence of density dependence in large populations (Horswill et al., 2017). While density-independent models lack the capacity for population recovery once it falls below a certain threshold, they are preferred for impact assessments due to their precautionary nature (Ridge et al. 2019). Please see Appendix 12.4 for further justification.

Table 12.68. PVA results for great black-backed gull impacts on the North Sea BDMPS.

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
Project alone				
BDMPS	3.0	<0.001	1.000	0.999
Biogeographic	3.0	<0.001	1.000	1.000
Project cumulatively				
BDMPS	1,371.4	0.015	0.984	0.557
Biogeographic	1,371.4	0.006	0.994	0.797

451. Consequently, this level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall. Given a magnitude change of negligible, and a sensitivity to collision of major, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

Lesser black-backed gull

452. As outlined in Section 12.8, lesser black-backed gulls show a high level of sensitivity to collision with WTGs.

453. Table 12.69 below presents the bio-season and annual collision mortality estimates for relevant OWFs in the UK North Sea and Channel BDMPS. Collision estimates were taken from the Sheringham Shoal and Dudgeon Offshore Windfarm Extension Projects Collision Risk Modelling (CRM) Updates Technical Note (Royal HaskoningDHV, 2023b). Up-to-date avoidance rates have been used to calculate impacts for previously submitted projects. As such, impacts presented here may differ from those presented at submission. Projects where impacts from previously submitted projects have been compensated are included here, ensuring that the approach delivers a precautionary assessment of cumulative impact.

454. Updates to these values included:

- Inclusion of values from Pentland Floating Windfarm, ForthWind Offshore Wind Demonstration Project, Berwick Bank, Green Volt, North Falls, and Five Estuaries;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time the Project is predicted to be operational; and
- Inclusion of values from the Project.

Table 12.69: Cumulative bio-season and annual collision mortality estimates for lesser black-backed gull from all Tier 1 and 2 projects.

Project	Breeding	Non-breeding	Annual total	Tier
Beatrice	0.0	0.0	0.0	1a
Blyth Demonstration Site	0.0	0.0	0.0	1a
Dudgeon	9.2	36.7	45.9	1a
East Anglia One	7.1	40.6	47.7	1a
European Offshore Wind Development Centre (EOWDC)	0.0	0.0	0.0	1a
Galloper	33.4	133.2	166.6	1a
Greater Gabbard	14.9	59.5	74.4	1a
Gunfleet Sands	0.6	0.0	0.6	1a
Hornsea Project One	5.3	20.9	26.2	1a
Humber Gateway	0.4	1.3	1.7	1a
Hywind 2 Demonstration	0.0	0.0	0.0	1a
Kentish Flats	-	-	0.0	1a
Kentish Flats Extension	0.3	1.3	1.6	1a
Kincardine	0.0	0.0	0.0	1a
Lincolnshire Node	2.0	8.2	10.2	1a
London Array	-	-	0.0	1a
Lynn and Inner Dowsing	-	-	0.0	1a

Project	Breeding	Non-breeding	Annual total	Tier
Methil	0.5	0.0	0.5	1a
Race Bank	51.8	13.0	64.8	1a
Rampion	1.9	7.6	9.5	1a
Scroby Sands	-	-	0.0	1a
Sheringham Shoal	2.0	7.9	9.9	1a
Teesside	0.0	0.0	0.0	1a
Thanet	3.8	15.4	19.2	1a
Westermost Rough	0.1	0.4	0.5	1a
Hornsea Project Two	2.4	2.4	4.8	1b
Moray East	0.0	0.0	0.0	1b
Neart na Gaoithe	0.4	1.4	1.8	1b
Triton Knoll	8.9	35.5	44.4	1b
Dogger Bank A & B	3.1	12.5	15.6	1b
Dogger Bank C & Sofia	2.9	11.5	14.4	1b
Seagreen Alpha and Bravo	2.5	10.1	12.6	1c
East Anglia Three	2.2	9.8	12.0	1c
Hornsea Three	9.6	1.2	10.8	1c
Inch Cape	0.0	0.0	0.0	1c
Moray West	0.0	0.0	0.0	1c
Norfolk Vanguard	10.1	4.3	14.4	1c
Norfolk Boreas	7.4	9.7	17.1	1c
East Anglia ONE North	1.1	0.7	1.8	1c
East Anglia TWO	5.0	0.6	5.6	1c
Hornsea Four	1.0	0.0	1.0	1c
ForthWind Offshore Wind Demonstration Project - phase 1	0.0	0.0	0.0	1c
SEP & DEP	1.9	0.3	2.2	1d
Berwick Bank	10.8	0.0	10.8	1d
Green Volt	-	-	0.0	1d
Rampion 2	0.7	1.4	2.1	2
North Falls (PEIR)	14.4	8.4	22.8	2
Five Estuaries	42.9	6.9	49.8	2
Total All Projects (without the Project)	260.6	462.7	723.3	
the Project	1.54	0.21	1.75	
Total (with the Project)	262.1	462.9	725.0	

Potential magnitude of impact

455. 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 lesser black-backed gull BDMPS for the North Sea and English Channel is 209,007 individuals, whilst the wider bio-geographic population is 864,000 individuals. When considering the average mortality rate of 0.124 (Table 12.9) the background mortality for these two population scales are 25,917 and 107,136 individuals per annum, respectively.

456. The potential cumulative loss of 537 (537.4) lesser black-backed gulls would represent an increase of 2.074% 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 0.502%. As the predicted impact exceeds a 1% increase in baseline mortality at the BDMPS scale, further consideration is given below in the form of PVA analysis.

457. PVA was undertaken on a range of scenarios for both the Project alone and cumulatively with other projects (as presented in Appendix 12.4) For each scenario, CGR and CPS values have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of a 35 year period which is the approximate anticipated operational life of the Project, relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis. PVA results are presented in Table 12.75.

458. At the BDMPS population scale, the predicted cumulative impact represents a 0.4% reduction in population growth rate, and 0.1% based on the biogeographic population scale. These impacts are expected to be indistinguishable from natural fluctuations in the population. Additionally, the precautionary nature of the assessment means that the actual impact is considered to be lower than the one predicted here.

459. As with great black-backed gull, a review of nocturnal activity found the use of 25% nocturnal activity to be more appropriate than the previously recommended 50% and currently used 37.5% (EATL, 2015). Applying the use of 25% to other project values would result in a significant reduction in annual cumulative collision estimates.

460. Additionally, collision estimates from many windfarms presented above which are now operational are calculated for designs with higher numbers of WTGs than have actually been installed (or are planned).

461. Within the context of wider UK lesser black-backed gull population changes (for example, a national decline of 49% between Seabird 2000 and Seabirds Count (a period of approximately 20 years), and decreases of 56% in England and 48% in Scotland (Burnell *et al* 2023), the changes in populations modelled by PVA from cumulative impacts are considered to be small compared to the natural fluctuations within the population, or changes brought about by other pressures.

Density dependence regulates population size by adjusting demographic rates to maintain a population around a carrying capacity. If impacts from OWFs decrease survival rates, the resulting decrease in competition for resources might lead to increased survival and/or productivity in the remaining population, consequently boosting population growth. The importance of density dependence is evident in natural ecosystems, where without it, populations would exhibit exponential growth. However, the mechanisms as to how this operates in seabirds are largely uncertain. Misinterpretation of density dependence in population assessments can result in unreliable predictions. As such, PVA models used in this assessment were density independent, despite ecological evidence suggesting the presence of density dependence in large populations (Horswill et al., 2017). While density-independent models lack the capacity for population recovery once it falls below a certain threshold, they are preferred for impact assessments due to their precautionary nature (Ridge et al. 2019). Please see Appendix 12.4 for further justification.

Table 12.70: PVA results for lesser black-backed gull impacts on the North Sea BDMPS

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
Project alone				
BDMPS	1.7	<0.001	1.000	1.000
Biogeographic	1.7	<0.001	1.000	1.000
Project cumulatively				
BDMPS	725.0	0.003	0.996	0.867
Biogeographic	725.0	0.001	0.999	0.963

462. Based on these elements of over-precaution, the magnitude of impact resulting from cumulative collision effects on lesser black-backed gull are considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall. Given a magnitude change of negligible, and a sensitivity to collision major, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

Herring gull

463. As outlined in Section 12.8, herring gulls show a major level of sensitivity to collision with WTGs.

464. Table 12.71 below presents the bio-season and annual collision mortality estimates for relevant OWFs in the UK North Sea and Channel BDMPS. Collision estimates were taken from the Five Estuaries PEIR (VE OWFL, 2023). Up-to-date avoidance rates have been used to calculate impacts for previously submitted projects. As such, impacts presented here may differ from those presented at submission. Projects where impacts from previously submitted projects have been compensated are included here, ensuring that the approach delivers a precautionary assessment of cumulative impact.

465. Updates to these values included:

- Inclusion of revised CRM estimates for Neart na Gaoithe and Inch Cape, and inclusion of values from Seagreen Alpha and Bravo, Pentland Floating Windfarm, ForthWind Offshore Wind Demonstration Project, Berwick Bank, Green Volt, North Falls, and Five Estuaries;
- Removal of Beatrice Demonstrator as the project will be decommissioned by the time the Project is predicted to be operational; and
- Inclusion of values from the Project.

Table 12.71: Cumulative bio-season and annual collision mortality estimates for herring gull from all Tier 1 and 2 projects.

Project	Breeding	Non-breeding	Annual total	Tier
Beatrice	59.3	236.9	296.2	1a
Beatrice demonstrator	0.0	0.0		
Blyth Demonstration Site	0.6	2.6	3.2	1a
Dudgeon	-	-	0.0	1a
East Anglia One	0.0	33.6	33.6	1a
European Offshore Wind Development Centre (EOWDC)	5.8	0.0	5.8	1a
Galloper	32.6	0.0	32.6	1a
Greater Gabbard	0.0	0.0	0.0	1a
Gunfleet Sands	-	-	0.0	1a
Hornsea Project One	3.5	13.9	17.4	1a
Humber Gateway	0.5	1.3	1.8	1a
Hywind 2 Demonstration	0.7	9.4	10.1	1a
Kentish Flats	0.0	0.0	0.0	1a
Kentish Flats Extension	0.6	2.0	2.6	1a
Kincardine	1.2	0.0	1.2	1a
Lincolnshire Node	0.0	0.0	0.0	1a
London Array	-	-	-	1a
Lynn and Inner Dowsing	0.0	0.0	0.0	1a
Methil	7.0	4.4	11.4	1a
Race Bank	0.0	0.0	0.0	1a
Rampion	186.0	0.0	186.0	1a
Scroby Sands	0.0	0.0	0.0	1a
Sheringham Shoal	0.0	0.0	0.0	1a
Teesside	10.4	41.4	51.8	1a
Thanet	5.9	23.5	29.4	1a
Westermost Rough	0.1	0.0	0.1	1a
Hornsea Project Two	28.6	0.0	28.6	1b
Moray Firth EDA	62.4	0.0	62.4	1b

Project	Breeding	Non-breeding	Annual total	Tier
Neart na Gaoithe	2.4	4.8	7.2	1b
Triton Knoll	0.0	0.0	0.0	1b
Dogger Bank Creyke Beck A & B	0.0	0.0	0.0	1b
Dogger Bank Teeside A & B	0.0	0.0	0.0	1b
Seagreen Alpha and Bravo	6.5	20.0	26.4	1c
East Anglia Three	0.0	27.6	27.6	1c
Hornsea Three	1.2	4.8	6.0	1c
Inch Cape	1.2	3.6	4.8	1c
Moray West	14.4	1.2	15.6	1c
Norfolk Vanguard	0.5	8.5	9.0	1c
Norfolk Boreas	1.8	6.5	8.3	1c
East Anglia ONE North	0.0	0.0	0.0	1c
East Anglia TWO	0.0	0.6	0.6	1c
Hornsea Four	0.6	0.4	1.0	1c
Pentland Floating	0.0	0.0	0.0	1c
ForthWind Offshore Wind Demonstration Project - phase 1	0.0	0.0	0.0	1c
Sheringham Shoal Extension	0.0	0.0	0.0	1d
Dudgeon Offshore Extension	0.3	0.0	0.3	1d
Berwick Bank	51.6	8.4	60.0	1d
Green Volt	0.0	4.5	4.5	1d
Rampion 2	-	-	-	2
North Falls (PEIR)	-	-	0.0	2
Five Estuaries	0.8	0.0	0.8	2
Total All Projects (without the Project)	486.4	460.0	946.4	
the Project	1.54	0.7	2.24	
Total (with the Project)	488.0	460.7	948.6	

Potential magnitude of impact

466. 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 herring gull BDMPS for the North Sea and English Channel is 466,511 individuals, whilst the wider bio-geographic population is 1,098,000 individuals. When considering the average mortality rate of 0.172 (Table 12.9) the background mortality for these two population scales are 80,240 and 188,856 individuals per annum, respectively.

467. The potential cumulative loss of 949 (948.6) herring gulls would represent an increase of 1.182% 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 0.502%. Given the predicted mortality is over a 1% increase on baseline levels at the BDMPS scale, further consideration is given below in the form of PVA analysis.

468. PVA was undertaken on a range of scenarios for both the Project alone and cumulatively with other projects (as presented in Appendix 12.4). For each scenario, CGR and CPS have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 35 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis. PVA results are presented in Table 12.72 below.

469. At the BDMPS population scale, the predicted cumulative impact represents a 0.2% reduction in population growth rate, and 0.1% based on the biogeographic population scale. These impacts are expected to be indistinguishable from natural fluctuations in the population. Additionally, the precautionary nature of the assessment means that the actual impact is considered to be lower than the one predicted here.

470. As with lesser black-backed gull, a review of nocturnal activity found the use of 25% nocturnal activity to be more appropriate than the previously recommended 50% and currently used 37.5% (EATL, 2015). Applying the use of 25% to other project values would result in a significant reduction in annual cumulative collision estimates.

471. A review of nocturnal activity in seabirds (EATL, 2015) found that the use of 50% to be an overestimate, with a value of 25% considered more appropriate. This has been recognised and supported by Natural England who recommend the use of both 25% and 50% (when CRM is run deterministically). Applying the use of 25% would result in a significant reduction in annual cumulative collision estimates.

472. Additionally, the contribution of the Project alone is only two mortalities, representing a <0.01% increase in baseline mortality at both the BDMPS and biogeographic scales. Therefore, it is considered that the Project is not making a material contribution to the cumulative collision mortality total.

473. Within the context of wider UK herring gull population changes (for example, a national decline of 44% between Seabird 2000 and Seabirds Count (a period of approximately 20 years) and decreases of 60% in England and 44% in Scotland (Burnell *et al* 2023)), the changes in populations modelled by PVA from cumulative impacts are considered to be small compared to the natural fluctuations within the population, or changes brought about by other pressures.

474. Density dependence regulates population size by adjusting demographic rates to maintain a population around a carrying capacity. If impacts from OWFs decrease survival rates, the resulting decrease in competition for resources might lead to increased survival and/or productivity in the remaining population, consequently boosting population growth. The importance of density dependence is evident in natural ecosystems, where without it, populations would exhibit exponential growth. However, the mechanisms as to how this operates in seabirds are largely uncertain. Misinterpretation of density dependence in population assessments can result in unreliable predictions. As such, PVA models used in this assessment were density independent, despite ecological evidence suggesting the presence of density dependence in large populations (Horswill et al., 2017). While density-independent models lack the capacity for population recovery once it falls below a certain threshold, they are preferred for impact assessments due to their precautionary nature (Ridge et al. 2019). Please see Appendix 12.4 for further justification.

Table 12.72: PVA results for herring gull impacts on the North Sea BDMPS.

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
Project alone				
BDMPS	2.2	<0.001	1.000	1.000
Biogeographic	2.2	<0.001	1.000	1.000
Project cumulatively				
BDMPS	948.6	0.002	0.998	0.915
Biogeographic	948.6	0.001	0.999	0.963

475. Based on this, the level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall. Given a magnitude change of negligible, and a sensitivity to collision of major, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

Sandwich tern

476. For the cumulative assessment of Sandwich tern, previous assessments for OWFs have used methods, notably avoidance rates, which are no longer recommended by Natural England for the estimation of collision risk. This assessment therefore re-calculated collision risk for relevant projects using avoidance rates which are recommended in the most recent Natural England guidance (Natural England, 2022a).

477. Cumulative collision data for relevant projects were extracted from the assessment undertaken for Sheringham Shoal and Dudgeon Offshore Wind Extension Projects (Royal HaskoningDHV, 2022). Project-specific collision estimates based on the previously used avoidance rate of 0.980 were adjusted using the following conversion factor to reflect the updated avoidance rate of 0.991 recommended by Natural England:

$$\frac{(1 - 0.991)}{(1 - 0.980)} = 0.45$$

478. Adjusted rates are presented in Table 12.73 below.

479. It is noted that the parameters of projects included in the assessments which have now been built (notably Sheringham Shoal and Dudgeon Offshore Wind Projects, Race Bank, and Triton Knoll) differ to the parameters which were included in the corresponding assessments. Therefore, two scenarios are provided:

- Scenario A, using consented project parameters and representing a worst-case scenario; and
- Scenario B, using the as-built designs (where relevant) and representing the more realistic cumulative impacts on Sandwich terns.

Table 12.73: Cumulative O&M phase collisions for Sandwich terns based on consented (Scenario A) and as built WTG parameters (Scenario B).

Project	Annual collisions (0.980 avoidance)	Annual collisions (0.991 avoidance)
Scenario A (consented project parameters)		
Dudgeon	40.1	18.0
Race Bank	91.5	41.1
Sheringham Shoal	17.3	7.8
Triton Knoll	17.8	8.0
DEP	7.6	3.5
SEP	1.9	0.9
Rampion 2	0.8	0.4
Total (other projects)	**177.0**	**79.8**
the Project		0.37
Total (all projects)	**-**	**80.2**
Scenario B (as-built project parameters)		
Dudgeon	33.3	15.0
Race Bank	30.9	13.9
Sheringham Shoal	17.3	7.8
Triton Knoll	6.1	2.7
DEP	7.6	3.4
SEP	1.9	0.9
Rampion 2	0.8	0.4
Total (other projects)	**97.9**	**44.1**
the Project	-	0.37
Total (all projects)	**-**	**44.5**

Potential magnitude of impact

480. 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 Sandwich tern BDMPS for the North Sea and English Channel is 38,051 individuals, whilst the wider bio-geographic population is 148,000 individuals. When considering the average mortality rate of 0.241 (Table 12.9) the background mortality for these two population scales are 9,170 and 35,668 individuals per annum, respectively.

481. Based on the CRM results using the consented OWF designs (Scenario A; Table 12.73), and using values based on Natural England's recommended avoidance rate of 0.991, an annual total of 81 (81.3) collision mortalities are predicted, of which the Project contributes less than two individuals. The potential cumulative loss of 81 individuals would represent a 0.886% increase in baseline mortality at the UK North Sea and English Channel BDMPS scale. At the biogeographic scale, this additional mortality would increase baseline mortality by 0.228%

482. Considering the CRM results using the more realistic as-built OWF designs (Scenario A; Table 12.73), the total number of predicted collision mortalities is reduced to 45 (45.6) individuals. This represents a 0.497% increase in baseline at the UK North Sea and English Channel BDMPS scale, and a 0.128% increase in baseline mortality at the biogeographic scale.

483. Based on the worst case-scenario (Scenario A), the predicted level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to collision of minor, the significance of effect is therefore concluded to be **negligible, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

Gannet

484. As outlined in Section 12.8, gannets show a medium level of sensitivity to collision with WTGs.

485. Table 12.74 below presents the bio-season and annual collision mortality estimates for relevant OWFs in the UK North Sea and Channel BDMPS. It should be noted that assessments at other OWFs have been conducted using a range of avoidance rates and alternative collision model options. This makes it challenging to apply a macro-avoidance rate cumulatively, as was done in the Project alone assessment. Consequently, the results have been presented for the full impact from collision and disturbance, which is considered to be highly precautionary, because the birds that are displaced from windfarms are impacted by displacement and continue to be at risk of collision. Collisions have been calculated using the most up-to-date avoidance rates for all projects in Table 12.34.

Table 12.74: Cumulative bio-season and annual collision mortality estimates for gannet from all Tier 1 and 2 projects.

Project	Migration-free breeding	Post-breeding migration	Return migration	Annual total
Beatrice	8.2	10.6	2.1	20.9
Beatrice demonstrator	0.2	0.3	0.2	0.7
Blyth Demonstration Site	0.8	0.5	0.6	1.9
Dudgeon	4.9	8.5	4.2	17.6
East Anglia One	0.7	28.6	1.4	30.7
European Offshore Wind Development Centre (EOWDC)	0.9	1.1	0.0	2.0
Galloper	3.9	6.7	2.7	13.3
Greater Gabbard	3.1	1.9	1.0	6.0
Gunfleet Sands				0.0
Hornsea Project One	2.5	7.0	4.9	14.4
Humber Gateway	0.4	0.2	0.3	0.9
Hywind 2 Demonstration	1.2	0.2	0.2	1.6
Kentish Flats	0.3	0.2	0.2	0.7
Kentish Flats Extension				0.0
Kincardine	0.7	0.0	0.0	0.7
Lincolnshire Node	0.5	0.3	0.4	1.2
London Array	0.5	0.3	0.4	1.2
Lynn and Inner Dowsing	0.1	0.0	0.1	0.2
Methil	1.8	0.0	0.0	1.8
Moray Firth EDA	17.6	7.7	1.9	27.2
Race Bank	7.4	2.6	0.9	10.9
Rampion	7.9	13.9	0.5	22.3
Scroby Sands				0.0
Sheringham Shoal	3.1	0.8	0.0	3.9
Teesside	1.1	0.4	0.0	1.5
Thanet	0.2	0.0	0.0	0.2
Westermost Rough	0.0	0.0	0.0	0.1
Hornsea Project Two	1.5	3.1	1.3	5.9
Neart na Gaoithe	17.0	1.3	1.3	19.7
Triton Knoll	5.8	14.0	6.6	26.4

Project	Migration-free breeding	Post-breeding migration	Return migration	Annual total
Dogger Bank A & B	17.7	18.2	11.9	47.8
Dogger Bank C & Sofia	3.2	2.2	2.4	7.8
Seagreen Alpha and Bravo	49.5	4.3	6.7	60.5
East Anglia Three	1.3	7.3	2.1	10.7
Hornsea Three	2.2	1.1	0.9	4.2
Inch Cape	20.6	1.0	0.8	22.3
Moray West	2.2	0.4	0.2	2.8
Norfolk Vanguard	1.8	4.1	1.2	7.1
Norfolk Boreas	3.1	2.8	0.9	6.8
East Anglia ONE North	2.7	2.4	0.2	5.3
East Anglia TWO	2.7	5.0	0.9	8.6
Hornsea Four	3.4	1.1	0.3	4.8
Pentland Floating Offshore Windfarm	0.4	0.0	0.0	0.4
ForthWind Offshore Wind Demonstration Project - phase 1	0.6	0.0	0.0	0.6
SEP & DEP	0.4	0.6	0.0	3.5
Berwick Bank	0.6	32.5	3.4	36.5
Green Volt				4.5
Rampion 2	2.6	0.6	0.2	3.4
North Falls (PEIR)	1.0	1.3	1.5	3.8
Five Estuaries	0.1	0.5	0.5	1.0
Total All Projects (without the Project)	208.3	195.5	65.4	476.3
the Project	0.07	1.05	0.36	1.48
Total (with the Project)	208.4	196.6	65.7	477.8

Potential magnitude of impact

486. 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 individuals whilst the wider bio-geographic population is 1,180,000 individuals. Using the average mortality rate of 0.191 (Table 12.9), the background mortality for these population scales are 87,151 and 225,380 individuals per annum, respectively.

487. Advice from Natural England suggests reducing the density of gannets in flight going into the CRM, either by a representative range of macro-avoidance rates of between 65% - 85% or by selecting a single rate of 70%. Applying the single macro-avoidance rate of 70% to projects presented in Table 12.74 would reduce the annual cumulative collision mortality to 893 (893.4) individuals, with the addition of four (3.7) individuals from the Project increasing this to 897 (897.1) individuals. Based on this value, the impact on the BDMPS population would be reduced to a 1.051% increase in baseline mortality, and the impact on the biogeographic population reduced to a 0.407% increase in baseline mortality. Applying a macro-avoidance rate range of 65% to 85% would reduce the annual predicted cumulative collision mortality to 450 – 1,046.

488. The Natural England interim CRM guidance (Natural England, 2022a) also advises the use of a nocturnal activity factor for gannet of 8% as opposed to the previously used 25%. To calculate the changes this makes for each windfarm included in the cumulative assessment would require calculation of a mortality adjustment rate for each month at each windfarm, since the duration of night varies with month and latitude (both of which are inputs to the collision model). This has not been undertaken for the current assessment, however the application of this would substantially reduce cumulative totals.

489. Additionally, collision estimates from many windfarms presented above which are now operational are calculated for designs with higher numbers of WTGs than have been installed (or are planned). MacArthur Green (2017) have presented a method for updating collision estimates based on this, with estimates expected to be reduced by around 7% (Appendix 12.3 of East Anglia TWO EIA submission).

490. Based on the realistic reductions in predicted cumulative collision rate owing to (i) inclusion of macro-avoidance in assessments, (ii) reduction in the nocturnal activity factor, and (iii) revisions to post-consent windfarm designs, the annual cumulative collision impact is considered to be of minor magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall. Given a magnitude change of minor, and a sensitivity to collision of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

12.10.5 Cumulative impact assessment: Combined collision risk and displacement (O&M phase)

Gannet

491. Since gannet has been assessed for impacts arising from both displacement and collision, a combined cumulative assessment has been undertaken to characterise the risk from these combined impacts at a cumulative level. It should be noted that these impacts are not able to act on the same birds (i.e., birds displaced from a windfarm cannot then be subject to collision mortality from the same site).

492. As presented in Section 12.8, the annual cumulative mortality estimate resulting from displacement is 354 (based on 70% displacement and 1% mortality), and for collision the mortality estimate is 478 (477.8) individuals. This results in a combined annual mortality of 883 (883.4) individuals.

493. Based on the largest UK North Sea and English Channel BDMPS of 456,298 and a baseline mortality of 85,328 individuals per annum, the addition of 883 mortalities per annum would result in a 1.034% increase in baseline mortality. Based on the biogeographic population of 1,180,000 individuals and a baseline mortality of 220,660, the addition of 883 additional mortalities would result in a 0.400% increase in baseline mortality.

494. As the cumulative impact exceeds a 1% increase in baseline mortality at the BDMPS population scale, further analysis in the form of PVA has been carried out.

495. PVA was undertaken on a range of scenarios for both the Project alone and cumulatively with other projects (as presented in Appendix 12.4: Population Viability Analysis [document reference: 6.3.12.4]). For each scenario, CGR and CPS values have been presented from the model outputs, measuring the changes in annual growth rate and population size respectively at the end of the impacted period of 35 years relative to a baseline scenario. The impact on adult survival is also presented, calculated as the number of mortalities divided by the relevant population size used in the PVA analysis. PVA results are presented in Table 12.75 below.

496. At the BDMPS population scale, even based on the realistic worst-case scenario of 70% displacement and 1% mortality, the predicted impact would only result in a 0.1% reduction in population growth, and 0.1% also at the biogeographic population scale.

497. It is also considered that the actual mortality rate will be considerably reduced in reality, based on evidence presented in the cumulative impact assessment above, notably the inclusion of up-to-date nocturnal activity rates and revisions to windfarm parameters post-consent. In addition, the UK gannet population has increased considerably over the last approximately 50 years, more than doubling from 113,006 pairs in 1970 to 293,161 pairs in 2013-15 (JNCC 2021). This trend is also reflected in the Flamborough and Filey Coast SPA, with the population rising from 3,498 pairs in 2002 to 13,392 pairs in 2017 based on data from the JNCC Seabird Monitoring Programme (SMP) database (JNCC, 2020). Considering these increases, the cumulative impacts resulting from the Project are highly unlikely to impact the trend of the increasing regional gannet population.

498. Within the context of wider UK gannet population changes (for example, a national increase of 39% between Seabird 2000 and Seabirds Count (a period of approximately 20 years) and increases of 240% in England and 40% in Scotland (Burnell *et al* 2023)), the changes in populations modelled by PVA from cumulative impacts are considered to be small compared to the natural fluctuations within the population, or changes brought about by other pressures.

499. Density dependence regulates population size by adjusting demographic rates to maintain a population around a carrying capacity. If impacts from OWFs decrease survival rates, the resulting decrease in competition for resources might lead to increased survival and/or productivity in the remaining population, consequently boosting population growth. The importance of density dependence is evident in natural ecosystems, where without it, populations would exhibit exponential growth. However, the mechanisms as to how this operates in seabirds are largely uncertain. Misinterpretation of density dependence in population assessments can result in unreliable predictions. As such, PVA models used in this assessment were density independent, despite ecological evidence suggesting the presence of density dependence in large populations (Horswill et al., 2017). While density-independent models lack the capacity for population recovery once it falls below a certain threshold, they are preferred for impact assessments due to their precautionary nature (Ridge et al. 2019). Please see Appendix 12.4 for further justification.

Table 12.75 PVA results for gannet (combined collision and displacement impacts) on the regional and biogeographic scales.

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
Project alone				
60% displacement, 1% mortality (BDMPS)	9.1	<0.001	1.000	0.999
70% displacement, 1% mortality (BDMPS)	10.0	<0.001	1.000	0.999
80% displacement, 1% mortality (BDMPS)	10.5	<0.001	1.000	0.999
60% displacement, 1% mortality (biogeographic)	9.1	<0.001	0.999	0.971
70% displacement, 1% mortality (biogeographic)	10.0	<0.001	0.999	0.969
80% displacement, 1% mortality (biogeographic)	10.5	<0.001	0.999	0.967
Project cumulatively				
60% displacement, 1% mortality (BDMPS)	825.5	0.001	0.999	0.968
70% displacement, 1% mortality (BDMPS)	883.4	0.001	0.999	0.963
80% displacement, 1% mortality (BDMPS)	941.3	0.001	0.999	0.958
60% displacement, 1% mortality (biogeographic)	825.5	<0.001	0.999	0.971
70% displacement,	883.4	<0.001	0.999	0.969

PVA Scenario	Annual mortality	Impact on survival	Medan CGR	Median CPS
1% mortality (biogeographic)				
80% displacement, 1% mortality (biogeographic)	941.3	<0.001	0.999	0.967

500. Based on this, the predicted level of change is considered to be of negligible magnitude at the UK North Sea and English Channel BDMPS scale and biogeographic scale overall, as it represents no discernible change to baseline mortality. Given a magnitude change of negligible, and a sensitivity to disturbance and displacement of minor to moderate, and a sensitivity to collision of moderate, the significance of effect is therefore concluded to be **minor adverse, which is not significant in EIA terms**, based on the matrix approach defined in Table 12.15.

12.10.6 Cumulative Impact Assessment: Decommissioning phase

Impacts arising during the decommissioning phase are expected to be equivalent to, or less than, during the construction phase. It is also not possible to predict which projects will temporally overlap with the decommissioning phase at this time. Please refer to the construction phase for further information (Section 12.10.2).

12.11 Inter-Relationships

501. The construction, operation and decommissioning of the Project would cause a range of impacts on offshore ornithological receptors. Impacts to ornithological receptors may be inter-related with impacts on other receptor groups; this is considered to be the case for indirect impacts on habitats and prey species only. For disturbance and displacement, and collision, it is assumed that there is no potential for interaction with other receptor groups.

502. Identified inter-relationships are summarised in Table 12.76, which indicates where assessments carried out in other chapters have been used to inform the offshore ornithology assessment.

Table 12.76: Inter-relationships relevant to the Project.

Impact	Related chapter	Where addressed in this chapter	Rationale
All phases			
Indirect impacts through effects on habitats and prey	▪ Volume 1, Chapter 10 – Fish and Shellfish Ecology ▪ Volume 1, Chapter 9 – Benthic Subtidal	Section 12.7	Potential impacts on fish, shellfish and benthic ecology during construction, O&M and decommissioning could affect prey resource for offshore ornithological receptors

Impact	Related chapter	Where addressed in this chapter	Rationale
	and Intertidal Ecology		

503. An assessment on the potential for effects on fish and shellfish ecology receptors was undertaken in Volume 1, Chapter 10: Fish and Shellfish Ecology. The assessment concluded no significant effects from the construction, operation and maintenance and decommissioning of the Project, and therefore no significant effects on prey resource for ornithology receptors are anticipated.

12.12 Transboundary Effects

504. Transboundary effects are defined as those effects upon the receiving environment of a European Economic Area (EEA) state, whether occurring from the Project alone, or cumulatively with other projects in the wider area.

505. While there is potential for collisions and displacement at OWFs outside of UK territorial waters, the spatial scale and therefore the seabird reference populations would be much larger. Therefore, any conclusions drawn from the existing cumulative impact assessment are considered highly unlikely to change, and any potential changes would likely be a relative reduction in scale of impact as opposed to an increase, due to the large size of the reference populations against which impacts would be assessed.

12.13 Conclusions

506. A summary of potential impacts assessed within this EIA, alongside any mitigation and residual effects, is presented in Table 12.77 and Table 12.78 below.

Table 12.77. Summary of potential impacts of the Project assessed for offshore and intertidal ornithology.

Description of Impact	Effect	Additional mitigation measures	Residual impact
Construction			
Impact 1: Disturbance and displacement: Offshore ECC	Minor significance for all species (red-throated diver and common scoter)	None proposed beyond existing commitments	No significant adverse residual effects
Impact 2: Disturbance and displacement: Array area	Minor to moderate significance of effect for gannet Moderate significance of effect for guillemot, razorbill and puffin.	None proposed beyond existing commitments	No significant adverse residual effects
Impact 3: Indirect impacts on IOFs due to effects on prey species habitat loss: Array area and Offshore ECC	Negligible significance of effect for all species	None proposed beyond existing commitments	No significant adverse residual effects
Impact 4: Disturbance and displacement: Artificial Nest Structure (ANS), Biogenic reef seeding and ORCPs.	Negligible significance of effect for all species	None proposed beyond existing commitments	No significant adverse residual effects
Operation and maintenance			
Impact 5: Disturbance and displacement: Array area	Minor to moderate significance of effect for gannet and red-throated diver Moderate significance of effect for guillemot, razorbill and puffin.	None proposed beyond existing commitments	No significant adverse residual effects
Impact 6: Collision risk: Array area	Negligible significance of effect for Sandwich tern	None proposed beyond existing commitments (e.g.	No significant adverse residual effects

Description of Impact	Effect	Additional mitigation measures	Residual impact
	Minor significance of effect for all other species.	Table 12.11 - Minimum tip height raised to 40m MSL from 22m MHWS.)	
Impact 7: Collision risk to migratory birds: Array area	Negligible significance of effect for all species	None proposed beyond existing commitments. (e.g. Table 12.11 -Minimum tip height raised to 40m above MSL)	No significant adverse residual effects
Impact 8: Indirect impacts on IOFs due to impacts on prey species habitat loss: Array area.	Negligible significance of effect for all species.	None proposed beyond existing commitments	No significant adverse residual effects
Decommissioning			
As with construction			

Table 12.78 Summary of potential cumulative impacts of the Project assessed for offshore and intertidal ornithology.

Description of effect	Effect	Additional mitigation measures	Residual impact
Construction			
Impact 1: Disturbance and displacement: Offshore ECC	Minor significance of effect for red-throated diver.	None proposed beyond existing commitments	Not significant
Impact 2: Disturbance and displacement: Array area	Minor significance of effect for red-throated diver.	None proposed beyond existing commitments	Not significant
Operation and maintenance			

Description of effect	Effect	Additional mitigation measures	Residual impact
Impact 5: Disturbance and displacement: Array area	Minor significance of effect for gannet, guillemot, razorbill and puffin. Impact for red-throated diver to be determined following PVA post-PEIR	None proposed beyond existing commitments	Not significant (Red-throated diver to be confirmed post-PEIR)
Impact 6: Collision risk: Array area	Negligible significance of effect for Sandwich tern Minor significance of effect for all other species.	Minimum tip height raised to 40m MSL from 22m	Not significant
Decommissioning			
As with construction			

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13 Annex 1

English names used in the text with relevant scientific names.

English name used in text	Scientific name
Dark-bellied brent goose	*Branta bernicula bernicula*
Pink-footed goose	*Anser brachyrhynchus*
Taiga bean goose	*Anser fabalis*
Shelduck	*Tadorna tadorna*
Mute swan	*Cygnus olor*
Bewick's swan	*Cygnus colombianus*
Shoveler	*Anas clypeata*
Wigeon	*Anas penelope*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas strepera*
Teal	*Anas crecca*
Pintail	*Anas acuta*
Pochard	*Aythya ferina*
Tufted duck	*Aythya fuligula*
Scaup	*Aythya marila*
Common scoter	*Melanitta nigra*
Goldeneye	*Bucephala clanga*
Great crested grebe	*Podiceps cristatus*
Oystercatcher	*Haematopus ostralegus*
Avocet	*Recurvirostra avosetta*
Lapwing	*Vanellus vanellus*
Golden plover	*Pluvialis apricaria*
Grey plover	*pluvialis squatarola*
Ringed plover	*Charadrius hiaticula*
Curlew	*Numenius arquata*
Bar-tailed godwit	*Limosa lapponica*
Black-tailed godwit	*Limosa limosa*
Turnstone	*Arenaria interpres*
Knot	*Calidris canutus*
Ruff	*Calidris pugnax*
Sanderling	*Calidris alba*
Dunlin	*Calidris alpina*
Redshank	*Tringa totanus*
Kittiwake	*Rissa tridactyla*
Black-headed gull	*Criococephalus ridibundus*
Little gull	*Hydrocoleous minutus*

English name used in text	Scientific name
Mediterranean gull	*Larus melanocephalus*
Common gull	*Larus canus*
Great black-backed gull	*Larus marinus*
Herring gull	*Larus argentatus*
Lesser black-backed gull	*Larus fuscus*
Sandwich tern	*Thalasseus sandvicensis*
Little tern	*Sternula albifrons*
Roseate tern	*Sternadougallii*
Common tern	*Sterna hirundo*
Arctic tern	*Sterna paradisaea*
Great skua	*Stercorarius skua*
Arctic skua	*Stercorarius parasiticus*
Guillemot	*Uria aalge*
Razorbill	*Alca torda*
Puffin	*Fratercula arctica*
Little auk	*Alle alle*
Red-throated diver	*Gavia stellata*
Great northern diver	*Gavia immer*
Fulmar	*Fulmarus glacialis*
Manx shearwater	*Puffinus puffinus*
Gannet	*Morus bassanus*
Cormorant	*Phalacrocorax carbo*
Shag	*Phalacrocorax aristotellis*
Bittern	*Botaurus stellaris*
Marsh harrier	*Circus aeruginosus*
Hen harrier	*Circus cyaneus*