FIVE ESTUARIES OFFSHORE WIND FARM

ENVIRONMENTAL STATEMENT

VOLUME 6, PART 2, CHAPTER 4: OFFSHORE ORNITHOLOGY

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DEFINITION OF ACRONYMS

Term	Definition
AR	Avoidance Rates
BDMPS	Biologically Defined Minimum Population Scale/size
BoCC	Birds of Conservation Concern
BTO	British Trust for Ornithology
CAA	Civil Aviation Authority
CI	Confidence Interval
CIEEM	Chartered Institute of Ecology and Environmental Management
CRM	Collision Risk Modelling
EC	European Commission
EIA	Environmental Impact Assessment
EMF	Electro-magnetic Field
ES	Environmental Statement
ESAS	European Seabirds at Sea database
ETG	Expert Topic Group
EU	European Union
FAME	Future of the Atlantic Marine Environment
GPS	Global Positioning System
HRA	Habitats Regulations Assessment
ICES	International Council for the Exploration of the Sea
IOF	Important Ornithological Feature
JNCC	Joint Nature Conservation Committee
MAGIC	Multi-Agency Geographic Information for the Countryside
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MRSea	A spatial modelling software package
MW	Megawatt
NAF	Nocturnal Activity Factor
NE	Natural England
NGO	Non-Governmental Organisation
NPPF	National Planning Policy Framework

Term	Definition
NPS	National Policy Statement
ORJIP	Offshore Renewables Joint Industry Programme
OWEZ	Offshore Wind Farm Egmond aan Zee, Netherlands
OWF	Offshore Windfarm
PAWP	Princess Amalia Wind Park, Netherlands
PBR	Potential Biological Removal
PCH	Potential Collision Height
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
PVA	Population Viability Analysis
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SE	Standard error (of the mean)
SNCB	Statutory Nature Conservation Body
SNH	Scottish Natural Heritage
SOSS	Strategic Ornithological Support Services
SPA	Special Protection Area
SSC	Suspended Sediment Concentration
SSSI	Site of Special Scientific Interest
UK	United Kingdom
WWT	Wildfowl and Wetlands Trust

GLOSSARY OF TERMS

Term	Definition
Array areas	The areas where the Wind Turbine Generators (WTGs) would be located. These are referred to as the northern and southern arrays to differentiate them.
Avoidance rate (AR)	Estimated value used in the collision risk model to determine what proportion of flight activity that birds of a species undertakes within a WTG array would show behavioural avoidance of operational WTGs.
Biogeographic population	A population of a species or a sub-species that is either geographically discrete from other populations at all times of the year, or at some times of the year only, or is a specified part of a continuous distribution so defined for the purposes of conservation management.
Biologically Defined Minimum Population Scales (BDMPS)	Population estimates, at an agreed scale, for seabird species occurring in UK waters. Where the proportion of each population that occurs in UK waters is known, the biogeographic population estimate can be narrowed to the numbers occurring within defined UK waters a BDMPS. The BDMPS spatial area is from the UK coast to the edge of UK territorial waters, bounded by defined lines running from selected points on the coast to the UK waters limit. These regionally defined populations are the appropriate ones to consider for EIA (Furness, 2015).
Collision Risk Modelling (CRM)	Modelling using baseline ornithology survey data to estimate rates of collisions with wind turbines for each species during a particular period, e.g., breeding season or year. The Band (2012) model has been used here (both deterministic and stochastic versions).
Development Consent Order	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 the Department for Energy Security and Net Zero (DESNZ).
Displacement	As per Marques *et al.* (2021), the reduced density of birds occurring near WTGs, due to long-term disturbance leading to functional habitat loss, i.e., the joint effect of macro-avoidance and meso-avoidance.
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact in question with the sensitivity of the receptor in question, in accordance with defined significance criteria.

Term	Definition
Export Cable Corridor (ECC)	The area where the offshore export cables would be located.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial, resulting from the activities associated with the construction, operation and maintenance, or decommissioning of the project.
Important Ornithological Features (IOFs)	Target species recorded during baseline surveys that are of higher conservation value and/or sensitive to impacts of wind farms, and therefore a significant effect cannot be excluded without detailed assessment. 'Feature' is equivalent to 'receptor' which may be used in other chapters. Follows CIEEM (2018) guidance on ecological impact assessments.
Maximum Design Scenario (MDS)	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.
Nocturnal Activity Factor (NAF)	Species-specific proportion of flight activity rates undertaken during hours of darkness compared to recorded daytime activity rates. For use in collision risk modelling.
PEIR	Preliminary Environmental Information Report. The PEIR was written in the style of a draft Environmental Statement (ES) and formed the basis of statutory consultation. Following that consultation, the PEIR documentation has been updated into the final ES that is accompanying the application for the Development Consent Order (DCO).
Statutory Nature Conservation Bodies (SNCBs)	Comprising the Joint Nature Conservation Committee, Natural England, Natural Resources Wales, Northern Ireland Environment Agency and NatureScot. *Advice on how to present assessment information on the extent and potential consequences of seabird displacement from Offshore Wind Farm (OWF) developments* was published jointly by SNCBs (2017; updated 2022).
WTG	Wind Turbine Generator

4 OFFSHORE ORNITHOLOGY

4.1 INTRODUCTION

4.1.1 This chapter provides a review of baseline conditions and an assessment of the potential impacts on offshore ornithology that may arise from the construction, operation and decommissioning of the offshore components of the proposed Five Estuaries Offshore Wind Farm (VE) project.

4.1.2 The chapter has been prepared by MacArthur Green and describes the offshore components of the proposed VE project relevant to offshore ornithological features; the relevant legislation, policy and guidance; the consultation that has been held with stakeholders; the scope and methodology of the assessment; the avoidance and mitigation measures that have been embedded through project design; the baseline data on birds and important sites and habitats for birds acquired through desk study and surveys; and assesses the significance of potential impacts on offshore ornithology features.

4.1.3 This chapter should be read in conjunction with the following:

- Volume 6, Part 2, Chapter 1: Offshore Project Description;
- Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes;
- Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology;
- Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology;
- Volume 6, Part 2, Chapter 8: Commercial Fisheries; and
- Volume 5, Report 4: Report to Inform Appropriate Assessment (RIAA), which provides specific assessment of the impacts on the national site network.

4.1.4 This chapter is also supported by the following Volume 6, Part 5 annexes:

- Annex 4.1: Offshore Ornithology Technical Report;
- Annex 4.2: Seabird Abundances by Month;
- Annex 4.3: Seabird Densities by Month;
- Annex 4.4: Seabird Abundances by Survey;
- Annex 4.5: Seabird Densities by Survey;
- Annex 4.6: Seabird Peak Seasonal Abundances;
- Annex 4.7: Seabird Peak Seasonal Densities;
- Annex 4.8: Collision Risk Modelling Inputs and Outputs;
- Annex 4.9: Seabird Distributions Recorded in Aerial Surveys;
- Annex 4.10: Collision Risk Modelling Comparison of Model Results;
- Annex 4.11: Design based bootstrap variance estimates;
- Annex 4.12: Digital video aerial surveys of seabirds and marine mammals at Five Estuaries: Annual report for March 2019 to February 2020;
- Annex 4.13: Digital video aerial surveys of seabirds and marine mammals at Five Estuaries: Two-year report March 2019 to February 2021;

- Annex 4.14: Migratory Collision Risk Modelling; and
- Annex 4.15: Apportioning Note.
- Annex 4.16: Population Viability Analysis

4.1.5 An assessment of the export cable landfall and onshore components of the project in relation to onshore ornithology features is included in Volume 3, Chapter 4: Onshore Biodiversity and Nature Conservation.

4.2 STATUTORY AND POLICY CONTEXT

4.2.1 This assessment has considered current legislation, policy and guidance relevant to offshore ornithology. Further information on policies relevant to Environmental Impact Assessment (EIA) and their status are provided in Volume 6, Part 1, Chapter 2: Policy and Legislation.

4.2.2 Legislation and policy relevant to offshore ornithology is identified in Table 4.1 along with a summary of how these have been considered in this chapter, or elsewhere.

Table 4.1: Legislation and policy context.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
Legislation		
Birds Directive - Council Directive 2009/147/EC on the Conservation of Wild Birds	The implementation of the Birds Directive has been subject to changes made by the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019) in creation of a national site network within the UK territory comprising the protected sites already designated under the Birds and Habitats Directives. The Birds Directive provided a 'General System of Protection' for all species of naturally occurring wild birds in the EU. The most relevant provisions of the Directive are the identification and classification of Special Protection Areas (SPAs) for rare or vulnerable species listed in Annex I of the Directive and for all regularly occurring migratory species (required by Article 4). It also established a general scheme of protection for all wild birds (required by Article 5). The Directive required national Governments to establish SPAs and to have in place	This chapter presents an assessment of the potential effects on seabirds, including those species protected under the Habitats Regulations (Birds Directive) in sections 4.10 to 4.16. Consideration has been given to SPAs (and associated Ramsar sites - see section 4.7: Designated Sites) with qualifying features that may be found in the marine environment and interact with the VE offshore project, in the Volume 5, Report 4: RIAA.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	mechanisms to protect and manage them. The SPA protection procedures originally set out in Article 4 of the Birds Directive have been replaced by the Article 6 provisions of the Habitats Directive.	
Wildlife and Countryside Act 1981, as amended	The Wildlife and Countryside Act 1981 (as amended) is the principal mechanism for the legislative protection of wildlife in Great Britain. It provides protection for all species of wild birds and their nests and establishes the system of Sites of Special Scientific Interest (SSSI).	Consideration has been given to SSSIs with ornithological qualifying features that may be found in the marine environment and interact with the VE offshore project (section 4.7: Designated Sites). These SSSIs generally are coincident in extent with SPAs, and support SPA qualifying features.
The Conservation of Offshore Marine Habitats and Species Regulations 2017	The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended), (referred to here as the 'Offshore Regulations') transposes the Birds Directive and the Habitats Directive into national law in the offshore environment (beyond 12 nautical miles within British Fishery Limits and the UK Continental Shelf Designated Area. The Offshore Regulations place an obligation on 'competent authorities' to carry out an appropriate assessment of any proposal likely to affect a SAC or SPA, to seek advice from Natural England (NE) and / or JNCC, and to not approve an application that would have an adverse effect on the integrity of a SAC or SPA (except pursuant to the formal public interest derogation process, as outlined in Planning Inspectorate (2022), Advice Note Ten).	This chapter presents an assessment of the potential effects on seabirds, including those species protected under the Habitats Regulations (Birds Directive) in sections 4.10 to 4.16. Consideration has been given to SPAs (and associated Ramsar sites – see section 4.7: Designated Sites) with qualifying features that may be found in the marine environment and interact with the VE offshore project, in the Volume 5, Report 4: RIAA.
The Conservation of Habitats and	The Conservation of Habitats and Species Regulations 2017 (hereafter called the 'Habitats Regulations'),	This chapter presents an assessment of the potential effects on

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
Species Regulations 2017	transposes the Birds Directive and the Habitats Directive into national law in the onshore environment and territorial waters out to 12 nautical miles, operating in conjunction with the Wildlife and Countryside Act 1981. The Habitats Regulations place an obligation on 'competent authorities' to carry out an appropriate assessment of any proposal likely to affect a SAC or SPA, to seek advice from Natural England and / or JNCC, and to not approve an application that would have an adverse effect on the integrity of a SAC or SPA (except pursuant to the formal public interest derogation process).	seabirds, including those species protected under the Habitats Regulations (Birds Directive) in sections 4.10 to 4.16. Consideration has been given to SPAs (and associated Ramsar sites - see section 4.7: Designated Sites) with qualifying features that may be found in the marine environment and interact with the VE offshore project in the Volume 5, Report 4: RIAA.
Policy		
National Planning Policy Framework (updated September 2023)	The National Planning Policy Framework sets out the UK Government's planning policies for England and how these are expected to be applied. The document establishes a number of core land-use planning principles that should underpin both plan-making and decision-taking, including contributing to conserving and enhancing the natural environment. Paragraph 174 states that: *"Planning policies and decisions should contribute to and enhance the natural and local environment by…minimising impacts on and providing net gains for biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures".*	The VE array areas were identified through the 2017 Crown Estate Extensions Round Siting Criteria process (see Volume 6, Part 1, Chapter 4: Site Selection and Alternatives) and subsequent refinements to the array areas and offshore export cable corridor (ECC) have been made which has helped to reduce the total area over which there is potential for impacts upon the natural environment.
UK Marine Policy Statement (MPS) (updated September 2020)	New systems of marine planning are being introduced in the UK. The MPS, adopted under section 44 of the Marine and Coastal Access Act 2009, is the framework for developing and implementing regional Marine Plans. It	The identification of the species most sensitive to the VE project has been undertaken through a process of consultation with statutory and non-

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	will contribute to the achievement of sustainable development in the United Kingdom marine area. High level objectives are for the protection, conservation and where appropriate recovery of biodiversity; healthy, resilient and adaptable marine and coastal ecosystems across their natural range; and oceans supporting viable populations of representative, rare, vulnerable and valued species.	statutory organisations (see Section 4.3). An assessment of the potential impacts of the proposed VE project-alone (see sections 4.10 to 4.12) and cumulatively with other projects (see section 4.13) has been undertaken to determine the potential for significant environmental effects on these species' populations. Where possible, mitigation measures (see section 4.8) will be implemented to reduce potential impacts as far as possible.
Overarching National Policy Statement (NPS) for Energy (EN-1) November 2023	Section 5.4: Biodiversity and Geological Conservation states that the government's policy for biodiversity in England has an aim *"…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."*	VE delivers benefits as a nationally significant low carbon energy infrastructure development, providing a long-term benefit to biodiversity interests, outweighing any minor harm to these interests. Climate change is a significant threat to bird biodiversity interests (Pearce-Higgins 2021). VE will contribute a significant amount of renewable energy (see Volume 6, Part 2, Chapter 1: Offshore Project Description; Volume 6 Part 4, Chapter 1: Climate Change; and Volume 6, Part 4, Chapter 1, Annex 1.1 Green House Gas Assessment), to the UK Government's target of producing 40GW of renewable energy from offshore wind by 2030 and

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
		achieving net zero by 2050 (BEIS 2020).
Overarching National Policy Statement (NPS) for Energy (EN-1) November 2023	Para. 5.4.42 states *"development should, in line with the mitigation hierarchy, aim to avoid significant harm to biodiversity and geological conservation interests, including through consideration of reasonable alternatives".*	VE has been designed to avoid significant harm to biodiversity interests through the site selection process. Further details are provided in Volume 6, Part 1, Chapter 4: Site Selection and Alternatives.
Overarching National Policy Statement (NPS) for Energy (EN-1) November 2023	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 (including those outside England), on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity, including irreplaceable habitats."*	Consideration has been given to designated sites with ornithological qualifying features that may be found in the marine environment and interact with the VE offshore project (section 4.7: Designated Sites). A detailed assessment of effects is presented in the Volume 5, Report 4: RIAA.
Overarching National Policy Statement (NPS) for Energy (EN-1) November 2023	Paragraph 4.6.6 states – *"Energy* [Nationally significant Infrastructure Projects] *NSIP proposals, whether onshore or offshore, should seek opportunities to contribute to and enhance the natural environment by providing net gains for biodiversity, and the wider environment where possible."*	The Applicant has explored, developed and created suitable opportunities for building-in beneficial biodiversity features as part of good design for VE, as detailed in the commitments listed in Volume 6, Part 2, Chapter 1: Offshore Project Description.
Overarching National Policy Statement (NPS) for Energy (EN-1) November 2023	Paragraph 5.4.16– reminds that *"Many individual species receive statutory protection under a range of legislative provisions. Other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales, as well as for their continued benefit for climate mitigation and adaptation and thereby requiring conservation action."*	Statutory protection afforded to bird species, as well as other non-statutory designations of species conservation status have been considered in determining the conservation value of receptors as part of this assessment, outlined in Section 4.5: Sensitivity.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
Overarching National Policy Statement (NPS) for Energy (EN-1) November 2023	Paragraph 5.4.55 – explains that *"…the Secretary of State should give substantial weight to any such harm to the detriment of biodiversity features of national or regional importance or the climate resilience and the capacity of habitats to store carbon, which it considers may result from a proposed development."*	VE is committed to minimising potential impacts on biodiversity, and mitigation measures are described in Section 4.8. The Applicant has taken into account other bird species and habitats that have been identified as being of principal importance for the conservation of biodiversity in England and thereby requiring conservation action in Section 4.5. The Applicant has ensured that these species and habitats are protected from the potentially adverse effects of VE by accepting the need for requirements as part of the consenting process, as detailed in the commitments listed in Volume 6, Part 2, Chapter 1: Offshore Project Description.
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.101 - states that the *"Applicants must undertake a detailed assessment of the offshore ecological, biodiversity and physical impacts of their proposed development, for all phases of the lifespan of that development, in accordance with the appropriate policy for offshore wind farm EIAs ".*	Assessment of potential effects on offshore ornithology across all stages of VE's lifespan have been described and considered within Sections 4.10 to 4.16.
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.102 states that the *"Applicants need to consider environmental and biodiversity net gain as set out in Section 4.6 of EN-1 and the Environment Act 2021."* Paragraph 2.8.103 states that the *"Applicants should assess the*	The Applicant has explored, developed and created suitable opportunities for building-in beneficial biodiversity features as part of good design for VE, as detailed in the commitments listed

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	potential of their proposed development to have net positive effects on marine ecology and biodiversity, as well as negative effects."	in Volume 6, Part 2, Chapter 1: Offshore Project Description.
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.104 states that the *"Applicants should consult at an early stage of pre-application with relevant statutory consultees and energy not-for profit organisations/ non-governmental organisations as appropriate, on the assessment methodologies, baseline data collection, and potential avoidance, mitigation and compensation options should be undertaken."*	Agreement on the assessment approach and survey methods has been sought through discussions with Natural England and other statutory consultees through the Evidence Plan process (Section 4.3).
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.106 states that *"Any relevant data that has been collected as part of postconstruction ecological monitoring from existing, operational offshore wind farms should be referred to where appropriate.".* Paragraph 2.8.107 states that *"Applicants should explain why their decisions on siting, design, and impact mitigation are proportionate and well-targeted, referring to relevant scientific research and literature as appropriate."*	The range of data and information used to inform the VE design, impact assessment in this chapter, and mitigation options, is listed in Section 4.4: Data Sources and referred to as appropriate throughout.
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.126 explains that *"Offshore wind farms have the potential to impact on birds through:* *• collisions with rotating blades;* *• direct habitat loss;* *• disturbance from construction activities such as the movement of construction/ decommissioning/ maintenance vessels and piling;* *• displacement during the operational phase, resulting in loss of foraging/roosting area;*	Assessment of potential effects on offshore ornithology across all stages of VE's lifespan have been described and considered within Sections 4.10 to 4.16.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	• impacts on bird flight lines (i.e. barrier effect) and associated increased energy use by birds for commuting flights between roosting and foraging areas; *• impacts upon prey species and prey habitat; and* *• impacts on protected sites."*	
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.143 states that *"Applicants should discuss the scope, effort and methods required for ornithological surveys with the relevant statutory advisor, taking into consideration baseline and monitoring data from operational windfarms."*	Baseline survey methods have been presented to and agreed with Natural England and RSPB through the Evidence Plan Process (see NE Discretionary Advice Service letter dated 20/05/2022 and Table 4.2).
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraphs 2.8.144 and 2.8.145 state that "*Applicants must undertake collision risk modelling, as well as displacement and population viability assessments for certain species of birds. Applicants are expected to seek advice from SNCBs."* and *"Where necessary, applicants should assess collision risk using survey data collected from the site at the pre-application EIA stage."*	Collision risk modelling and displacement analysis has been undertaken using survey data and parameters that have been agreed with Statutory Nature Conservation Bodies (SNCBs) through the Evidence Plan process. Potential effects from displacement and collision risk are presented and assessed in Section 4.11.
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.302 – states that *"The Secretary of State should consider the effects of a proposed development on marine ecology and biodiversity, considering all relevant information made available by the applicant."*	The offshore ornithology aspects of marine ecology and biodiversity have been described and considered within this chapter for VE.
NPS for Renewable Energy Infrastructure (EN-3)	Paragraph 2.8.303 – states that "*The Secretary of State should be satisfied that, in the development of their proposal, the applicant has made appropriate, and extensive, use of up-*	The range of data and information used to inform the VE design, impact assessment in this chapter, and mitigation

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
November 2023	*to-date evidence from previous deployments and research results from scientific peer reviewed papers and the programmes listed in paragraph 2.8.97 and assessed through HRA/MCZ processes (including the mitigation hierarchy), the impact on any protected species or habitats."*	options, is listed in Section 4.4: Data Sources and referred to as appropriate throughout.
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.305 states that – *"Where adverse effects on site integrity/conservation objectives are predicted the Secretary of State should consider the extent to which the effects are temporary or reversible, and the timescales for recovery."*	VE has been designed to avoid and/ or mitigate potential adverse effects on the national site network, as described in the Volume 5, Report 4: RIAA.
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.240 – requires that *"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."*	VE has been designed with consideration of and within the limits of, lighting requirements for aviation and navigation purposes, to minimise lighting in order to avoid attracting birds, taking into account potential impacts on safety. Further consideration to the impacts of lighting is given in Section 4.11.
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.240 – notes that, *"Subject to other constraints, wind turbines should be laid out within a site, in a way that minimises collision risk."* Paragraph 2.8.231 – notes that, *"Turbine parameters should also be developed to reduce collision risk where the assessment shows there is a significant risk of collision (e.g., altering rotor height)."*	VE has selected larger and more widely spaced WTGs with higher rotor tip clearance above mean sea level (28m), in order to reduce seabird collision risks (see Table 4.15). The collision risk assessment in Section 4.11 has shown non-significant unmitigated effects of collisions on all

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
		species under the worst-case scenario.
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraph 2.8.242 – requires that *"Construction vessels and post-construction maintenance vessel traffic associated with offshore wind farms should, where practicable and compatible with operational requirements and navigational safety, avoid rafting seabirds during sensitive periods and follow agreed navigation routes to and from the site and minimise the number of vessel movements overall."*	During construction, operation and maintenance works, vessels associated with VE will, where practicable and compatible with operational requirements and navigational safety, follow a best-practice protocol to minimise disturbance to the Outer Thames Estuary SPA population of red-throated diver (see Section 4.9 and Table 4.16)
NPS for Renewable Energy Infrastructure (EN-3) November 2023	Paragraphs 2.8.243 and 2.8.244 – explain that *"The exact timing of peak migration events is inherently uncertain, although research is ongoing into estimates for peak migration periods for a number of bird species and detection technologies (e.g., using radar and integrated sensors) are improving.* *Currently, shutting down turbines within migration routes during estimated peak migration periods is unlikely to offer suitable mitigation, but this might be a possibility in the future."*	Appropriate mitigation measures for offshore ornithology have been considered within the VE assessment process where relevant (Section 4.9: Mitigation). Additional risks with regards to migratory movements of birds associated with SPAs are further considered within the Volume 5, Report 4: RIAA.
East Offshore Marine Plans updated September 2022	Policy ECO1: *"Cumulative impacts affecting the ecosystem of the East marine plans and adjacent areas (marine, terrestrial) should be addressed in decision-making and plan implementation"*	Cumulative effects are considered in Section 4.13.
East Offshore Marine Plans updated September 2022	Policy BIO1: *"Appropriate weight should be attached to biodiversity, reflecting the need to protect biodiversity as a whole, taking account of the best available evidence*	Due consideration to the baseline characterisation of the site has been given in Volume 6, Part 5, Annex 4.1: Offshore Ornithology

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	including on habitats and species that are protected or of conservation concern in the East marine plans and adjacent areas (marine, terrestrial)".	Technical Report, which is informed by the best available evidence, inclusive of consideration of protected or conservation species. This is summarised in Section 4.7. Potential impacts on protected or conservation species have been assessed in Sections 4.10, 4.11, 4.12 and 4.13.
East Offshore Marine Plans updated September 2022	Policy MPA1: *"Any impacts on the overall marine protected area (MPA) network must be taken account of in strategic level measures and assessments, with due regard given to any current agreed advice on an ecologically coherent network".*	Designated nature conservation sites, with regards to offshore ornithology and within the VE study area have been described in Section 4.7. Potential impacts to features of designated sites have been assessed in Sections 4.10, 4.11, 4.12 and 4.13.
East Offshore Marine Plans updated September 2022	Policy MPA-1: *"Any impacts on the overall Marine Protected Area network must be taken account of in strategic level measures and assessments, with due regard given to any current agreed advice on an ecologically coherent network."*	Designated nature conservation sites, with regards to offshore ornithology and within the VE study area have been described in Section 4.7. Potential impacts to features of designated sites have been assessed in Sections 4.10, 4.11, 4.12 and 4.13.
East Offshore Marine Plans updated September 2022	Policy BIO-2: *"Where appropriate, proposals for development should incorporate features that enhance biodiversity and geological interests."*	Potential impacts on offshore ornithology receptors have been assessed in Sections 4.10, 4.11, 4.12 and 4.13, and mitigation is detailed in Section 4.9.

4.2.3 The most relevant guidance on EIA for marine ecology receptors, including birds, is the '*Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine'* published by the Chartered Institute of Ecology and Environmental Management (CIEEM 2018; v1.2 updated April 2022). The EIA methodology described in section 4.5 and applied in this chapter is based on the CIEEM guidance.

4.2.4 Additional guidance on the assessment of the potential impacts of renewable energy generation on birds has been produced by a number of statutory bodies, NGOs and consultants including, but not limited to the following:

- *Delivering Proportionate Environmental Impact Assessment ('EIA'): A Collaborative Strategy for Enhancing UK Environmental Impact Assessment Practice* (IEMA, 2017);
- *Advice Note Seventeen: Cumulative Effects Assessment* (Planning Inspectorate, 2019);
- *Advice Note Ten: Habitats Regulations Assessment relevant to nationally significant infrastructure projects* (Version 9) (Planning Inspectorate, 2022);
- *Assessment methodologies for offshore windfarms* (Maclean et al., 2009);
- *Collision risk modelling to assess bird collision risks for offshore windfarms* (Band 2012);
- *Assessing the risk of offshore wind farm development to migratory birds* (Wright et al. 2012);
- *Vulnerability of seabirds to offshore windfarms* (Furness and Wade, 2012; Furness et al., 2013; Wade et al. 2016);
- *Mapping seabird sensitivity to Offshore Windfarms* (Bradbury et al. 2014);
- *The avoidance rates of collision between birds and offshore turbines* (Cook et al. 2014);
- *Joint Response from the Statutory Nature Conservation Bodies to the Marine Scotland Science Avoidance Rate Review* (JNCC et al. 2014);
- *Non-breeding season populations of seabirds in UK waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Reports, Number 164* (Furness 2015);
- *Advice on assessing displacement of birds from offshore windfarms* (SNCB 2017; updated 2022);
- *Interim advice on updated Collision Risk Modelling parameters* (Natural England, July 2022a); and
- *Offshore Wind Marine Environmental Assessments: Best Practice Advice for Evidence and Data Standards. Phase III: Expectations for data analysis and presentation at examination for offshore wind applications* (Parker *et al.* 2022c).

4.3 CONSULTATION

4.3.1 To date, consultation with regards to offshore ornithology has been undertaken via Expert Topic Group (ETG) meetings under the Evidence Plan process, described within Volume 6, Part 1, Chapter 3 EIA Methodology, with meetings held in October 2020, 2021, and 2022; and September 2023. Furthermore, consultation has been carried out through formal submission of the VE Scoping Report and feedback has been received from the Preliminary Environmental Information Report (PEIR) presented to consultees. All feedback received through this process has been considered in preparing the ES where appropriate.

4.3.2 The responses received from stakeholders with regards to the Scoping Report and PEIR, as well as feedback to date from the offshore ornithology ETG meetings are summarised in Table 4.2, including details of how these have been taken account of within this chapter.

Table 4.2: Summary of consultation relating to offshore ornithology.

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
12/07/2019 Pre-scoping advice from Natural England (NE) on aerial survey methodology submitted by The Applicant on 23/02/2019.	Description of the proposed survey and survey design: NE welcomes 24-month survey programme. NE requests that analysis of aerial survey data is provided to demonstrate that there is the evidence to justify that 10% coverage of the study site's surface area is adequate to characterise the site. NE requests confirmation that the data from all four cameras will be analysed, if it is deemed that the results from just two cameras does not provide an adequate level of coverage.	Response to comments and justification of survey coverage and flight height methods was provided by the Applicant on 30/08/2019.
	Flight height methodology: NE advises that where robust and reliable site-specific flight height data can be obtained, these should be used for collision modelling.	Response to comments and justification of survey coverage and flight height methods was provided by The Applicant on 30/08/2019.

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	Modelling outputs should be presented including the upper and lower confidence intervals. HiDef proposes to calculate bird flight heights from digital video aerial survey data using size-based estimation. However, it is important that HiDef provide evidence to demonstrate the accuracy of this method.	
27/09/2019 Pre-scoping advice from NE on aerial survey methodology (2nd response)	Further request for information on the proposed survey coverage to demonstrate that there is the evidence to justify the proposed 10-15% coverage. Whilst NE note that a method of flight height estimates based on the relative size of a bird in flight, there is a need to provide evidence that the method can be validated. It should be set out clearly why HiDef do not recommend that site flight height data are relied upon for consenting. It is not clear if the intention is to use Band Option 1 (with site specific potential collision height) in collision risk modelling (CRM) using these methods.	Response to further comments and justification of survey coverage and flight height data was provided by The Applicant on 06/11/2019. It was proposed at the time to present CRM results from both Band (2012) Option 1 and Band Option 2.
10/02/2020 Pre-scoping ETG meeting	CRM: It was agreed that both Band (2012) model Options 1 and 2 would be used within the PEIR and ES and presented side by side.	Following subsequent consultation (see below), the deterministic Band (2012) and stochastic CRM have used Option 2 in preparation of this chapter. See Volume 6, Part 5 Annex 4.8: Collision Risk Modelling inputs and outputs.
18/09/2021 Pre-scoping ETG meeting	Survey coverage: a potential disagreement over where 10% aerial bird survey coverage is sufficient for the purposes of baseline characterisation.	Subsequent agreement has been reached for an aerial survey site coverage of 15% (data from three cameras) to be used for calculating density and

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
		abundance for all surveys (see VE Offshore Ornithology Method Statement, dated 24/03/2022 and NE Discretionary Advice Service letter, dated 20/05/2022).
November 2021 Scoping Opinion	The Inspectorate has agreed that the following impacts can be scoped out of the ES: > Collision risk with installed but not commissioned WTG and construction vessels; and > Disturbance and displacement along the offshore export cable corridor during operation (subject to the DCO including clear and detailed commitments on the management of vessel movements during the operation and maintenance stage).	These potential impacts have been scoped out of the assessment (see section 4.4).
	The Inspectorate recommends that the following impacts should be scoped into the ES, unless evidence demonstrating agreement with the relevant consultation bodies and the absence of a likely significant effect on the environment is provided: > Impacts on prey species and habitats from accidental pollution during construction; > Barrier effects during operation; > Disturbance during construction; > Non-breeding season impacts; > Cumulative effects with non-OWF projects; and > Cumulative construction and decommissioning impacts.	The impacts taken forward for assessment are presented in section 4.4. It should be noted that barrier effects during operation are considered within Impact 3: Direct Disturbance and Displacement. Additionally, non-OWF projects were subsequently scoped out of the cumulative assessment (section 4.13, para 4.13.6) as these activities are long-established, and their impacts would therefore have been accounted for within the environmental characterisation data. Cumulative decommissioning impacts are considered to be equal to or less than those predicted for the construction phase, and so reference should be made to the conclusions in section 4.13.

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	The ES should provide a clear justification as to why the study area used in the assessments reflects the zone of influence for the VE project.	The study area has been agreed through the consultation process (see above) and is described in section 4.4.
	The Scoping Report states that the aerial surveys achieved a coverage of 10 – 15% of the array areas with a 4km buffer. The ES should provide evidence as to why this level of coverage is considered to provide a robust baseline data set.	Subsequent agreement has been reached for an aerial survey site coverage of 15% (data from three cameras) to be used for calculating density and abundance for all surveys (see above, and Volume 6, Part 5 Annex 4.1: Offshore Ornithology Technical Report).
	The baseline in the ES should be as comprehensive as possible to give the Examining Authority confidence in the assessments. Advice from NE on additional data sources which could be used in the assessment is provided.	To build up as comprehensive a baseline as possible, additional data sources have been used throughout the assessment, including those listed in Table 4.3.
	The list of Important Ornithological Features (IOFs) should include all species recorded in the site-specific aerial surveys which are features of designated sites with connectivity to the study area.	IOFs initially taken forward for assessment are all of those recorded during the site-specific aerial surveys. Depending on estimated abundance/densities or sensitivity, some IOFs have been screened out for the detailed assessment of particular impacts (see introduction text of each Impact 1 to 8 in sections 4.10 to 4.13).
	The Applicant is advised to agree assessment methodologies with relevant stakeholders represented on the ornithology Expert Working Group (EWG). If fundamental disagreements remain on the methods for assessing effects from displacement and collision-related mortality the ES should include assessments based on The	Agreement on methodologies has been reached with consultees during the ETG process, as described in this table. Where justification or rationale has been required, this has been provided in the appropriate section.

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	Applicant's preferred method and those advocated by Natural England.	
	The ES should provide a clear explanation of how displacement impacts have been assessed for both the array areas and the cable route. If it is not possible to an appropriate methodology with the ornithology EWG then the ES should include assessments based on the Applicant preferred method and those advocated by NE.	Agreement on displacement impact assessment methodology has been reached during the consultation process. Methodology is described in section 4.11, Impact 3 and generally follows recommended SNCB (2017; updated 2022) guidance.
14/12/2021 Post-scoping ETG meeting	It was agreed that the proposed approach for quantifying displacement of seabirds will utilise the SNCB (2017; updated 2022) metric (% displacement x % mortality).	Agreement on this displacement impact assessment methodology has been reached during the consultation process. Methodology is described in section 4.11, Impact 3.
	It is proposed to use the Band 2012 deterministic CRM model. Following analysis then the stochastic CRM may be utilised.	Results of the deterministic Band (2012) and stochastic CRM have been used in preparation of this chapter and are presented in Volume 6, Part 5 Annex 4.8: Collision Risk Modelling inputs and outputs and summarised for assessment in section 4.11, Impact 4.
	British Trust for Ornithology (BTO) flight data will be used to inform the CRM (Option 2).	The Option 2 variant of the deterministic Band (2012) model and stochastic CRM has been used for calculating collision rates, which uses BTO flight data. This is consistent with the Natural England (2022a) Interim Advice on updated Collision Risk Modelling parameters.
	Migrant collisions will be considered using the BTO tool produced for the SOSS-05 BTO report (Wright *et al.* 2012)	Potential impacts on migrant species, in relation to SPA populations, have been assessed in the Volume 5, Report 4: RIAA.

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
20/5/2022 Natural England Method Statement Response	**Baseline characterisation:** The advice from Thaxter and Burton (2009) for a minimum of 20 aerial survey transects is specifically for digital aerial surveys of seabirds therefore it is relevant for the VE surveys. Until there is more up to date advice on digital aerial survey design, Natural England's (NE's) position is that the Thaxter and Burton (2009) advice is used unless power analysis has been undertaken to show why other survey designs are suitable.	The survey design was agreed with stakeholders prior to the surveys being undertaken. The Thaxter and Burton (2009) guidance derived from visual aerial surveys conducted as line transects and the need to estimate distance detection functions, for which 16-20 transects is recommended as the minimum (Buckland *et al*. 2001). Digital aerial surveys are conducted as strip transects and object detection is assumed to be 100% (i.e., no need to estimate detection functions) so this recommendation does not apply.
	In relation to assessing the relationship of precision with aerial survey coverage percentage, VE has requested a test sample of data for a few representative months from HiDef. Natural England welcomes this and looks forward to seeing which months have been selected, the methods and results of the analysis clearly presented in the future.	This information was discussed through the ETG process with analysis of digital aerial survey coverage provided to Natural England for consultation (30th November 2021) and in the Project's Ornithology Method Statement 24th March 2022). Natural England provided their agreement with the proposed approach on the 22nd May 2022.
	Density and abundance estimate methods Natural England welcomes the fact that [aerial survey] site coverage of 15% (data from three cameras) will be used for calculating density and abundance for all surveys.	Noted. The 15% coverage was used for calculating density and abundance (see methods in Volume 6, Part 5, Annex 4.1: Offshore Ornithology Technical Report).
	Natural England is happy to see the clarification regarding the approach that will be used in generating the design-based abundance/density estimates, 95% confidence intervals	Noted. Methodology for calculating density and abundance is presented in Volume 6, Part 5, Annex 4.1: Offshore Ornithology Technical Report.

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	and levels of precision that will be used in impact assessments. Natural England is satisfied with the method proposed for calculating the 95% confidence intervals in the method statement. The values from this method should be presented alongside the values using the HiDef transect based approach to clearly see how they differ. Natural England request confirmation in writing from HiDef that this approach is appropriate for their survey data.	Confirmation from HiDef relating to the appropriateness of approach was provided on 24th March 2022 via email (and reproduced in the Ornithology Method Statement).
	Natural England welcomes the use of adjustment rates for adjusting availability bias for auks.	This process has been used for estimating abundance and densities of auk species for the purposes of assessment (see Volume 6, Part 5, Annex 4.1: Offshore Ornithology Technical Report for details).
	Natural England would expect birds identified as auk sp. to be apportioned to the individual auk species (e.g., razorbill, guillemot etc. recorded during the surveys) based on the proportion of birds identified to species level.	A process of apportioning has been used for estimating abundance and densities of individual auk species for the purposes of assessment (see Volume 6, Part 5, Annex 4.1: Offshore Ornithology Technical Report for details).
	Assessment of effects Natural England recommends the use of the stochastic CRM for the basic model (i.e. Options 1 and 2), but not the extended model (Options 3 and 4), as there are no agreed upon suitable avoidance rates for the extended, stochastic model. If the deterministic model is to be used, Natural England recommends that uncertainty around key input	Option 2 of the Band (2012) model has been used to estimate the collision rates for all species (see Volume 6, Part 5, Annex 4.8 for details of deterministic and stochastic models). The largest contributor to variation in collision estimates is seabird density, which typically has a CV (coefficient of variation) an order of magnitude greater than those for bird

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	parameters is captured by undertaking multiple runs.	dimensions and flight speed and four orders of magnitude greater than that due to variation in avoidance rates. Therefore, since variations in collision predictions are overwhelmingly due to variations in seabird density only that measure has been used to derive upper and lower estimates in the deterministic collision modelling.
	Species biometric values for seven species are laid out in the Natural England (Parker *et al.* 2022c) Best Practice for Data Analysis document (gannet, kittiwake, lesser black-backed gull, herring gull, greater black-backed gull, little gull, sandwich tern). The values match those contained in Table 1 of the Method Statement, except the flight speed of little gull, where Natural England recommends the use of 12.2. For the species not included in the Best Practice document, the BTO values are suitable for the CRM.	The species' biometrics used for collision risk calculations are consistent with those recommended by Natural England (Parker *et al.* 2022c), including for little gull. See Table 20 of Volume 6, Part 5, Annex 4.8 for details.
	Natural England recommends following the guidance for displacement matrices laid out in the Natural England (2022) Best Practice for Data Analysis document.	The Natural England (Parker *et al.* 2022c) matrix-based methodology for assessing displacement impacts has been used. See section 4.11, Impact 3 for details.
17/11/2022 ETG meeting (pre-PEIR)	VE presented planned assessment methods for the PEIR relating to offshore ornithology, namely: > Definition of study area; > Confirmation of number and appropriateness of aerial survey transects;	No queries were received from consultees on these topics, with the exception of those listed in the rows below.

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	> Key guidance to be used, including Natural England's 2022 guidance and their interim guidance for avoidance rates to use in collision modelling; > Methods to estimate the baseline densities and abundances; and > Impact assessment methods for collision risk and displacement, and requirements of PVA (where adverse effect is >1%).	
	RSPB stated a preference is for model-based estimates, as opposed to design-based estimates for densities and abundances, but will consider the justification of method provided in the PEIR.	A description and justification of the model-based estimates is provided in section 4.4, Density and Abundance Estimates Methodology. The methodology was discussed with HiDef and the Centre for Ecological and Evolutionary Modelling at St Andrews who agreed that it appears to be a sensible approach for bootstrapping aerial survey data. Interim conversations with Natural England have also been undertaken on this methodology.
	Natural England confirmed that the updated avoidance rates in Natural England's interim guidance should be applied respectively for the cumulative and in-combination assessments.	The cumulative assessment (section 4.13) considers the implications of changes to species' avoidance rates over time and how the discrepancies in older project estimates affects the cumulative impact predictions here.
	VE confirmed that macro-avoidance adjustment will be applied prior to modelling collisions for gannet, as per Natural England's interim guidance. RSPB requested that gannet collisions are also presented without the macro-avoidance factor	Estimates of gannet collision rates with and without the macro-avoidance factor are considered in this chapter (section 4.11, Impact 5 and Volume 6, Part 5, Annex 4.8).

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	for gannet owing to awaiting the final publication of the associated interim report.	
Natural England 12/05/2023 Response to Section 42 PEIR	**<u>Collision Risk Modelling</u>** The PEIR presented collision risks calculated using the deterministic Band (2012) CRM implemented within the stochLAB R package. This tool has not yet been tested or reviewed by Natural England and therefore we do not currently advocate its use. Furthermore, no exhaustive testing is available for review to the best of our knowledge. NE recommended to undertake the CRM following NE best practice guidance and/or present evidence in support of the stochLAB package.	To address Natural England's comments Volume 6, Part 5, Annex 4.10: Collision Risk Modelling: Comparison of Model Results provides a comparison of collision risk model outputs as obtained from the following versions of the Band CRM: • Deterministic Band (implemented in R using stochLAB); • Stochastic Band (implemented in R using stochLAB); and • Stochastic Band implemented using the online shiny app[1] tool. The comparison demonstrated that the different implementations of the Band CRM generate mean values that are very similar (differences < 1-2%), with variation due simply to chance. The deterministic collision estimates, and stochastic collision estimates using the stochLAB R Package were therefore used in this chapter for appropriate species (see Volume 6, Part 5, Annex 4.8).
Natural England 12/05/2023	NE note that the deterministic Band model has been used in the PEIR. NE recommend using the stochastic model to fully incorporate uncertainty and variability in input parameters. If deterministic model is	As noted above, the stochastic CRM using stochLAB has been considered appropriate to use for the assessment of species where sufficient data are

[1] available at https://dmpstats.shinyapps.io/avian_stochcrm/

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
Response to Section 42 PEIR	used, advise that key input parameters such as: monthly bird density; flight height; avoidance rate and nocturnal activity factor should be considered on an individual parameter basis. This can be done using the Band (2012) spreadsheet or by running the sCRM model developed by McGregor (2018).	available. Details are provided in Volume 6, Part 5, Annex 4.8. Volume 6, Part 5, Annex 4.10 demonstrates that variation in density accounts for the majority of variation in the stochastic outputs, since the upper 95% confidence interval collision estimates derived using just the seabird densities (deterministic) were approximately half the size of those obtained with variation in the other six (avoidance rate, flight height, flight speed, body length, wingspan, nocturnal activity).
Natural England 12/05/2023 Response to Section 42 PEIR	<u>**Cumulative Assessment**</u> NE draws attention to their Best Practice Advice with regards to the cumulative assessment. Magnitude of impacts and significance of effects should be based on parameters that reflect their guidance. All plans and projects within the relevant spatial scale should be screened into the cumulative assessment. The relevant spatial scale varies according to species and should be evidence-based.	The NE guidance on cumulative assessment (Parker *et al.* 2022c) has been considered in this chapter. This includes scoping projects in at relevant spatial scale (UK North Sea and Channel), recommended project tiers for assessment, and use of 'worst-case' turbine parameters.
Natural England 12/05/2023 Response to Section 42 PEIR	Only OWFs are considered in the cumulative assessment. Marine aggregates, oil & gas, cabling and commercial shipping are all considered part of the baseline characterisation of the site and not considered in the offshore ornithology assessment. NE advises the ES should provide more evidence that these activities are not likely to cause cumulative / in-combination impacts.	Information is presented in Section 4.13. Worst-case cumulative totals from other offshore wind farm projects have been based on "as consented values". Parker *et al.* (2022c) advises that *"Built and operational projects should be included within the cumulative assessment where they have not been included within the environmental*

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	Cumulative totals should be based on "as consented" parameters within all assessments.	*characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and/or any residual impact may not have yet fed through to and been captured in estimates of 'baseline; conditions, such as 'background' distribution or mortality rate for birds."* All of the considered non-OWF activities are long-established, and their impacts would therefore have been accounted for within the environmental characterisation data.
Natural England 12/05/2023 Response to Section 42 PEIR	NE is actively engaged with industry considering ways that 'as-built' parameters can be used within assessments. However, at present we do not consider it appropriate to reduce impact estimates by considering as-built parameters, unless legally secured through the DCO licence. Natural England advises that the ES should present cumulative/in-combination totals based on 'as consented' parameters within all relevant assessments.	Noted. The NE guidance on cumulative assessment (Parker *et al.* 2022c) has been followed in this respect.
Natural England 12/05/2023 Response to Section 42 PEIR	The PEIR cumulative assessment indicates >1% change to the baseline mortality of the largest BDMPS for seven species (including three species with scoped in SPA populations). However, in all cases the magnitude of the cumulative effect has been defined as negligible or low and the significance of the impacts, minor adverse. NE advises presenting the magnitude of impacts and significance of effects based on	The predicted levels of significance for each species, based on VE judgement, and based on NE guidance, have been described for each impact. For impacts due to the VE project alone, there would be no difference of magnitude of impact and significance of effect when considering the two approaches. Any differences in significance of effect due to cumulative impacts, resulting from the differences in

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	NE's guidance alongside the projects proposed impacts in all tables as well as the report text. i.e., using parameters reflecting NE guidance and not only those determined to be more realistic by the developer. Where >1% change to baseline mortality of a species relevant population is predicted using NE's advised parameters, NE would expect further investigation of these impacts further through Population Viability Analysis (PVA).	approach, are noted in Section 4.13, and presented in Section 4.17 Summary of Effects, Table 4.69. No predicted impact due to the VE project alone has resulted in a >1% change to baseline mortality of the species' BDMPS. Where this threshold has been met due to cumulative impacts, an assessment has taken into consideration outputs of modelling undertaken for relevant offshore wind projects such as East Anglia THREE (MacArthur Green, 2015), Norfolk Boreas (MacArthur Green, 2019c), Hornsea 4 (APEM, 2021, 2022), Rampion 2 Wind Farm (APEM, 2023) which are based on North Sea and Channel BDMPS and wider biogeographic population scales.
Natural England 12/05/2023 Response to Section 42 PEIR	NE is concerned with an arbitrary 500 km buffer to scope in other projects for consideration. They advise that NE best practice guidance should be followed re the following point: "All plans and projects within the relevant spatial scale should be screened into the cumulative / in-combination assessments. The relevant spatial scale will vary between species and should be based on a suitable evidence base, such as the relevant BDMPS (Furness, 2015)."	NE guidance has been followed in the cumulative assessment (Section 4.13), and projects within the relevant spatial scale (UK North Sea and Channel, equivalent to the BDMPS scale) have been included.
Natural England 12/05/2023	NE noted that North Falls OWF baseline characterisation has not been included in the EIA. NE advises that this data should be added to the cumulative assessment.	North Falls data, as gathered from the project's PEIR, has been included in the cumulative assessment for each impact and species.

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
Response to Section 42 PEIR		
Natural England 12/05/2023 Response to Section 42 PEIR	**Project Parameters** NE would like clarification on the location of the two offshore substation platforms (OSPs), with the ES showing their location in relation to Marine Protected Areas. NE would have concerns if the OSPs would be located in the Outer Thames Estuary SPA.	The two proposed OSPs would be located >10km from the Outer Thames Estuary SPA (see Figure 10.1 in Volume 6, Part 2, Chapter 10: SLVIA), and therefore based on SNCB (2017; updated 2022) guidance, would be at distances unlikely to affect red-throated divers (or any other species) within the SPA.
Natural England 12/05/2023 Response to Section 42 PEIR	Offshore and inshore ECCs were not specifically surveyed for birds, with impacts assessed using data from latest Outer Thames Estuary SPA survey undertaken in winter 2017/18. NE acknowledges that these data are the best available but consider results should be considered with caution considered the age of the data.	The limitations of the Irwin *et al.* (2019) data usage for the offshore ECC have been acknowledged in section 4.6 Uncertainty and Technical Difficulties Encountered, and a precautionary approach has been applied in the assessment.
Natural England 12/05/2023 Response to Section 42 PEIR	NE advises that work on the offshore ECC in the Outer Thames SPA is not undertaken during sensitive period for red-throated diver, in particular between 1st November and 1st March. As a minimum standard, NEs best practice protocol should be adopted for this period.	The overlap with the Outer Thames SPA is a relatively small proportion of the offshore ECC, at 16 km (c. 17% of the total length). A Best Practice Protocol for Red-throated Divers would be implemented during construction (see Section 4.9 Mitigation). As a result, export cable installation will not be carried out within the Outer Thames Estuary SPA between 1 November to 31 March inclusive to mitigate disturbance impacts on red throated diver. See Volume 9, Report 9.18: Outline Project Environmental Management Plan (PEMP) and Volume 9,

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
		Report 18.1: Working in Proximity to Wildlife for further information.
Natural England 12/05/2023 Response to Section 42 PEIR	<u>**Data, Analysis and Reporting**</u> A design-based approach is used to estimate bird abundance and density. Variations in the seabird abundancies and densities are estimated using a novel approach to improve the precision of the estimates. NE is broadly supportive of the novel approach taken to calculating design-based estimates. However, we reiterate our request that a comparison is presented against data derived from a standard design-based approach (i.e., using the entire transect as the smallest independent unit for resampling). This would evidence the claimed improvement in precision, increase confidence that suitable estimates have been generated, and allow SNCBs to properly consider more general application of the method at other appropriate projects. Note this was requested by NE at an ETG on 20/05/22.	Volume 6, Part 5, Annex 4.11: Design based bootstrap variance estimates: Comparison of transect level results with auto-correlation based time-series method provides a comparison of the abundance estimates obtained when the data are resampled at the level of the transect (as per the NE guidance) and using the auto-correlation corrected sampling block approach used for the VE analysis. This provides more details on the methodology and demonstrates the advantages of the latter approach with respect to improved precision around estimates.
Natural England 12/05/2023 Response to Section 42 PEIR	Monthly abundance and density estimates were tabulated with means, upper and lower Confidence Intervals (CIs) but Coefficient of Variation (CVs) are not shown. If feasible, the submitted ES should show coefficient of variations with the standard deviations and CIs for each estimate as per NE's best practice advice.	The CVs and standard deviations for each density and abundance estimate are presented within the output tables of Volume 6, Part 5, Annexes 4.2 to 4.7.
Natural England 12/05/2023	NE note impacts for the worst-case scenario are derived following NE best practice using displacement figures assessed against BDMPS	The predicted levels of significance for each impact, based on VE judgement, and based on NE guidance, have

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
Response to Section 42 PEIR	and biogeographic regional populations. However, the magnitude and significance of the worst-case scenario are downgraded to lower scales based on qualitative assessments of these results, notably for the cumulative assessment. NE advise the ES should draw conclusions based on a range of predicted effects, drawing on outputs derived from NE best practice guidance alongside the project's proposed impact estimates.	been described for each impact and presented in 4.17 Summary of Effects, Table 4.68 and Table 4.69.
Natural England 12/05/2023 Response to Section 42 PEIR	Displacement impacts on gannet are based on 60-80% displacement and 0-1% mortality. Justification for selecting the lower range of mortality has been given based on the literature and expert opinion but given the paucity of evidence, as currently drafted it is questionable whether the worst-case scenario has been captured.	The assessment uses the best available evidence to determine an appropriate, but still precautionary, level of mortality. Table 4.26 to Table 4.31 do however show the full ranges of potential displacement and mortality which can be used to determine impacts.
Natural England 12/05/2023 Response to Section 42 PEIR	Breeding kittiwake population from Lowestoft is not included in the EIA, but VE array lies within the mean-max foraging range of the species. NE advise adding this population to the list of IOFs and include it in the cumulative assessment.	This is relevant to the Volume 5, Report 4: RIAA and is addressed there. For EIA the appropriate population scale is the BDMPS which has been used in this assessment. Parker *et al.* (2022c) states that *"All plans and projects within the relevant spatial scale should be screened into the cumulative / in-combination assessments. The relevant spatial scale will vary between species and should be based on a suitable evidence base, such as the relevant BDMPS".*
Natural England	No population modelling was undertaken as all impacts were	No predicted impact due to the VE project alone has resulted in

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
12/05/2023 Response to Section 42 PEIR	determined to be negligible or low for all species except lesser black-backed gull (in the breeding season). A PVA for this species will be presented in the VE RIAA. However, cumulative effects causing >1% change to baseline mortality of the largest BDMPS were reported for red-throated diver, razorbill, guillemot, gannet, great black-backed gull, lesser black-backed gull, and kittiwake. All are discounted in the PEIR as the VE contribution is considered very small and those impacts from other OWFs likely too precautionary due to various reasons. NE does not support this approach. For those species that cumulative effects will likely cause >1% change to the baseline mortality, undertake a PVA.	a >1% change to baseline mortality of the species' BDMPS. Where this threshold has been met due to cumulative impacts, an assessment has been made using outputs of recent modelling undertaken for relevant offshore wind projects such as Hornsea 4 (APEM, 2021, 2022) and Rampion 2 Wind Farm (APEM, 2023) which are based on North Sea and Channel BDMPS and wider biogeographic population scales .
Natural England 12/05/2023 Response to Section 42 PEIR	NE highlight that there no citation for tracking studies of lesser black-backed gulls crossing the North Sea is given, although the PEIR suggests they provide evidence of low interconnectivity and help indicate likely insignificant transboundary effects. NE recommend a follow up discussion in the ES, citing the studies used as evidence.	The results of studies of tagged breeding lesser black-backed gulls in the Netherlands (e.g., Vanermen *et al.* 2022; van Bemmelen *et al.* 2023) have shown that birds normally remain on the continental side of the North Sea.
RSPB 12/05/2023 Response to Section 42 PEIR	**<u>Red-throated Diver</u>** RSPB disagrees with the definitions as taken from Furness (2015) stating that February is spring migration for Red-throated Diver. Although some birds may start to move in late February, the main spring passage is from March, as evidenced by observations at Bird Observatories of spring movements	The best available abundance data for the offshore ECC area is from Irwin *et al.* (2019) which states *"Surveys were originally programmed for the months of January and February when red-throated diver density in the SPA is known to be highest".* The two surveys for that Irwin study were

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	up the English Channel, for example Sandwich Bay and Dungeness Bird Observatories. In our opinion the PEIR misuses Furness (2015) to inaccurately extend the migration season and minimise the wintering period for this species, with knock on effects in the impact assessment for the species at that time.	eventually undertaken in February 2018. The assessment of construction impacts in the offshore ECC area is considered to be sufficiently precautionary because it uses recorded densities at likely peak times to determine impacts and compares it with the BDMPS for winter (which is lower in size than during spring migration).
RSPB 12/05/2023 Response to Section 42 PEIR	Lesser black-backed gull: The nearest breeding colonies to the project are on the Suffolk coast. The RSPB is concerned about the project's impacts on Lesser Black-backed Gulls within the Alde-Ore Estuary SPA. Recent tracking studies have confirmed this species forages into the area of the proposed Five Estuaries array/offshore cable corridor. The RSPB disagrees with the PEIR conclusions drawn within paragraphs 4.13.89 to 4.13.96 which argue the adoption of precautionary calculation methods and a conclusion of 'minor adverse' (paragraph 4.13.96).	The conclusion of minor adverse refers to lesser black-backed gull impacts at a regional/national level rather than Alde-Ore Estuary SPA impacts which form part of the Volume 5, Report 4: RIAA.
RSPB 12/05/2023 Response to Section 42 PEIR	In Table 4.16 it is claimed that "use of larger and more widely spaced WTGs with higher rotor tip clearance above mean sea level (28m) than previous developments … typically reduces collision risks and is also likely to reduce displacement effects." The RSPB would welcome evidence of these expressed project design benefits.	The study by Johnston *et al.* (2014) on seabird flight heights produced information to suggest that a higher rotor tip clearance above mean sea level would generally reduce predicted collision rates. In a study of responses of birds to Dutch offshore wind farms, Leopold *et al.* (2013) concluded that *"In the present, first inter-wind farm comparison,*

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
		admittedly based on only two wind farms, a lay-out with larger, but more spaced-out turbines, disturbed the birds to a lesser extent than a wind farm with smaller but more densely packed turbines."
RSPB 12/05/2023 Response to Section 42 PEIR	The RSPB have concerns about the narrative regarding in-combination impacts with other offshore wind farm projects, for example that other wind farms may not build to their full (consented) potential, and that the in-combination project risks may hence be being overstated and are consequently highly precautionary. We question reliance on this position. This is linked in the discussion on lesser black backed gulls (paragraph 4.13.95 of the PEIR) with comment on nocturnal activity parameters and impacts on gull species.	The cumulative assessment in Section 4.13 follows the NE guidance on cumulative assessment (Parker *et al.* 2022c), which uses 'worst-case' turbine parameters for each project. The possible over-precautionary assumptions built into cumulative assessments of particular impacts on species are highlighted, although not relied on to determine overall level of significance.
04/09/2023 ETG Meeting (pre-ES)	NE noted that their current NE advice is not to accept StochLAB CRM now due to a recent review by JNCC. RSPB noted that they are relatively comfortable that StochLAB produces outputs similar to the Shiny scrum.	Outputs from sCRM have been compared to those from StochLAB in Volume 6, Part 5, Annex 4.10: Collision Risk Modelling: Comparison of Model Results. This found consistency between the results from the two methods.
	The Applicant noted that VE will use a 1% mortality rate for gannet displacement and that NE's response had requested the range of 1-10%. It was noted that, with the exception of Hornsea 4, 1% has been accepted as the appropriate displacement mortality rate for gannet in previous applications (e.g. Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects). The reason for the higher	The assessment of displacement effects on gannet is presented in section 4.11, Impact 3: Direct Disturbance and Displacement. It is considered that a 1% mortality rate used in the matrix approach is sufficiently precautionary, as this species has high habitat flexibility (Furness and Wade, 2012) indicating that displaced (non-breeding) birds are predicted to

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	rate applied at Hornsea 4 (up to 10%) was due to its proximity to Flamborough & Filey Coast SPA, which does not apply to VE. NE noted that they advise 1-10 %, however may only need 1%, based on recent decisions.	readily find alternative habitats including foraging areas.
	NE noted that red-throated diver guidance should be included in an outline vessel management plan for construction and embedded from the outset. It was also noted that even with vessel management a seasonal restriction may be needed. NE advised that the commitment on best practice in the Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects application gives a clear indication of what they would like to see.	A best practice protocol for red-throated divers within the Outer Thames Estuary SPA has been committed to and is highlighted in section 4.9: Mitigation but also further details can be found within Volume 9, Report 18.1: Working in Proximity to Wildlife for further information.
Natural England 18/09/2023 Sep 2023 ETG Meeting Outcomes	NE suggests the following approach to reaching consensus on the appropriate CRM method: 1. VE to set out which species it is possible to compare sCRM and stochLAB outputs for, in order to help form a view on the suitability of the new model. 2.VE to set out which species it has not been possible to compare, to judge how many species of significant interest may have no comparison available. 3. For those species of interest without comparisons, undertake worth with DMP Stats [developer of sCRM software] to allow supported access to the older sCRM for this project. This will also production of comparisons of use for general acceptance of the new model. NE's	A comparison of the two models is presented in Volume 4, Annex 4.10: Collision Risk Modelling: comparison of model results. This comparison used two species, gannet and lesser black-backed gull, on the basis that between them they spanned a wide range of predicted collisions (an order of magnitude) and bracketed the values for most other species. This comparison demonstrated that the different implementations of the Band CRM generate central point (i.e., mean) values that are very similar (differences < 1-2%), with variation due simply to chance.

Date and consultation phase/ type	Consultation and key issues raised	Where comment addressed
	understanding is that it should be possible run the older sCRM offline if needs be.	
Natural England 15/12/2023 Advice on Ornithology Derogation Documents (comments relevant to HRA are addressed in Volume 5, Report 4: RIAA).	***Annex 4.10 Collision Risk Modelling: Comparison of Model Results*** NE advises presenting CRM results from stochLAB alongside those from the older 2018 sCRM tool, as part of the testing process. NE is reasonably satisfied that, based on the findings presented in Technical Annex 4.10, the use of the stochLAB tool likely makes no material difference to the CRM findings. However, because stochLAB remains at a beta stage of development, NE's position and advice on its use may change if/when new evidence emerges. NE's current advice is that developers use the new tool at their own risk. However, this risk could largely be addressed by running a comparison for kittiwake in addition to gannet and lesser black-backed gull [these two latter species are modelled in Annex 4.10].	We welcome this agreement from Natural England that it makes no material difference to the assessment which collision model tool is used. As noted here, a comparison of the results for two species (gannet and lesser black-backed gull) has been provided which demonstrated that the collision predictions are the same (albeit with small differences as a result of their stochastic formaulation) from both sCRM and stochLAB. There is no reason why this would not also be the case for all other species, kittiwake included, since the two tools are fundamentally identical and use the same input data.
	Annex 4.11 Design Based Bootstrap Variance Estimates: Comparison of Transect Level Results with Auto-Correlation Based Time-series Method NE has reviewed the preferred approach and agrees with its use for characterising the variation in the baseline seabird densities in this case.	Noted.

4.4 SCOPE AND METHODOLOGY

SCOPE OF THE ASSESSMENT

IMPACTS SCOPED IN FOR ASSESSMENT

4.4.1 The following impacts have been scoped into this assessment:

- Construction:
  - Impact 1: Direct disturbance and displacement; and
  - Impact 2: Indirect impacts through effects on habitats and prey species (including accidental pollution events).
- Operation and maintenance:
  - Impact 3: Direct disturbance and displacement (including barrier effects, from offshore infrastructure and due to increased vessel and helicopter activity within the array areas);
  - Impact 4: Indirect impacts through effects on habitats and prey species;
  - Impact 5: Collision risk; and
  - Impact 6: Combined operational displacement risk and displacement.
- Decommissioning:
  - Impact 7: Direct disturbance and displacement; and
  - Impact 8: Indirect impacts through effects on habitats and prey species.

4.4.2 For each potential impact, they are assessed:

- In the order of construction, operation and decommissioning;
- Where appropriate (and not scoped out, see following section), separated into predicted impacts on the offshore ECC and array areas, followed by an overall assessment of impact of the VE offshore project;
- Following the impact assessment methodology that is described in section 4.5;
- On the basis of the worst-case potential impacts set out in section 4.8; and
- Accounting for the mitigation that is described in section 4.8.

IMPACTS SCOPED OUT OF ASSESSMENT

4.4.3 On the basis of the baseline environment and the project description outlined in Volume 6, Part 2, Chapter 1: Offshore Project Description and in accordance with the Scoping Opinion (Planning Inspectorate, 2021) (see Table 4.2) a number of impacts have been scoped out, these are:

- Construction and decommissioning:
  - Collision risk with installed but not commissioned (or decommissioned) WTG and construction vessels.
- Operation and maintenance:

> Disturbance and displacement along the offshore export cable corridor (ECC) during operation (subject to the DCO including clear and detailed commitments on the management of vessel movements during the operation and maintenance stage).

STUDY AREA

4.4.4 For baseline surveys, a study area was defined that was relevant to the consideration of potential impacts on offshore ornithological features. The suitability of the study area for the purpose of environmental impact assessment was agreed with Natural England and RSPB during the Evidence Plan Process (Table 4.2).

4.4.5 This study area, based on SNCB (2017; updated 2022) guidance in relation to maximum displacement buffers, comprises the VE array areas and a 4 km buffer placed around them (Volume 6, Part 5, Annex 4.9: Seabird distributions recorded in aerial surveys, Figure 2.4.1).

4.4.6 The SNCB guidance was updated in 2022 to reconsider displacement impacts on red-throated diver in the non-breeding season, where evidence was presented which suggests displacement impacts >4 km have been demonstrated at a number of offshore wind farms and can exceed 10 km. It was however recommended that a displacement buffer of at least 10 km is applied where an array is within 10 km of a SPA designated for red-throated diver in the non-breeding season (SNCBs, 2017; updated 2022). In the case of the VE array areas, these are approximately 17 km from the Outer Thames Estuary SPA, and so a 4 km study area is applicable.

4.4.7 In addition to the array areas covered by aerial surveys, the study area over which potential impacts on offshore bird species are considered includes the linear export cable route (within which the offshore ECC would be located) beyond the array boundary, up to and including the intertidal zone at Holland Haven, ending at the mean high-water spring (MHWS) (Volume 6, Part 5, Annex 4.9: Seabird distributions recorded in aerial surveys , Figure 2.4.1). Refer to Volume 6, Part 3, Chapter 4: Onshore Biodiversity and Nature Conservation for assessment of impacts on birds above the MHWS.

DATA SOURCES

PROJECT-SPECIFIC SURVEYS

4.4.8 A series of project-specific aerial surveys were undertaken between March 2019 to February 2021. The data collected during the aerial surveys have been used to identify the bird species present and their seasonal abundance. This assessment makes use of all of the available analysed data.

4.4.9 The survey area encompassed the array areas and a 4 km buffer (Volume 6, Part 5, Annex 4.9: Seabird distributions recorded in aerial surveys, Figure 2.4.1); the aerial survey transect lines were each separated by 2.5 km^2 across the 606 km^2 survey area. The two-year programme carried out a total of 24 surveys, one per month, to provide distribution and density/abundance data for all observed species at a coverage rate of 15% (see Table 4.2 for consultation on this matter).

4.4.10 The baseline aerial surveys provide information on species (or species-groups if species identification is not possible), abundance, distribution, behaviour, location, numbers, sex and age (where possible) and direction (although it should be noted that flight height estimation from aerial surveys is subject to a large degree of uncertainty and these data are not currently supported for use in assessment of collision risk, see Table 4.2 for consultation on this matter). The assessment identifies the nature of the use of the site by birds recorded - i.e., seasonal differences and activities (foraging, overwintering, migrating or other) in order to determine the importance of the site relative to the wider area for seabird populations throughout the year.

OTHER BASELINE DATA SOURCES

4.4.11 A variety of sources of information (Table 4.3) have been considered as part of a desk-based survey to describe the baseline environment, including both peer-reviewed scientific literature and the 'grey literature' such as other OWF project submissions and reports. Published literature on seabird ecology and distribution, and on the potential impacts of wind farms have also been considered.

4.4.12 Owing to the short-term nature and small spatial scale of potential impacts on IOFs from installation of the offshore ECC, no specific surveys in the offshore cable ECC were conducted (outside of the 4 km study area defined above), and therefore other data sources (primarily aerial surveys described by Irwin *et al.* 2019), which are considered to provide an appropriate level of detail for impact assessment purposes, are used to inform the baseline characterisation and impact assessment for the offshore ECC.

Table 4.3: Key sources of information for offshore ornithology.

Source	Summary	Spatial coverage of VE
Aerial survey of the Outer Thames SPA in 2018 (Irwin *et al*. 2019)	Flown on two survey days in February 2018, with the core objective being to ascertain numbers of red-throated divers, although other species were also recorded.	Covers the area of the SPA, with partial overlap with the offshore ECC.

Source	Summary	Spatial coverage of VE
Survey data from other southern North Sea OWFs, e.g., Galloper, Greater Gabbard, East Anglia projects, Norfolk projects, London Array, Thanet.	Vessel-based and aerial seabird surveys (pre-, during-, post-construction).	Potential for spatial overlap of records with VE array areas, 4 km study area and offshore ECC.
Information on SPAs such as Natural England site condition assessments, MAGIC and JNCC websites.	To determine seabird sites with potential connectivity	Individuals from SPA colonies may utilise VE array areas and offshore ECC.
2004-05, 2005-06, 2007-08 aerial surveys of the Thames Strategic Area (Department of Trade and Industry, 2006; Department of Energy & Climate Change, 2009), and SeaMaST (Bradbury *et al*. 2014).	Regional and large-scale datasets of seabird activity.	May overlap with the VE array areas and the offshore ECC.
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*. 2017; SNCB, 2017, updated 2022; Jarrett *et al*. 2018; Leopold & Verdaat, 2018; Mendel *et al*. 2019; Tjørnløv *et al.* 2022.	Scientific literature describing potential impacts of OWFs on birds.	Species studied and types of study are likely to be applicable for impacts associated with the VE array areas and offshore ECC.
Mitchell *et al*. 2004; BirdLife International 2004; Holling *et al*. 2011; Musgrove *et al*. 2013; Furness 2015; Horswill *et al*. 2017; Burnell *et al.* 2023.	Scientific literature describing bird population estimates and demographic rates.	Species studied include those associated with the VE array areas and offshore ECC.
Cramp and Simmons 1977-94; Del Hoyo *et al*. 1992-2011; Robinson 2005.	Scientific literature on bird breeding ecology.	Species studied include those associated with the VE array areas and offshore ECC.
Stone *et al*. 1995; Brown and Grice 2005; Kober *et al*. 2010; Balmer *et al*. 2013.	Scientific literature on bird distribution.	Areas covered by studies include the VE array areas and offshore ECC.

Source	Summary	Spatial coverage of VE
Wernham *et al*. 2002; Thaxter *et al*. 2012; Woodward *et al*. 2019.	Scientific literature on bird migration and foraging movements.	Areas covered by studies include the VE array areas and offshore ECC.

DESIGNATED SITES

4.4.13 Information on statutory designated sites and their interest features has been drawn from the web-based resource Multi-Agency Geographic Information for the Countryside [MAGIC www.magic.defra.gov.uk], Natural England [www.naturalengland.org.uk] and JNCC [www.jncc.defra.gov.uk] websites.

FLIGHT HEIGHT DATA

4.4.14 Collision risk modelling (CRM) was conducted using the deterministic Band (2012) model for all species and for key collision risk species (gannet, kittiwake, herring gull, lesser black-backed gull and great black-backed gull) using the stochastic implementation provided in the stochLAB R Package.

4.4.15 As agreed during consultation (Table 4.2), all modelling used the Band (2012) CRM Option 2, using BTO data on species flight height distributions, since the flight height sample sizes recorded on the surveys were very small (e.g. kittiwake 135, gannet 53, lesser black-backed gull 42, great black-backed gull 3 and herring gull 0). For deterministic estimates the maximum likelihood height values were used, while for stochastic estimates the bootstrap data samples were used (as made available by the BTO; Johnston et al. 2014a,b).

4.4.16 Details of CRM methods and results are presented in Volume 6, Part 5, Annex 4.8: Collision Risk Modelling Inputs and Outputs. A comparison of the deterministic and stochastic models is also presented in Volume 6, Part 5, Annex 4.10: Collision Risk Modelling: comparison of model results, in response to discussions with Natural England (see Table 4.2).

DENSITY AND ABUNDANCE ESTIMATES METHODOLOGY

4.4.17 Detailed analysis includes density and abundance estimates (with associated confidence intervals, standard deviation and coefficients of variation), which are presented in Volume 6, Part 5, Annexes 4.2 to 4.7.

4.4.18 A design-based method has been used to estimate each species' densities and abundances, based on aerial survey records within the study area. Since the data recorded along each transect, once assigned to sequential 500 m segments, are similar to a time-series of population counts, a time-series bootstrap method was used to resample the data and obtain confidence intervals.

4.4.19 This novel approach for estimating offshore wind farm seabird densities includes explicit allowance for auto-correlation (the tendency for closer segments to have more similar numbers than more widely spaced ones) in the data and was adopted following consideration of Natural England's consultation comments (Table 4.2).

4.4.20 The bootstrap method includes a 'blocking' variable which is used to control for autocorrelation. In the analysis the length of the block was derived for each species by analysing the segment counts and obtaining a measure of autocorrelation along the transect (the number of segments over which autocorrelation was observed). The advantage of this method is that it can allow for a greater number of data points from which to resample, rather than simply using the transect as the smallest independent unit. By increasing the sample size for resampling in this robust manner the uncertainty in the density estimates is minimised.

4.4.21 Further detail of the methodology and the rationale behind its selection is provided in Volume 6, Part 5, Annex 4.11: Design based bootstrap variance estimates: Comparison of transect level results with auto-correlation based time-series method.

4.5 ASSESSMENT CRITERIA AND ASSIGNMENT OF SIGNIFICANCE

4.5.1 The impact assessment methodology will be based on that described in Volume 6, Part 1, Chapter 3: EIA Methodology, tailored to make it applicable to ornithology IOFs, and aligned with the key guidance document produced on impact assessment of ornithological features (CIEEM 2018; updated 2022).

4.5.2 The assessment approach uses a 'source-pathway-receptor' model, which identifies likely impacts on IOFs resulting from the proposed construction, operation and decommissioning of the offshore infrastructure. 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 impact of the activity could affect an IOF, e.g. for the example above, re-suspended sediment could settle and smother the seabed.
- Receptor (in this case 'feature', as per CIEEM (2018; updated 2022) guidance) – 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.

SENSITIVITY

4.5.3 The overall sensitivity level of each ornithological feature is determined by a combination of the behavioural sensitivity (tolerance and response to impact) of the feature, and its conservation value at an appropriate population level.

4.5.4 Definitions of the different behavioural sensitivity levels for ornithological features, using the example of disturbance from construction activity, are included in Table 4.4.

Table 4.4: Definitions of the Different Sensitivity Levels for Ornithological Features in Relation to Construction Disturbance.

Sensitivity	Definition
High	Ornithological feature (bird species) has very limited tolerance of and/or recovery from a potential impact, e.g. strongly displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.
Medium	Ornithological feature (bird species) has limited tolerance of and/or recovery from a potential impact, e.g. moderately displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.
Low	Ornithological feature (bird species) has some tolerance of and/or recovery from a potential impact, e.g. partially displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.
Negligible	Ornithological feature (bird species) is generally tolerant of a potential impact and can easily recover e.g. not displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.

4.5.5 The conservation value of ornithological features is based on the population from which individuals are predicted to be drawn. This reflects current understanding of the movements of bird populations. Therefore, conservation value for a species can vary through the year depending on the relative sizes of the number of individuals predicted to be at risk of impact and the population from which they are estimated to be drawn. Ranking therefore corresponds to the degree of connectivity which is predicted between the study area and protected populations. Using this approach, the conservation importance of a species seen at different times of year may fall into any of the defined categories.

4.5.6 Example definitions of the value levels for ornithological features are given in Table 4.5. SPAs are internationally designated sites which carry strong protection for populations of qualifying seabird species in the UK, and their populations are therefore a key consideration for the ornithology assessment.

Table 4.5: Definitions of the Conservation Value Levels for an Ornithological Feature.

Value	Definition
High	A species population for which individuals at risk can be clearly connected to a particular SPA, Ramsar site, SSSI or which would otherwise qualify under selection guidelines. Species present in internationally important numbers (>1% biogeographic population).
Medium	A species for which individuals at risk are probably drawn from particular SPA, SSSI or Ramsar site populations, although other populations may also contribute to individuals at risk.

Value	Definition
	Species present in nationally important numbers (>1% breeding or non-breeding population).
Low	A species for which individuals at risk have no known connectivity to SPAs, Ramsar sites or SSSIs, or for which no sites are designated. Species not present in nationally important numbers.

MAGNITUDE OF IMPACT

4.5.7 The definitions of the magnitudes of impact on ornithological features are set out in Table 4.6. This set of definitions has been determined on the basis of changes to bird populations.

Table 4.6: Definitions of the Magnitude of Impact on an Ornithological Feature.

Value	Definition
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 5 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 reversible and 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 reversible and 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. Reversible, and recovery from that change is predicted to be rapid (i.e. no more than circa 6 months) following cessation of the development related activity.
No change	No loss of, or gain in, size or extent of distribution of the relevant biogeographic population or the population that is the interest features of a specific protected site.

SIGNIFICANCE OF EFFECT

4.5.8 Following the identification of the ornithological feature's overall sensitivity and the determination of the magnitude of the impact, the significance of the effect will be determined. That determination will be guided by the matrix as presented in Table 4.7. Effects shaded red or orange represent those with the potential to be significant in the context of the EIA Regulations 2017.

Table 4.7: Matrix to determine effect significance.

			Sensitivity			
			High	**Medium**	**Low**	**Negligible**
Magnitude	**Adverse**	**High**	Major	Major	Moderate	Minor
		Medium	Major	Moderate	Minor	Negligible
		Low	Moderate	Minor	Minor	Negligible
	Neutral	**Negligible**	Minor	Minor	Negligible	Negligible
	Beneficial	**Low**	Moderate	Minor	Minor	Negligible
		Medium	Major	Moderate	Minor	Negligible
		High	Major	Major	Moderate	Minor

Note: shaded cells are defined as significant with regards to the EIA Regulations 2017.

4.5.9 It is important that the matrix (and indeed the definitions of sensitivity and magnitude) is seen as a framework to aid understanding of how a judgement has been reached from the narrative of each impact assessment. It is not a prescriptive formulaic method. Expert judgement has been applied to the assessment of likelihood and ecological significance of a predicted impact.

4.5.10 In particular it should be noted that conservation value and behavioural sensitivity levels may not be consistent for a particular impact. A feature could be of high conservation value (e.g. an interest feature of a SPA) but have a low or negligible behavioural sensitivity to an impact and vice versa. Potential effect significance will not be inflated simply because a feature is 'valued'. Similarly, potentially highly significant effects will not be deflated simply because a feature is not valued. The narrative behind the assessment is important here; the conservation value of an ornithological feature can be used where relevant as a modifier for the sensitivity (to the effect) already assigned to the feature.

4.5.11 For the purpose of the assessment of significance, the CIEEM (2018) guidance has been followed. This states that *'significance is a concept related to the weight that should be attached to effects when decisions are made… so that the decision maker is adequately informed of the environment consequences of permitting a project'*. CIEEM (2018) defines significance as follows: *'In broad terms, significant effects encompass impacts on the structure and function of defined sites, habitats or ecosystems and the conservation status of habitats and species (including extent, abundance and distribution). Significant effects should be qualified with reference to an appropriate geographic scale, for example a significant effect on a Site of Special Scientific Interest … is likely to be of national significance.'*

4.5.12 Where possible, assessment is based upon quantitative and accepted criteria and/or methods (for example, guidance from SNCBs on collision risk modelling (Band 2012), and displacement (SNCB 2017; updated 2022)), together with the use of value judgement and expert interpretation to establish to what extent an effect is significant.

CUMULATIVE EFFECTS

4.5.13 The impact assessment methodology applied in this Chapter is based on that described in Volume 6, Part 1, Chapter 3: EIA Methodology, adapted to make it applicable to ornithological features.

4.5.14 The methodology has also been aligned with the approach to the assessment of cumulative effects (see section 4.13) that has been applied by Ministers when consenting offshore windfarms and confirmed in recent consent decisions. It also follows the approach set out in guidance from Parker *et al.* (2022c) and considers guidance from the Planning Inspectorate (2019) and from the renewables industry (RenewableUK 2013).

4.6 UNCERTAINTY AND TECHNICAL DIFFICULTIES ENCOUNTERED

BASELINE DATA

4.6.1 The marine environment is highly variable, both spatially and temporally. The baseline site characterisation for this assessment is based on two years of survey data which are considered to be representative of the study area for the purpose of impact assessment. Given the project's location (beyond the foraging range of most breeding seabirds) and the results obtained from surveys conducted for other wind farm applications (e.g. Galloper, East Anglia ONE and TWO), the data are considered to be consistent with previous survey results.

4.6.2 Aerial surveys were conducted concurrently with post-construction monitoring of the adjacent Galloper OWF. Any impacts that the presence of the Galloper OWF may have on bird distribution and abundance within the study area is considered to represent part of the baseline conditions, because the Galloper OWF project would be operational at the same time as the VE project.

4.6.3 Although no project-specific surveys were undertaken within the majority of the offshore ECC route, sufficient data are considered to be available from other sources, in particular the most recent aerial surveys conducted in 2018 by Irwin *et al*. (2019), to determine species assemblage present and allow a robust assessment of associated impacts to occur. A precautionary approach has been taken in the assessment of impacts associated with the offshore ECC based on the available information.

REFERENCE POPULATIONS AND HIGHLY PATHOGENIC AVIAN INFLUENZA VIRUS

4.6.4 Reference populations for assessing effects on each species' population sizes have been based on the best available, and most appropriate, information at the time of undertaking the assessment (Table 4.3), and have been agreed with key stakeholders (Table 4.2).

4.6.5 Baseline surveys were undertaken prior to the widespread effects of highly pathogenic avian influenza virus (HPAIV) within seabird populations across the UK and western Europe since 2021. The current strain of HPAIV is more infectious than previous strains, and so infections have continued beyond the normal winter period and affected seabird breeding colonies in 2022 and 2023, including species which are not normally affected such as gannets, great skuas, terns, guillemots and black-headed gulls. The scale of mortality in has been unprecedented with significant losses of adult birds and even larger mortality of chicks reported (e.g., Natural England, 2022b).

4.6.6 With seabird species of conservation concern being affected, understanding the currently unknown long-term impacts of HPAIV and other existing pressures on seabirds will be important. Natural England has been commissioned by Defra to assess the vulnerability of seabird species in light of the pressures they are facing, and to propose recommendations to address them (also see Pearce-Higgins *et al.* 2023 for outcomes of a 2022 HPAIV workshop on future planning).

4.6.7 For the purposes of this assessment, all reference populations used have been estimated from data collected prior to the most widespread effects of HPAIV on seabirds in 2022-23, and therefore because the baseline aerial survey data were also collected prior to the outbreak, the predicted magnitudes of impacts on seabird populations should remain consistent with current populations (i.e. it is assumed that the proportion of the population affected by an impact will be similar before and after HPAIV impacts, with numbers of birds recorded within the study area declining proportionately with population sizes). It is also the case that the most comprehensive reference for breeding seabird populations (the national Seabird Monitoring Programme census, Burnell *et al.* 2023) gathered data in the years prior to the HPAIV outbreak on breeding seabirds in the UK. Consequently, no adjustments to account for assessment of impacts of HPAIV on populations are considered necessary for the assessment.

4.7 EXISTING ENVIRONMENT

4.7.1 This section summarises the baseline ornithological information from the desk-based assessment and the aerial surveys listed above and detailed in Volume 6, Part 5, Annexes 4.1 to 4.13.

THE ARRAY AREAS

4.7.2 Table 4.8 provides a summary of species that were recorded during baseline aerial surveys within the VE array areas plus a 4 km buffer. The presence of the species is noted in the North (N) and South (S) array areas.

4.7.3 The conservation status, including population trends in relation to climate change, of species recorded is also provided in Table 4.6. The locations of all species observed are plotted on figures in Volume 6, Part 5, Annex 4.9: Seabird Distributions in Aerial Survey.

4.7.4 Impacts are assessed in relation to relevant biological seasons, as defined by Furness (2015). For the non-breeding period, the seasons and relevant population sizes for Biologically Defined Minimum Population Scales (BDMPS) were taken from Furness (2015) (Table 4.9)

Table 4.8: Bird species recorded during baseline aerial surveys of the array areas and the 4km buffer between March 2019 and February 2021.

Species	Scientific name	Conservation status	Array areas	4km buffer
Red-throated diver	*Gavia stellata*	Outer Thames Estuary SPA species, Birds of Conservation Concern (BoCC) (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' status. 'High benefit'[2] breeding population vulnerability to climate change (Pearce-Higgins 2021)	N, S	N, S
Fulmar	*Fulmarus glacialis*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. 'High risk' breeding population vulnerability to climate change	N, S	N, S
Gannet	*Morus bassanus*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. 'Limited impact' breeding population vulnerability to climate change	N, S	N, S
Cormorant	*Phalacrocorax carbo*	BoCC Green listed, Birds Directive Migratory Species	S	S

[2] The vulnerability score of species' populations in relation to climate change is derived from various studies and modelling, as described in Pearce-Higgins *et al.* (2021). Levels range from high risks to high benefits.

Species	Scientific name	Conservation status	Array areas	4km buffer
		'High risk' breeding population vulnerability to climate change		
Arctic skua	*Stercorarius parasiticus*	BoCC Red listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. 'High risk' breeding population vulnerability to climate change	-	S
Great skua	*Stercorarius skua*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. Not assessed breeding population vulnerability to climate change	S	S
Puffin	*Fratercula arctica*	BoCC Red listed, Birds Directive Migratory Species 'High risk' breeding population vulnerability to climate change	-	N, S
Razorbill	*Alca torda*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Near Threatened' status. 'Medium risk' breeding population vulnerability to climate change	N, S	N, S
Guillemot	*Uria aalge*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status. 'Medium risk' breeding population vulnerability to climate change	N, S	N, S

Species	Scientific name	Conservation status	Array areas	4km buffer
Common tern	*Sterna hirundo*	Outer Thames Estuary SPA species, BoCC Amber listed, Birds Directive Annex I, Migratory Species, IUCN Red List 'Least Concern' status. 'High benefit' breeding population vulnerability to climate change	N	N, S
Sandwich tern	*Sterna sandvicensis*	BoCC Amber listed, Birds Directive Migratory Species 'Medium risk' breeding population vulnerability to climate change	S	N, S
Kittiwake	*Rissa tridactyla*	BoCC Red listed, Birds Directive Migratory Species, IUCN Red List 'Vulnerable' status. 'High risk' breeding population vulnerability to climate change	N, S	N, S
Black-headed gull	*Chroicocephalus ridibundus*	BoCC Amber listed, Birds Directive Migratory Species 'High benefit' breeding population vulnerability to climate change	S	N, S
Little gull	*Hydrocoloeus minutus*	BoCC Green listed, Birds Directive Migratory Species, IUCN Red List 'Near Threatened' status. 'Not assessed breeding population vulnerability to climate change	N	N, S
Common gull	*Larus canus*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List 'Least Concern' status.	N, S	N, S

Species	Scientific name	Conservation status	Array areas	4km buffer
		‘Medium benefit’ breeding population vulnerability to climate change		
Lesser black-backed gull	*Larus fuscus*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List ‘Least Concern’ status. ‘High benefit’ breeding population vulnerability to climate change	N, S	N, S
Herring gull	*Larus argentatus*	BoCC Red listed, Birds Directive Migratory Species, IUCN Red List ‘Near Threatened’ status. ‘High risk’ breeding population vulnerability to climate change	N, S	N, S
Great black-backed gull	*Larus marinus*	BoCC Amber listed, Birds Directive Migratory Species, IUCN Red List ‘Least Concern’ status ‘High risk’ breeding population vulnerability to climate change	N, S	N, S

Table 4.9: Species specific seasonal definitions and biologically defined minimum nonbreeding population sizes (in brackets) have been taken from Furness (2015).

Species	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
Red-throated diver	Mar-Aug	May-Aug	Sep-Nov (13,277)	Dec-Jan (10,177)	Feb-Apr (13,277)	-
Fulmar	Jan-Aug	Apr-Aug	Sep-Oct (957,502)	Nov (568,736)	Dec-Mar (957,502)	-
Gannet	Mar-Sep	Apr-Aug	Sep-Nov (456,298)	-	Dec-Mar (248,385)	-
Cormorant	Apr-Aug	May-Jul	-	-	-	Sep-Mar (10,460)
Arctic skua	May-Jul	Jun-Jul	Aug-Oct (6,427)	-	Apr-May (1,227)	-
Great skua	May-Aug	May-Jul	Aug-Oct (19,556)	Nov-Feb (143)	Mar-Apr (8,485)	-
Puffin	Apr-Aug	May-Jun	Jul-Aug	Sep-Feb	Mar-Apr	Mid-Aug-Mar (231,957)
Razorbill	Apr-Jul	Apr-Jul	Aug-Oct (591,874)	Nov-Dec (218,622)	Jan-Mar (591,874)	-
Guillemot	Mar-Jul	Mar-Jun	Jul-Oct	Nov	Dec-Feb	Aug-Feb (1,617,306)

Species	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
Common tern	May-Aug	Jun	Jul-Sep (308,841)	-	Apr-May (308,841)	-
Sandwich tern	Apr-Aug	Jun	Jul-Sep (38,051)	-	Mar-May (38,051)	Sep-Mar
Kittiwake	Mar-Aug	May-Jul	Aug-Dec (829,937)	-	Jan-Apr (627,816)	-
Black-headed gull	Not included in Furness 2015					
Common gull	Not included in Furness 2015					
Little gull (Not included in Furness 2015)	Apr-Jul	May-Jul	-	-	-	Aug-Apr
Lesser black-backed gull	Apr-Aug	May-Jul	Aug-Oct (209,007)	Nov-Feb (39,314)	Mar-Apr (197,483)	-
Herring gull	Mar-Aug	May-Jul	Aug-Nov	Dec	Jan-Apr	Sep-Feb (466,511)
Great black-backed gull	Mar-Aug	May-Jul	Aug-Nov	Dec	Jan-Apr	Sep-Mar (91,399)

4.7.5 In addition to BDMPS populations, the biogeographic populations and proportions of immatures in the population are also considered in the assessment where appropriate. These are provided in Table 4.10.

Table 4.10 Biogeographic population sizes and proportions of immatures taken from Furness (2015).

Species	Biogeographic population with connectivity to UK waters (adults and immatures)	Estimated immatures per breeding adult in population
Red-throated diver	27,000	0.74
Fulmar	8,055,000	0.62
Gannet	1,180,000	0.81
Cormorant	324,000	1.17
Arctic skua	229,000	0.71
Great skua	73,000	1.42
Puffin	11,840,000	1.04
Razorbill	1,707,000	0.75
Guillemot	4,125,000	0.74
Common tern	248,000	0.67
Sandwich tern	148,000	0.63
Kittiwake	5,100,000	0.88
Black-headed gull	Not in Furness (2015)	-
Common gull	Not in Furness (2015)	-
Great black-backed gull	235,000	1.26
Herring gull	1,098,000	1.09
Lesser black-backed gull	864,000	0.68
Little gull (not included in Furness 2015)	75,000*	-

* Estimated passage population (Steinen *et al*., 2007)

4.7.6 The effect of additional mortality due to wind farm impacts is assessed in terms of the change in the baseline mortality rate which could result. It has been assumed that all age classes are equally at risk of effects, with each age class affected in proportion to its presence in the population. Therefore, a weighted average baseline mortality rate has been calculated which is appropriate for all age classes for use in assessments, calculated for those species screened in for assessment. These were calculated using the different rates for each age class and their relative proportions in the population.

4.7.7 Demographic rates for each species were taken from Horswill and Robinson (2015) and entered into a matrix population model. This was used to calculate the expected stable proportions in each age class (note, to obtain robust stable age class distributions for less well studied species such as divers it was necessary to adjust the rates in order to obtain a stable population size). Each age class survival rate was multiplied by its stable age proportion and the total for all ages summed to give the weighted average survival rate for all ages. Subtracting this value from 1 gives the average mortality rate. The demographic rates and the age class proportions, and average mortality rates calculated from them are presented in Table 4.11.

Table 4.11 Average mortality across all age classes. Average mortality calculated using age specific demographic rates (DR) and population age ratios (PAR).

Species	Para-meter	Survival (age class)						Productivity	Average mortality
		0-1	1-2	2-3	3-4	4-5	Adult		
Red-throated diver	DR	0.6	0.62	-	-	-	0.84	0.571	0.228
	PAR	0.179	0.145	-	-	-	0.676	-	
Gannet	DR	0.424	0.829	0.891	0.895	-	0.912	0.7	0.191
	PAR	0.191	0.081	0.067	0.06	-	0.6	-	
Common tern[1]	DR	0.441	0.441	0.85	-	-	0.883	0.764	0.263
	PAR	0.223	0.103	0.048	-	-	0.626	-	
Kittiwake	DR	0.79	0.854	0.854	0.854	-	0.854	0.69	0.156
	PAR	0.155	0.123	0.105	0.089	-	0.53	-	
Lesser black-backed gull	DR	0.82	0.885	0.885	0.885	-	0.885	0.53	0.124
	PAR	0.134	0.109	0.095	0.083	-	0.579	-	
Herring gull	DR	0.798	0.834	0.834	0.834	-	0.834	0.92	0.172
	PAR	0.178	0.141	0.117	0.097	-	0.467		
Great black-backed gull	DR	0.815	0.815	0.815	0.815	-	0.885	0.53	0.144
	PAR	0.137	0.112	0.093	0.076	-	0.581	-	
Guillemot	DR	0.56	0.792	0.917	0.939	0.939	0.939	0.672	0.14
	PAR	0.168	0.091	0.069	0.062	0.056	0.552	-	
Razorbill[2]	DR	0.63	0.63	0.895	0.895	-	0.895	0.57	0.174

Species	Para-meter	Survival (age class) 0-1	1-2	2-3	3-4	4-5	Adult	Productivity	Average mortality
	PAR	0.159	0.102	0.065	0.059	-	0.613	-	
Puffin[3]	DR	0.709	0.709	0.76	0.805	-	0.906	0.617	0.167
	PAR	0.162	0.115	0.082	0.063	-	0.577	-	

1 – Common tern has a combined survival rate from 0 – 2 of 0.441, giving an annual rate of 0. 66.

2 – Razorbill has a combined survival rate from 0 – 2 of 0.63, giving an annual rate of 0.79.

3 – Puffin has a combined survival rate from 0 – 3 of 0.709, giving an annual rate of 0.89

4.7.8 The bird abundance estimates and how they were derived are presented in detail in Volume 6, Part 5, Annexes: 4.1 to 4.7. Detail from this report has not been repeated in this chapter to minimise unnecessary repetition. Bird abundances and assemblages have been estimated from the VE site-specific surveys.

4.7.9 The mean peak counts within species-specific seasons (as defined in Table 4.9) recorded within the array areas are provided in Table 4.12. The mean peak in any given season was calculated as follows: (i) the population density and abundance for each survey was calculated using design-based estimation methods, with 95% confidence intervals calculated using non-parametric bootstrapping (see Volume 6, Part 5, Annex 4.1: Offshore Ornithology Technical Report for further details); (ii) the abundance for each calendar month was calculated as the mean of estimates for each month (e.g. mean of two values); (iii) the seasonal mean peak was taken as the highest from within the months falling in each season. In some cases, the peak was recorded in a month which is included in overlapping seasons and therefore the same value has been identified in both seasons.

4.7.10 For the non-breeding period, the reference populations used for the impact assessment are the relevant BDMPS taken from Furness (2015). These reference populations are included in parentheses in Table 4.9.

4.7.11 For the breeding period, the potential for connectivity to known breeding populations has been considered. However, it should be noted that bird abundance was low for most species during the breeding season, with many species absent in one or more of the summer months (Table 4.12). This suggests that very few breeding birds utilise the VE array areas. The seasonal definitions in Furness (2015) include overlapping months in some instances due to variation in the timing of migration for birds which breed at different latitudes (i.e., individuals from breeding sites in the north of the species' range may still be on spring migration when individuals farther south have already commenced breeding).

Table 4.12 Mean Peak Counts (and 95% Confidence Intervals) by Biological Season for Bird Species within the North and South Array Areas Recorded during Baseline Surveys.

Species	Biological Season									
	Spring migration		Breeding (full)		Autumn migration		Winter		Non-breeding	
	North	South	North	South	North	South	North	South	North	South
Red-throated diver	0 (0-0)	3.37 (0-10.1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	3.38 (0-10.13)	0 (0-0)	0 (0-0)	0 (0-0)
Fulmar	0 (0-0)	0 (0-0)	21.06 (0-56.24)	24.28 (94-41.63)	0 (0-0)	3.54 (0-7.08)	0 (0-0)	0 (0-0)	0 (0-0)	3.54 (0-7.08)
Gannet	20.21 (0-53.9)	10.07 (0-26.85)	49.25 (7.06-98.35)	84.98 (0-233.71)	142.46 (24.48-281.54)	140.81 (45.76-249.99)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Cormorant	-	0 (0-0)	-	0 (0-0)	-	21.25 (0-42.51)	-	0 (0-0)	-	21.25 (0-42.51)
Arctic skua	0 (0-0)	-	0 (0-0)	-	0 (0-0)	-	0 (0-0)	-	0 (0-0)	-
Great skua	-	0 (0-0)	-	3.5 (0-10.5)	-	0 (0-0)	-	0 (0-0)	-	0 (0-0)
Puffin[1]	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 (0-0)	0 (0-0)
Razorbill[1]	198.77 (47.79-358.9)	161.37 (46.82-288.68)	14.03 (0-28.06)	13.79 (0-41.36)	71.34 (0-150.32)	16.85 (0-37.9)	290.21 (13.53-562.37)	121.06 (8.99-260.11)	290.21 (13.53-562.37)	180.62 (43.35-353.38)

Species	Biological Season									
Guillemot[1]	312.37 (39.75-629.74)	1412.67 (632.77-2184.57)	326.41 (95.81-571.63)	192.25 (57.88-350.33)	73.98 (8.7-147.96)	35.04 (0.01-65.08)	118.87 (30.61-213.12)	214.99 (52.53-403.84)	312.37 (39.75-629.74)	1412.67 (632.77-2184.57)
Common tern	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	3.52 (0-7.04)	0 (0-0)	0 (0-0)	0 (0-0)	3.52 (0-7.04)	0 (0-0)
Sandwich tern	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	3.5 (0-10.51)	0 (0-0)	3.5 (0-10.51)
Kittiwake	40.3 (0-90.76)	43.54 (13.38-77.03)	105.39 (28.02-196.72)	103.17 (31.11-182.18)	31.07 (0-65.51)	57.41 (16.89-104.68)	0 (0-0)	0 (0-0)	40.3 (0-90.76)	57.41 (6.89-104.68)
Black-headed gull	0 (0-0)	0 (0-0)	0 (0-0)	6.74 (0-13.48)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	3.53 (0-10.6)
Little gull	0 (0-0)	0 (0-0)	7.01 (0-14.2)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Common gull	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	3.37 (0-10.11)	10.07 (0-20.14)
Lesser black-backed gull	0 (0-0)	3.36 (0-10.07)	477.31 (0-1291.56)	111.82 (0-258.5)	10.4 (0-24.16)	10.63 (0-24.8)	3.38 (0-10.13)	6.75 (0-20.24)	10.4 (0-24.16)	10.63 (0-24.8)
Herring gull	0 (0-0)	0 (0-0)	38.47 (0-94.36)	7 (0-20.99)	3.36 (0-10.09)	3.5 (0-10.51)	6.74 (0-16.84)	0 (0-0)	6.74 (0-16.84)	3.5 (0-10.51)

Species	Biological Season									
Great black-backed gull	3.38 (0-10.13)	6.81 (0-20.43)	3.51 (0-10.54)	0 (0-0)	3.51 (0-10.53)	10.63 (0-31.88)	16.87 (0-40.51)	0 (0-0)	16.87 (0-40.51)	10.63 (0-31.88)
[1]. Including unidentified auks apportioned using identified auk ratios and accounting for availability bias										

THE OFFSHORE EXPORT CABLE CORRIDOR

4.7.12 For the offshore ECC, no site-specific ornithology surveys were carried out. The assessment for this component of the development has therefore been conducted with reference to the most recent report on aerial surveys of the Outer Thames Estuary SPA in 2018 commissioned by Natural England (Irwin *et al*. 2019). Although the primary focus of this study was to record red-throated diver distribution and abundance, a secondary objective was to generate population estimates for, and an understanding of the distribution of, all other species of birds encountered.

4.7.13 Although the offshore ECC only overlaps with the SPA for 16 km, or 17 % of the whole offshore ECC length (see Volume 6, Part 5, Annex 4.9: Seabird Distributions Recorded in Aerial Surveys, Figure 2.4.1), the Irwin *et al.* (2019) survey area was coincidental with the extent of the SPA component parts, and therefore some of the offshore ECC either overlapped or was directly adjacent to the 'southern' SPA area and relatively close to the 'northern (large)' SPA area.

4.7.14 Red-throated divers were the most abundant species, with a peak SPA estimate of 22,280 individuals (peak in the southern area was 16,002 individuals, and in northern (large) area was 4,587 individuals) (Table 4.13). Large numbers of gulls were also present, with peak counts of over 1,000 individuals for common gull, herring gull, black-headed gull and great black-backed gull, and over 700 kittiwake individuals.

4.7.15 Common scoters were frequently recorded, with a peak of over 500 individuals in each SPA area, and a peak count of over 1,000 cormorants was estimated. Great crested grebes were frequent, but distribution maps showed that the species favoured the southern Kent coastal area, well away from the VE project area.

4.7.16 Records of pelagic seabirds were relatively low, with auks uncommon. Gannets were only recorded in the second survey with records typically away from the coast and with a strong bias to the most offshore part of the southern zone.

4.7.17 Based on the abundance and distribution of species recorded during the surveys, the only species, in addition to those recorded during the project-specific aerial surveys, considered necessary to be screened in for assessment of impacts related to the offshore ECC, is common scoter.

Table 4.13 Peak population estimates for species within the Outer Thames SPA in February 2018 (from Irwin et al. 2019).

Species	Peak population estimate (individuals)	
	Southern SPA area	**Northern (large) SPA area**
Red-throated diver	16,002	4,587
Common scoter	513	509
Surf scoter	7	0
Red-breasted merganser	20	0
Fulmar	0	41

Species	Peak population estimate (individuals)	
Gannet	429	10
Cormorant	1,140	257
Great crested grebe	839	103
Kittiwake	718	82
Little gull	7	0
Black-headed gull	2,083	41
Mediterranean gull	14	11
Common gull	3,239	511
Lesser black-backed gull	271	93
Herring gull	1,047	931
Great black-backed gull	1,070	329
Guillemot	53	288
Razorbill	60	21

DESIGNATED SITES

4.7.18 The impact assessment considers potential connectivity of the VE array areas and offshore ECC with sites with statutory designation for nature conservation, which have birds listed as qualifying features. Four classes of statutory designated sites are considered: SPAs, Ramsar sites and SSSIs.

4.7.19 Sites which may have connectivity to the VE array areas and/or offshore ECC include those designated for breeding seabirds and those for terrestrial, coastal or marine bird interests (typically overwintering aggregations).

4.7.20 The Outer Thames Estuary SPA overlaps 16 km (17 %) of the offshore ECC (Volume 6, Part 5, Annex 4.9: Seabird Distributions Recorded in Aerial Surveys, Figure 2.4.1). The array areas do not directly overlap with any ornithological designations, however, as breeding seabirds can travel considerable distances it is necessary to give consideration to designated sites beyond the array area boundaries.

4.7.21 The extent of connectivity between seabird colonies and offshore wind farms during the breeding season is largely a function of distance and species-specific foraging ranges. Outside the breeding season, patterns of migration are used to infer the origins of species recorded. Coastal sites designated for migrant species outside the breeding season may therefore be connected on the grounds of passage movements through the array areas.

4.7.22 Full consideration of connectivity of European Sites (SPAs and Ramsar sites) is provided in the Volume 5, Report 4: RIAA. This covers in more detail matters associated with European designations and has been subject to consultation with Natural England and RSPB as part of the DCO application process. The RIAA identified six designated sites (SPAs and Ramsar sites) requiring further consideration in relation to potential effects. All remaining sites were not considered to be within range or to have a pathway for a potential effect in relation to the proposed VE project.

4.7.23 Although the HRA process is separate from the EIA, the screening carried out is also considered to be appropriate in terms of identifying potential connectivity for the ornithological impact assessment, so the same six sites (with one or more SSSI components) are identified in Table 4.14.

Table 4.14 Designated Sites for Birds with Potential Connectivity to the Proposed VE Project.

Site	Distance to array areas	Distance to offshore ECC	Ornithological features with potential connectivity to VE project
Outer Thames Estuary SPA	17.11	0.00	Red-throated diver Common tern Little tern
Alde-Ore Estuary SPA, Ramsar site and SSSI	37.31	12.21	Lesser black-backed gull Sandwich tern Little tern
Minsmere-Walberswick SPA, Ramsar site and SSSIs	41.75	37.00	Little tern
Hamford Water SPA and SSSIs	51.04	3.12	Little tern
Thanet Coast and Sandwich Bay SPA and SSSIs	57.64	46.10	Little tern
Flamborough and Filey Coast SPA and SSSIs	275.50	264.64	Kittiwake Gannet

4.7.24 Where a species that is a qualifying feature of one or more of the designated sites listed in Table 4.14 is screened in for assessment in relation to a potential impact, the potential for connectivity with that site is considered in the assessment.

4.7.25 The assessment of likely significant effects and, where this is the case, an appropriate assessment of the interest features of the internationally designated sites (SPAs and Ramsar sites) is carried out through the HRA process and this is reported separately in the Volume 5, Report 4: RIAA.

EVOLUTION OF THE BASELINE

SEABIRD POPULATION TRENDS

4.7.26 Trends in breeding populations of seabird species are better known, and better understood than trends in numbers at sea within particular areas. Breeding numbers are regularly monitored at many colonies, and in the British Isles there have been three comprehensive censuses of breeding seabirds in 1969-70, 1985-88, 1998-2002 (Mitchell *et al*. 2004), and 2015-2021 (Burnell *et al.* 2023) as well as single-species surveys (such as the decadal counts of breeding gannet numbers, Murray *et al*. 2015). In contrast, the European Seabirds at Sea (ESAS) database is incomplete, and few data have been added since 2000, so that current trends in numbers at sea in areas of the North Sea are not so easy to assess.

4.7.27 Results of the most recent seabird census (Burnell *et al.* 2023) have shown that 11 of the 21 seabird species, where there is sufficient confidence in trends, have declined by over 10% since the previous census in 1998-2002 (Mitchell *et al*. 2004). This includes kittiwake and great black-backed gull. The breeding populations of five species (including gannet and razorbill) have increased by over 10% and a further five (including guillemot) have remained stable. These trends in British seabird populations seem likely to continue in the short to medium term future, although for some species such as gannet, which has notably been susceptible to the effects of HPAIV (e.g., Pearce-Higgins *et al.* 2023), the long-term impact on the population trend is currently unclear, albeit there is some preliminary evidence that gannets revealed specific immunity showing exposure and recovery in a proportion of birds (Lane *et al.* 2024).

DRIVERS OF CHANGE

4.7.28 Burnell *et al.* (2023) identified that the main drivers for declining seabird populations in the UK are predation by native and invasive predators and climate change. Adverse weather conditions potentially associated with climate change affect nesting and foraging, and increased water temperatures reduce the availability of sandeels and other prey species. These impacts are exacerbated by fish stock depletion by commercial fisheries, resulting in depleted food resources during the breeding season.

4.7.29 A review for NatureScot (Furness *et al.* in prep.) has also identified strong evidence that climate change, mammal predators (especially introduced alien mammal species), and depletion of forage fish stocks by industrial fisheries are the major pressures on many seabird species breeding in Scotland. There are also many other smaller pressures affecting particular species of seabirds which may contribute to baseline conditions changing in the North Sea.

4.7.30 In individual studies, key drivers of seabird population size in western Europe have been identified as climate change (Sandvik *et al*. 2012; Frederiksen *et al*. 2004, 2013; Burthe *et al*. 2014; Macdonald *et al*. 2015; Furness 2016; JNCC 2016; Pearce-Higgins 2021), and fisheries (Tasker *et al*. 2000; Frederiksen *et al*. 2004; Ratcliffe 2004; Carroll *et al*. 2017; Sydeman *et al*. 2017). Pollutants (including oil, persistent organic pollutants, plastics), alien mammal predators at colonies, disease, and loss of nesting habitat also impact on seabird populations but are generally much less important and often more local factors (Ratcliffe 2004; Votier *et al*. 2005, 2008; JNCC 2016). Since 2021 HPAIV has adversely affected survival and productivity within seabird colonies across the UK, and investigations are underway to determine the long-term effects on species' populations, combined with the other pressures (see e.g., Pearce-Higgins *et al.* 2023).

4.7.31 Pearce-Higgins (2021) assessed the impact that climate change has already had on UK bird populations by relating their long-term trends to separately published species' responses to climate change, temperature and rainfall. It was found that of the 20 seabird species found in the UK, 14 are regarded as being at high or medium risk of negative climate change impacts. Documented declines in sandeel populations have led to reduced breeding success in seabirds, and at least partially underpin long-term population declines (Johnston *et al*. 2021).

4.7.32 Prior to the Seabirds Count 2015-21 results being published, there was already good evidence that kittiwake, Arctic skua, puffin and fulmar are being affected by climate processes (Frederiksen *et al*. 2004, Burthe *et al*. 2014, Cook *et al*. 2014, Perkins *et al*. 2018).

4.7.33 Fisheries management is also likely to influence future numbers in seabird populations. The Common Fisheries Policy (CFP) Landings Obligation ('discard ban') will further reduce food supply for scavenging seabirds such as great black-backed gulls, lesser black-backed gulls, herring gulls, fulmars, kittiwakes and gannets (Votier *et al*. 2004; Bicknell *et al*. 2013; Votier *et al*. 2013; Foster *et al*. 2017). Recent changes in fisheries management that aid recovery of predatory fish stock biomass are likely to further reduce food supply for seabirds that feed primarily on small fish such as sandeels, as those small fish are major prey of large predatory fish (see Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology for further information on these prey species).

4.7.34 Therefore, anticipated future increases in predatory fish abundance resulting from improved management to constrain fishing mortality on those commercially important species at more sustainable levels than in the past are likely to cause further declines in stocks of small pelagic seabird ‘food-fish’ such as sandeels (Frederiksen *et al*. 2007; Macdonald *et al*. 2015). Lindegren *et al*. (2018) concluded that sandeel stocks in the North Sea, the most important prey fish stock for North Sea seabirds during the breeding season (Furness and Tasker 2000), have been depleted by high levels of fishing effort. These stocks are unlikely to recover fully even if fishing effort was reduced, because climate change has altered the North Sea food web to the detriment of productivity of fish populations. (e.g. Dulvy *et al.* 2008; Hiddink *et al.* 2015) As a result, seabird populations are likely to continue to experience food shortages in the North Sea, especially for those species most dependent on sandeels as food.

SPECIES THREATS

4.7.35 Future decreases in **kittiwake** breeding numbers are likely to be particularly pronounced, as kittiwakes are very sensitive to climate change (Frederiksen *et al*. 2013; Carroll *et al*. 2015) and to fishery impacts on sandeel stocks near breeding colonies (Frederiksen *et al*. 2004; Carroll *et al*. 2017), and the species will lose the opportunity to feed on fishery discards as the Landings Obligation comes into effect.

4.7.36 **Gannet** numbers may continue to increase for some years, but evidence suggests that this increase is already slowing (Murray *et al*. 2015), which may be exacerbated by HPAIV impacts, and numbers may peak not too far into the future. While the Landings Obligation will reduce discard availability to gannets in European waters, in recent years increasing proportions of adult gannets have wintered in west African waters rather than in UK waters (Kubetzki *et al*. 2009), probably because there are large amounts of fish discarded by west African trawl fisheries and decreasing amounts available in the North Sea (Kubetzki *et al*. 2009; Garthe *et al*. 2012). The flexible behaviour and diet of gannets probably reduces their vulnerability to changes in fishery practices or to climate change impacts on fish communities (Garthe *et al*. 2012).

4.7.37 **Fulmars, terns, common guillemot, razorbill** and **puffin** appear to be highly vulnerable to climate change, so numbers may decline over the next few decades (Burthe *et al*. 2014). Strong declines in **shag** numbers are likely to continue as they are adversely affected by climate change, by low abundance of sandeels and especially by stormy and wet weather conditions in winter (Burthe *et al*. 2014; Frederiksen *et al*. 2008).

4.7.38 Most of the **red-throated divers** and **common scoters** wintering in the southern North Sea originate from breeding areas at high latitudes in Scandinavia and Russia. Numbers of red-throated divers and common scoters wintering in the southern North Sea may possibly decrease in future if warming conditions make the Baltic Sea more favourable as a wintering area for those species so that they do not need to migrate as far as UK waters. There has been a trend of increasing numbers of sea ducks remaining in the Baltic Sea overwinter (Mendel *et al*. 2008; Fox *et al*. 2016; Ost *et al*. 2016) and decreasing numbers coming to the UK (Austin and Rehfisch 2005; Pearce-Higgins and Holt 2013), and that trend is likely to continue, although to an uncertain extent.

4.7.39 ESAS data indicate that there has already been a long-term decrease in numbers of **great black-backed gulls** wintering in the southern North Sea (S. Garthe *et al*. in prep.), and the Landings Obligation will probably result in further decreases in numbers of north Norwegian great black-backed gulls and **herring gulls** coming to the southern North Sea in winter. It is likely that further redistribution of breeding herring gulls and **lesser black-backed gulls** will occur into urban environments (Rock and Vaughan 2013), although it is unclear how the balance between terrestrial and marine feeding by these gulls may alter over coming years; that may depend greatly on the consequences of Brexit for UK fisheries and farming.

4.7.40 Some of the human impacts on seabirds are amenable to effective mitigation (Ratcliffe *et al*. 2009; Brooke *et al*. 2018), but the scale of efforts to reduce these impacts on seabird populations has been small by comparison with the major influences of climate change and fisheries. This is likely to continue to be the case in future, and the conclusion must be that with the probable exception of gannet, numbers of almost all other seabird species in the UK North Sea region will most likely be on a downward trend over the next few decades, due to population declines, redistributions or a combination of both.

ASSESSMENT CONTEXT

4.7.41 For offshore ornithology, the ecological impact assessment is therefore carried out within the general context determined by Burnell *et al.* (2023) of declining baseline populations for the majority of seabird species. Where a species is declining, the assessment takes into account whether a given impact is likely to exacerbate a decline in the relevant reference population and prevent a species from recovery should environmental conditions become more favourable.

4.7.42 Climate change has been identified as one of the strongest influences on future seabird population trends. In this context it is noted that a key component of global strategies to reduce climate change is the development of low-carbon renewable energy developments such as offshore windfarms (see Volume 6, Part 4, Chapter 1: Climate Change).

4.8 KEY PARAMETERS FOR ASSESSMENT

4.8.1 The following section identifies the Maximum Design Scenario (MDS) in environmental terms, defined by the project design envelope. This is to establish the maximum potential impact associated with the project on offshore ornithology. It considers the impacts scoped into the assessment during the scoping phase and as a result of consultation with stakeholders during the evidence plan process (Table 4.2).

4.8.2 The key offshore elements of VE will be as follows:

- Up to 79 offshore WTGs and associated foundations;
- Up to 200 km of inter-array cables;
- Up to 2 offshore substation platforms (OSPs); and
- Up to 196 km of offshore export cables, each in its own trench within the overall cable corridor.

4.8.3 For the purposes of defining the MDS two indicative WTG scenarios are considered in Volume 6, Part 2, Chapter 1: Offshore Project Description:

- Large WTGs – The largest WTGs within the design envelope. For the purposes of assessment this is assumed to be up to 41 of the largest possible WTGs with a Rotor Diameter (RD) of up to 360 m; and
- Small WTGs – The greatest number of WTGs within the design envelope. For the purposes of this assessment is assumed to be up to 79 smaller WTGs with a RD of up to 260 m.

4.8.4 For each impact it is considered that the Small WTGs MDS is the worst-case scenario for the array areas, and justification is provided in Table 4.15.

4.8.5 In relation to the construction and operation of the offshore ECC, there is a single MDS which is outlined in Volume 6, Part 2, Chapter 1: Offshore Project Description, which is assumed to be implemented for the purposes of this assessment (see Table 4.15).

Table 4.15: Maximum design scenario for the project alone.

Potential effect	Maximum design scenario assessed	Justification
Construction		
Impact 1: Direct disturbance and displacement	**<u>Array Areas:</u>** > Small WTGs: > 79 monopile WTGs with foundation of 13m x 15m, RD of 260 m, minimum blade tip height of 28 m above MHWS and maximum blade tip height of 320 m above MHWS. > Large WTGs: > 41 monopile WTGs with foundation of 15m x 15m, RD of 360 m, minimum blade tip height of 28 m above MHWS and maximum blade tip height of 395 m above MHWS. > 2 monopile OSPs 125 m x 100 m > Total length of array cables = 200 km > Minimum spacing of WTGs = 830 m > Aviation lighting = up to 2000 cd on WTGs **<u>Offshore ECC:</u>** > Number of export cable circuits = 2, with minimum 5 m and nominal 200 m spacing; > Total length of export cables = 196 km; > Indicative width of seabed affected by installation per cable = 18 m; > Total area of seabed disturbed by cable installation = 3.52 km^2.	With more WTGs to be constructed under the Small WTGs scenario, the area subject to construction disturbance, and the overall duration of disturbance is likely to be greater.

Potential effect	Maximum design scenario assessed	Justification
	Vessels: > Indicative peak numbers of construction vessels: ▪ Foundations = 38; ▪ WTGs = 10; ▪ Inter-array cables = 12; ▪ Offshore ECC = 12; ▪ Other installation vessels = 24; > Max total vessels offshore (combination of peaks) = 96; > Indicative peak total vessels offshore = 35. > Indicative max number of vessel round trips: ▪ Array areas (WTGs, foundations, substations) = 69 peak, 1,734 round trips; ▪ Offshore ECC = 12 peak, 278 round trips; ▪ Other vessels = 15 peak, 2,300 round trips; ▪ Total = 96 peak, 4,311 round trips. > Up to 530 round trips, by up to two helicopters. **Construction Programme:** > Programme to occur over five-year period; > Onshore preliminary works anticipated to commence 2027. Main offshore construction works are anticipated to commence in 2029, with some preliminary survey and clearance works potentially	

Potential effect	Maximum design scenario assessed	Justification
	taking place in 2028 and 2027. The windfarm is anticipated to be operational in 2030. > Indicative duration of works: ▪ Offshore preconstruction works (survey/clearance etc) = 27 months from Year 1; ▪ Offshore substation installation and commissioning = 12 months from Year 3; ▪ Offshore ECC installation = 9 months from Year 3; ▪ Foundation installation = 12 months from Year 3; ▪ Array cable installation = 9 months from Year 3; ▪ WTG installation = 12 months from Year 4; ▪ WTG and foundation commissioning/ snagging = 30 months from Year 3. > 24-hour offshore working will be required, with illumination required on construction vessels during night-time and low light conditions. **Piling:** > Number of monopiles = 81. > Maximum duration of piling per day = 15 hrs monopile, 24 hrs pin pile; > Total duration per monopile = 7.5hrs max, 3.0hrs average; > Number of simultaneous monopile piling events = 2; > Number of monopiles to be installed in 1 day (assuming 2 piling vessels) = 1 indicative, 4 worst case highest value.	

Potential effect	Maximum design scenario assessed	Justification
Impact 2: Indirect impacts through effects on habitats and prey species	<u>**Noise Impacts:**</u> ***Array Areas*** **Spatial MDS (for stationary prey species):** The sequential installation of piling four pin piles at the same WTG location in 24 hours 79 jacket foundations (3.5 m pin pile diameter) 2 OSP jacket foundations (3.5 m pin pile diameter) Maximum hammer energy 3,000kJ **Spatial MDS (for fleeing prey species)** Piling of one monopile in a 24 hour period 79 monopiles (15 m monopile diameter) 2 OSP monopile foundations (15 m diameter) Maximum hammer energy of 7,000 kJ 7.5 hour piling duration per pile 592.5 hours of piling. **Temporal MDS (for stationary and fleeing prey species):** The sequential installation of piling four pin piles at the same WTG location in 24 hours Total 340 pin piles > 79 small WTGs on piled jacket foundations (four 3.5 m diameter pin piles per jacket) –316 pin piles	For the array area, the spatial MDS for stationary prey species results from the sequential piling of pin piles for 79 WTGs, and two OSPs using 3,000 kJ hammer energy (a total of 340 pin piles). This would result in the largest spatial noise impact at any given time when considering impacts to stationary receptors. The spatial MDS for fleeing prey species results from the piling of monopiles for 79 WTGs and 2 OSPs, using 7,000 KJ hammer energy. This would result in the largest spatial noise impact at any given time when considering impacts to fleeing receptors. The temporal MDS for the array area would be associated with the sequential piling of pin piles for 79 WTGs, and two OSPs using 3,000 kJ hammer energy. Total of 1,360 hours of piling across the whole project within a one-year construction window.

Potential effect	Maximum design scenario assessed	Justification
	> Two Offshore Substation Platform (OSP) foundations (six 3.5 m diameter pin piles per jacket) –24 pin piles Maximum hammer energy of 3,000 kJ Four hours piling duration per pile 1,360 hours of piling ***Offshore ECC*** Piling of sheet pile exit pits: Installation of 660 sheet piles using percussive drilling in the shallow subtidal 750 mm wide sheets Piling of eight piles within a 24 hour period Maximum hammer energy of 300 kJ **Suspended Sediment Impacts:** **Total sediment volume released on Order Limits = 39,846,167 m^3** ***Array areas*** **Total sediment volume suspended in array areas = 29,339,094 m^3** Seabed preparation for foundations = 949,467 m^3 79 small GBS (WTG) foundations = 893,467 m^3; 2 GBS foundations for OSP = 56,000 m^3	The MDS for foundation installation results from the largest volume suspended from seabed preparation and presents the worst-case for WTG installation. For cable installation, the MDS results from the greatest volume from sandwave clearance and installation. This also

Potential effect	Maximum design scenario assessed	Justification
	Drill arisings from foundation installation = 563,223 m^3 79 small steel monopile WTG foundations = 536,080 m^3 (assumes 50% of locations are drilled) 2 OSP monopile foundations = 27,143 m^3 Cable trenching = 3,150,000 m^3 Installation of 200 km of inter-array cables by mass flow excavator (MFE) resulting in the suspension of 3,150,000 m^3 of sediment Sandwave clearance for cable installation= 22,795,580 m^3 Sandwave clearance for 150 km of array cables resulting in the suspension of 22,795,580 m^3 of sediment JUV and anchoring operations = 1,880,824 m^3 JUV disturbance volumes for WTG and OSP installation in the array = 7,985,985 m^3 Anchor disturbance volumes WTG and OSP installation in array area = 1,508,542 m^3 Anchor disturbance volumes for array cables= 372,282 m^3 ***Offshore ECC*** **Total sediment volume suspended in offshore ECC = 10,507,073 m^3** Sandwave clearance for cable installation = 6,988,922 m^3 Sandwave clearance for 98 km of export cables resulting in the suspension of 6,988,922 m^3 of sediment. Seabed preparation for export cable vessel laydown areas = 57,600 m^3	assumes the largest number of cables and the greatest burial depth. The MDS for foundation installation results from the largest volume suspended from seabed preparation and presents the worst-case for WTG installation. For cable installation, the MDS results from the greatest volume from sandwave clearance and installation. This also assumes the largest number of cables and the greatest burial depth. The MDS for temporary habitat disturbance in the intertidal area from the HDD works is included. The maximum volume of bentonite which could be released as part of the landfall activities is considered. For this assessment, it is considered that the bentonite would not be captured and is released into the marine environment.

Potential effect	Maximum design scenario assessed	Justification
	Seabed preparation for 8 vessel laydown areas resulting in suspension of 57,600 m^3 of sediment. Cable trenching = 3,079,125 m^3 Installation of 370 km of export cables by mass flow excavator resulting in the suspension of 3,079,125 m^3 of sediment. JUV and anchoring operations = 363,906 m^3 Anchor disturbance volumes in ECC (ECC installation)= 363,906 m^3 **Intertidal sediment volume = 17,520 m^3** Three offshore HDD exit pits require excavation which will be side-cast onto the adjacent seabed. Backfilling of exit pits will recover a similar amount from the surrounding seabed, as required. It has not been confirmed whether exit pits will occur in the subtidal or intertidal. Maximum volume of drilling fluid that is expected to be released from the HDD into the intertidal/subtidal = 14,820 m^3 > Indicative maximum volume of cuttings expected to be released from the HDD into the intertidal / subtidal = 2,700 m^3 **<u>Accidental Pollution Events:</u>** Synthetic compound, heavy metal and hydrocarbon contamination resulting from offshore infrastructure installation and a maximum of 5,110 round trips to port by construction vessels over the construction period. Water-based drilling muds associated with drilling to install foundations, should this be required.	These parameters are considered to represent the likely maximum design scenario with regards to vessel movements during construction.

Potential effect	Maximum design scenario assessed	Justification
	Potential contamination of intertidal habitats resulting from machinery use and vehicle movement. Potential contamination of intertidal habitats from drilling mud (e.g. bentonite) used to facilitate the installation of export cables via trenchless installation techniques (e.g. horizontal directional drilling (HDD), thrust boring, auger boring or pipe ramming).	
Operation		
Impact 3: Direct disturbance and displacement	**Array Areas and Offshore ECC specifications as per Impact 1.** Project lifespan = 24 to 40 years Indicative max lifetime number of major component replacement events for WTG's and platforms (jacking-up activities) = 284 Indicative number of offshore export cable subsea repairs – actual whole project lifetime = 9 Indicative peak vessels on-site simultaneously = 27, with 1,776 round trips annually Up to 125 helicopter return trips per year	A larger number of WTGs under the Small WTG scenario is likely to result in a larger area of habitat to be effectively lost as a result of displacement responses. More WTGs will require more vessel and helicopter activity for maintenance reasons.
Impact 4: Indirect impacts through effects on habitats and prey species	**Total Habitat change** > Max footprint for all WTG foundations = 13,960 m^2 > Max footprint of all OSPs = 353 m^2	A larger number of WTGs under Small WTG scenario is likely to affect a larger extent of habitat, as well as increased displacement of prey species. A larger number of

Potential effect	Maximum design scenario assessed	Justification
	> Max scour protection volume for project (rock) including WTG, OSP and Met mast = 2,257,300m^3 > Maximum area of seabed disturbed by up to 200 km of array cable installation = 3,600,000m^2 > Maximum area of seabed disturbed by up to 196 km Offshore ECC installation = 3,520,000m^2 **Operational disturbance to seabed** > Indicative max seabed disturbance per year from jacking-up activities = 12,496 m^2 > Total seabed area disturbed by array cable replacement through life = 276,656 m^2 > Total seabed area disturbed by export cable repairs through life = 145,842 m^2	WTGs is also likely to increase the possibility of a pollution incident.
Impact 5: Collision risk	> Small WTGs: > 79 monopile WTGs with foundation of 13 m x 15 m, RD of 260 m, minimum blade tip height of 28 m above MHWS and maximum blade tip height of 324 m above MHWS. > Large WTGs: > 41 monopile WTGs with foundation of 15 m x 15 m, RD of 360 m, minimum blade tip height of 28 m above MHWS and maximum blade tip height of 395 m above MHWS.	The MDS in relation to collision risk is species-specific and dependent on the behaviour and ecology of individual IOFs. As the number of WTGs is the factor likely to have the greatest influence on collision rates under the deterministic and stochastic CRMs, the Small WTGs has been taken forward for assessment, with the higher annual collision rates predicted for all species.

Potential effect	Maximum design scenario assessed	Justification
Impact 6: Combined operational collision risk and displacement	As per Impact 3 and Impact 5.	A larger number of WTGs under the Small WTG scenario is likely to result in increased displacement. A larger number of WTGs is also likely to increase the possibility of collisions.
Decommissioning		
Impact 7: Direct disturbance and displacement	See Impact 1. The decommissioning sequence will generally be in the reverse of construction (reverse lay) and is expected to involve similar types and numbers of vessels and equipment and take place over a three-year period.	With more WTGs to be decommissioned, the area subject to disturbance, and the overall duration of disturbance is likely to be greater under the Small WTG scenario.
Impact 8: Indirect impacts through effects on habitats and prey species	See Impact 2 for guidance on extent of areas affected.	A larger number of WTGs to be removed under the Small WTG scenario is likely to affect a larger extent of habitat, as well as increased displacement of prey species. A larger number of WTGs is also likely to increase the possibility of a pollution incident.

4.9 MITIGATION

4.9.1 This section describes elements of the adopted design, materials, construction approach, etc. that have been agreed and will be included in the project either to specifically mitigate anticipated impacts or to avoid or reduce impacts.

4.9.2 The embedded mitigation contained in Table 4.16 are mitigation measures or commitments that have been identified and adopted as part of the evolution of the project design of relevance to offshore ornithology, these include project design measures, compliance with elements of good practice and use of standard protocols.

4.9.3 General embedded mitigation measures, which would apply to all parts of the project, are set out first in Table 4.16. Thereafter mitigation measures that would apply specifically to offshore ornithology issues associated with the array areas and offshore ECC, are described separately.

Table 4.16: Mitigation relating to offshore ornithology.

Project phase	Mitigation measures
General	
Project design	A key driver for the identification of the preferred offshore ECC was the location of ornithological designations present along the coastline to the west of the VE array areas, and avoidance of these, while minimising overlap with the Outer Thames Estuary SPA as far as possible (see Volume 6, Part 5, Annex 4.9: Seabird Distributions Recorded in Aerial Surveys, Figure 2.4.1). Furthermore, with respect to the Outer Thames Estuary SPA, the offshore ECC is aligned with deeper water channels which is both less preferred habitat for red-throated divers and also already subject to higher levels of vessel traffic. Therefore, additional disturbance to this species will be kept to a minimum.
Project design	Use of larger and more widely spaced WTGs with higher rotor tip clearance above mean sea level (28m) than previous developments, following advances in wind turbine technology, to achieve the required overall maximum export capacity, which typically reduces collision risks (e.g., Johnston *et al.* 2014) and is also likely to reduce displacement effects (e.g., Leopold *et al.* 2013).
Construction	
Direct and indirect construction impacts	Development of, and adherence to, a PEMP to reduce direct and indirect disturbance-displacement or pollution impacts in the array areas and around the offshore ECC through compliance with legislation, guidance, training and set protocols (see Volume 9, Report 9.18: Outline Project Environmental Management Plan and Volume 9, Report 18.1: Working in Proximity to Wildlife).
Construction disturbance	Implementation of a best practice protocol for minimising disturbance to the Outer Thames Estuary SPA population of red-

Project phase	Mitigation measures
	throated diver during construction, operation and maintenance works, which is summarised in Volume 9, Report 18.1: Working in Proximity to Wildlife.
Construction disturbance	Piling operations of foundations (for both WTGs and OSP) will undergo a soft start and ramp-up to help reduce disturbance impacts on IOFs and their prey species (see Volume 9, Report 14.1: Outline Marine Mammal Mitigation Protocol - Piling).
Operation	
Disturbance	Implementation of a best practice protocol as outlined above for construction phase.
Decommissioning	
Disturbance	Development of, and adherence to, the best practice protocol as outlined above for construction phase.

4.10 ENVIRONMENTAL ASSESSMENT: CONSTRUCTION PHASE

4.10.1 In the assessment below the identified impacts are assessed:

- In the order of construction, operation and maintenance, and decommissioning;
- Following the impact assessment methodology that is described in section 4.5;
- On the basis of the MDS for each impact as set out in Table 4.15; and
- Accounting for the mitigation that is described in Table 4.16.

4.10.2 The current project design includes an ECC to shore to facilitate power export from the array areas to the national electricity grid. Under the Offshore Transmissions Network Review (OTNR) options, work to consider the potential for an offshore connection has been commenced but is not well advanced. An offshore connection is not a viable or deliverable alternative at this time. However, in order to allow identification of impact that be relevant were this to become an option, the assessment for each potential impact has been split into “Array Area Impacts” and “Offshore Export Cable Corridor Impacts.” Further details on the OTNR process are outlined in Volume 9, Report 29: Offshore Connection Scenario.

IMPACT 1: DIRECT DISTURBANCE AND DISPLACEMENT

4.10.3 The VE project has the potential to affect bird populations in the marine environment through disturbance due to construction activities leading to displacement of birds from construction areas. This would effectively result in temporary habitat loss through reduction in the area available for feeding, loafing and/or moulting.

4.10.4 Construction related disturbance and displacement is most likely to affect foraging birds. Any impacts resulting from disturbance and displacement from construction activities would be short-term, temporary and reversible in nature, lasting only for the duration of construction activity, with birds expected to return to the area once construction activities have ceased. Furthermore, modelling of the consequences of displacement for fitness of displaced birds suggests that even in the case of breeding seabirds that are displaced on a daily basis, there is likely to be little or no impact on survival unless the offshore windfarm is close to the breeding colony (Searle *et al*. 2014, 2017).

4.10.5 The MDS would be the Small WTG scenario, with the worst-case offshore ECC (Table 4.15), as it would comprise more WTGs being constructed over a larger area and occur over a longer duration. The offshore construction phase of the proposed VE project would be spread over a timeframe of approximately five years, which would overlap with a maximum of five or six breeding and non-breeding seasons.

4.10.6 Foundations would be constructed within 12 months for both array areas. Both simultaneous (up to two foundations being piled at once) and consecutive piling (being piled one after another) are proposed.

4.10.7 The construction phase would require the mobilisation of vessels, helicopters and equipment and the installation of foundations, export cables and other infrastructure. These activities have the potential to disturb and displace birds from within and around the array areas and offshore ECC. The level of disturbance at each work location would differ dependent on the activities taking place, but there could be vessel movements at any time of day or night over the construction period.

4.10.8 The principal source of noise during construction would be subsea noise from piling works associated with the installation of foundations for WTGs and associated offshore substations.

4.10.9 While assessed for marine mammals and fish, subsea noise is not considered a risk factor for diving birds. Seabirds and other diving bird species will spend most of their time above or on the water surface, where hearing will detect sound propagated through the air. It has been speculated, based on what is known about the physiology of hearing in birds, and comparison to the underwater hearing ability of humans, that birds do not hear well underwater (Dooling and Therrien 2012). Anatomical studies of ear structure in diving birds suggest that there are adaptations for protection against the large pressure changes that may occur while diving, which may reduce hearing ability underwater but also protect the ear from damage due to acoustic over-exposure (Dooling and Thierren 2012).

4.10.10 Above water noise disturbance from construction activities is not considered in isolation as a risk factor for birds; but rather, combined with the presence of vessels, man-made structures, and human activity, part of the overall disturbance stimulus that causes birds to avoid boats and other structures – as discussed below.

4.10.11 Lighting of construction sites, vessels and other structures at night may potentially be a source of attraction (phototaxis), as opposed to displacement, for birds; however, the areas affected would be very small, and restricted to offshore construction areas which are active at a given time. Phototaxis can be a serious hazard for fledglings of some seabird species but occurs over short distances (hundreds of metres) in response to bright white light close to breeding colonies of these species. It is not seen over large distances or in older (adult and immature) seabirds (Furness 2018). Construction sites associated with the offshore development area would be far enough removed from any seabird breeding colonies as to render this risk negligible. Phototaxis of nocturnal migrating birds can be a problem, especially in autumn during conditions of poor visibility, but is generally seen where birds are exposed to intense white lighting such as from lighthouses; light from construction sites is likely to be one or two orders of magnitude less powerful than that from lighthouses (Furness 2018).

SCREENING OF SPECIES FOR ASSESSMENT OF DISTURBANCE

4.10.12 There are several different measures used to assess bird disturbance and displacement from areas of sea in response to activities associated with an offshore windfarm. Garthe and Hüppop (2004) developed a scoring system for such disturbance factors which they applied to seabird species in German sectors of the North Sea. This was refined by Furness and Wade (2012) and Furness *et al*. (2013) with a focus on seabirds using Scottish offshore waters. The approach uses information in the scientific and ‘grey’ literature, as well as expert opinion to identify disturbance ratings for individual species, alongside scores for habitat flexibility and conservation importance. These factors were used to define an index value that highlights the sensitivity of a species to disturbance and displacement. As many of these references relate to disturbance from helicopter and vessel activities, these are considered relevant to this assessment.

4.10.13 Bird species differ in their susceptibility to anthropogenic disturbance and in their responses to noise and visual disturbance stimuli. Gulls are not considered susceptible to disturbance, as they are often associated with fishing boats (e.g. Camphuysen 1995; Hüppop and Wurm 2000) and have been noted in association with construction vessels at the Greater Gabbard offshore 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); and Irwin *et al*. (2019) found that great black-backed gull distribution within the Outer Thames Estuary SPA showed a slight skew towards shipping lanes in the southern sector. However, species such as divers and scoters have been observed to avoid shipping by several kilometres (Mitschke *et al*. 2001 from Exo *et al*. 2003; Garthe and Hüppop 2004; Schwemmer *et al*. 2011), and Irwin *et al*. (2019) found that red-throated divers clearly showed displacement from shipping lanes within the Outer Thames SPA.

4.10.14 In order to focus the assessment of disturbance and displacement, a screening exercise was undertaken to identify those species most likely to be at risk (Table 4.17). Any species recorded only in very small numbers within the study area and/or with a low sensitivity to displacement was screened out of further assessment.

4.10.15 The species screened in for assessment are **red-throated diver, common scoter, guillemot** and **razorbill**. These were assessed for impacts during the construction period, based on spatial locations where effects were likely.

4.10.16 Birds recorded during the species-specific spring and autumn migration periods are assumed to be moving through the area between breeding and wintering areas. As these individuals will be present in the site for a short time and the potential zone of construction displacement will be comparatively small, it has been assumed that there are negligible risks of impact at these times of year. Consequently, the following assessment focuses on the breeding and nonbreeding periods (seasons following Furness 2015).

Table 4.17: Construction Disturbance and Displacement Screening.

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Rationale
Red-throated diver	Very High	IN	High susceptibility to disturbance and displacement. Low numbers recorded within array areas but likely present in higher numbers around the offshore ECC, in particular within the section overlapping the Outer Thames Estuary SPA for which red-throated diver is a qualifying species.
Common scoter	Very High	IN	High susceptibility to disturbance and displacement. Likely to be present in relatively large numbers around the more coastal section of the offshore ECC, as indicated from Irwin *et al*. (2019).
Fulmar	Low	OUT	Low susceptibility to disturbance
Gannet	Low	OUT	Low susceptibility to disturbance
Cormorant	High	OUT	Recorded in low numbers during baseline surveys (6 records in 4km study area)
Arctic skua	Low	OUT	Recorded in low numbers on baseline surveys, during passage migration periods (2 records in 4km study area)

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Rationale
Great skua	Low	OUT	Recorded in low numbers on baseline surveys, during passage migration periods (7 records in 4km study area)
Puffin	Medium	OUT	Recorded in low numbers on baseline surveys (2 positively identified records in 4km buffer only)
Razorbill	Medium	IN	Potentially susceptible to disturbance during non-breeding periods and in the VE array areas in particular.
Guillemot	Medium	IN	Potentially susceptible to disturbance during non-breeding periods and abundant in the VE array areas in particular.
Common tern	Low	OUT	Low susceptibility to disturbance and recorded in low numbers within study area
Sandwich tern	Low	OUT	Low susceptibility to disturbance and recorded in low numbers within study area
Kittiwake	Low	OUT	Low susceptibility to disturbance
Black-headed gull	Low	OUT	Low susceptibility to disturbance
Little gull	Low	OUT	Low susceptibility to disturbance
Common gull	Low	OUT	Low susceptibility to disturbance
Lesser black-backed gull	Low	OUT	Low susceptibility to disturbance
Herring gull	Low	OUT	Low susceptibility to disturbance
Great black-backed gull	Low	OUT	Low susceptibility to disturbance
1. With reference to Garthe and Hüppop, 2004; Furness and Wade, 2012; Furness *et al*., 2013; Wade *et al*., 2016; Goodship and Furness, 2022.			

RED-THROATED DIVER

SENSITIVITY

4.10.17 Red-throated diver is classified as being of **high sensitivity** to human activities in marine areas, including the disturbance effects of ship and helicopter traffic (Garthe and Hüppop 2004; Bellebaum *et al*. 2006; Schwemmer *et al*. 2011; Furness and Wade 2012; Furness *et al*. 2013; Bradbury *et al*. 2014; Mendell *et al*. 2019). A selectivity index derived from aerial surveys in the German North Sea indicated that the numbers of divers (red- and black-throated divers could not be reliably distinguished during the surveys) were significantly lower in shipping lanes than in other areas, although there were insufficient data to estimate flush distances of divers from ships (Schwemmer *et al*. 2011). In this study it was assumed that the responses of red and black-throated divers to disturbance was similar. Observational studies of responses of marine birds to disturbance in Orkney inshore waters found that red-throated and black-throated divers showed similar flush behaviour from ferries (with respectively 75% (n=88) and 62% (n=21) of birds showing an evasive response within 300m of a passing ferry). Red-throated divers were highly likely to fly in response to marine activity whereas black-throated divers were more likely to swim away (although these differences may be related to differences in the timing of moult in the two species, which affects flight ability) (Jarett *et al*. 2018).

MDS IMPACT

4.10.18 The assessment takes account of mitigation in the form of a best practice protocol for minimising construction disturbance of red-throated divers within the Outer Thames Estuary SPA (see Table 4.16).

4.10.19 Despite the implementation of the protocol, there remains potential for some disturbance and displacement of non-breeding red-throated divers resulting from the presence of vessels and helicopters related to the installation of the WTG array infrastructure and the offshore export cables. The offshore ECC extends eastwards from the landfall between Holland-on-Sea and Frinton-on-Sea on the Essex coast, overlapping with the Outer Thames Estuary SPA for approximately 16 km (c. 17% of the total length), (Volume 6, Part 5, Annex 4.9: Seabird Distributions Recorded in Aerial Surveys, Figure 2.4.1), although the offshore ECC working corridor width is small (for instance, the maximum width of the Pre Lay Grapnel Run (PLGR) corridor is 30m).

4.10.20 The MDS for cable-laying operations is that there would be two export cable installation spreads, each of which would utilise up to six vessels on-site at any one time (Table 4.15). For each cable installation spread this comprises: a cable lay vessel, a cable support vessel, a seabed prep, a rock dumper and two tugs. It should however be noted that many parts of the construction cannot be undertaken concurrently and so this number is not representative throughout the majority of the construction period.

4.10.21 The greatest potential for the displacement of red-throated divers would lie with the vessels associated with cable laying, although it should be noted that cable laying vessels are static for large periods of time and move slowly and over short distances as cable installation takes place. Offshore cable installation activity is also a relatively low noise emitting operation, particularly when compared to activities such as piling.

4.10.22 The magnitude of disturbance to red-throated diver has been estimated on a worst-case basis. This assumes that there would be 100% displacement of those birds in a 2km buffer surrounding the source, in this case a maximum of three separate, non-overlapping locations along the offshore ECC route where vessels are congregated. This assumes 2 x simultaneous export cable installation spreads, plus another vessel/aggregation, in a precautionary scenario where e.g., seabed prep is taking place away from cable laying.

4.10.23 This 100% displacement is consistent with the suggestion that all red-throated divers present fly away from approaching vessels at a distance of 1km or less (Bellebaum *et al*. 2006; Topping and Petersen 2011). This may be a very precautionary assumption, for example (as noted above) studies of responses of marine birds to disturbance in Orkney inshore waters found that 75% (n=88) red-throated divers flushed within 300m of ferries (Jarett *et al*. 2018), implying that in this study not all birds were flushed even within 300m of vessels.

OFFSHORE EXPORT CABLE CORRIDOR

4.10.24 The number of red-throated divers that would potentially be at risk of displacement from the offshore ECC during the cable laying process was based on the data available in Irwin *et al.* (2019) who estimated the density of red-throated divers within the Outer Thames Estuary SPA. A precautionary approach has therefore been taken, based on the assumption that most of the offshore ECC (c.83% of the total length) is outside of the demarcated SPA, and would be suboptimal for red-throated divers, located mainly in deeper water, with higher shipping frequency, and therefore hosting lower densities of birds than within the SPA (Thompson *et al.* (2023) for example, found that depth-tagged red-throated divers mainly foraged at depths of less than 8 m).

4.10.25 Irwin *et al.* (2019) found that red-throated divers clearly showed displacement from shipping lanes within the Outer Thames SPA, and the non-SPA part of the offshore ECC is an example of this. Results of baseline shipping observations presented in Volume 6, Part 2, Chapter 9: Shipping and Navigation show that over a 14-day period in the January 2022, there was an average of 44 unique vessels per day recorded within the offshore ECC study area and 37 unique vessels per day intersecting the offshore ECC. During a 14-day survey period in June 2022, there was an average of 70 unique vessels per day recorded within the offshore ECC study area and 59 unique vessels per day intersecting the offshore ECC. The main vessel types within the offshore ECC study area were cargo vessels, tankers and dredgers, with the addition of recreational vessels in summer.

4.10.26 The most recently available red-throated diver data for the SPA derive from two aerial surveys undertaken on 4 and 17 February 2018 (Irwin *et al*. 2019). The densities of red-throated divers recorded within the SPA 'southern area', which overlaps with the offshore ECC, was calculated at 3.64 birds/km² in survey 1, with a density of 7.10 birds/km² in survey 2. The adjacent 'northern (large)' area to the north of the offshore ECC recorded lower densities of 0.62 birds/km² in survey 1, and 3.77 birds/km² in survey 2.

4.10.27 These two surveys, less than two weeks apart, took place within a period which was noted by Irwin *et al.* (2019) as having the highest red-throated diver densities within the Outer Thames SPA. The second survey may overlap with the start of the spring migration and the increase in density may therefore be reflective of individuals passing through on migration in the second half of February.

4.10.28 Mean densities across the whole offshore ECC, extending further offshore, are likely to be much lower than those recorded within the SPA 'southern area'. A reasonably precautionary assumption would therefore be to use the lower density values obtained within the adjacent 'northern (large)' SPA area as an approximate mean density for the whole offshore ECC extent.

4.10.29 The worst-case area from which birds could be displaced was defined as a circle with a 2km radius around each of the three vessels/aggregations associated with cable laying operations, which is 37.71km² (3 x 12.57km²). This is considered precautionary because it is unlikely that there would be three vessel aggregations spaced 2km apart (e.g., the maximum spacing between the two cable circuits is 750m), and there would most likely be some overlap in displacement areas.

4.10.30 If 100% displacement is assumed to occur within this combined area, then based on densities of 0.62 – 3.77 birds per km² within the northern (large) SPA area, 23 to 142 divers would be displaced at any given time.

4.10.31 It is however considered reasonable to assume that disturbance impacts are temporary, and birds will reoccupy areas following passage of the vessel. Cable laying vessels will move at a slow rate for ploughing or jetting, and even slower for trenching, compared to tidal flow rates. For context, a modest tidal flow rate for the Outer Thames would be in the region of 30m per minute (0.5m per second, derived from DECC 2009), which is likely to be much faster than the cable laying vessel. Birds on the water surface are likely to be drifting with the tide and moving at the same speed as the tidal flow. Thus, even while moving, the vessels would be effectively stationary as far as birds are concerned, so the zone of impact around the vessel would be more or less fixed.

4.10.32 Consequently, for the purposes of this assessment it can be assumed that the estimated number of red-throated divers displaced at any one time from cable-laying vessels represents the total number displaced over the course of a single winter. As noted above, the numbers displaced are based on density estimates within what Irwin *et al.* (2019) considers to be the period when red-throated diver density in the Outer Thames SPA is known to be highest (January-February). Thus, using SPA densities during this period to estimate the number of birds displaced over the course of an entire winter (largely outside of the SPA) is highly precautionary.

4.10.33 Definitive mortality rates associated with displacement for any seabird are not known and precautionary estimates have to be used. There is no empirical evidence that displaced birds suffer any consequent mortality; any mortality due to displacement would be most likely a result of increased density in areas outside the affected area, resulting in increased competition for food where density was elevated. Such impacts are most likely to be negligible (Dierschke *et al*. 2017), and below levels that could be quantified. Impacts of displacement are also likely to be context dependent. In years when food supply has been severely depleted, as for example by unsustainably high fishing mortality of sandeel stocks as has occurred several times in recent decades (ICES 2013; Lindegren *et al*. 2018), displacement of sandeel-dependent seabirds from optimal habitat may increase mortality. In years when food supply is good, displacement is unlikely to have any negative effect on seabird populations. Red-throated divers may feed on sandeels, but take a wide diversity of small fish prey, so would be buffered to an extent from fluctuations in abundance of individual fish species.

4.10.34 A detailed review of the likely effects of displacement of red-throated divers on mortality during the non-breeding season is included in the East Anglia ONE North and East Anglia TWO Offshore Windfarms Ltd (2021) application documents. The annual mortality rate of red-throated divers is 16% per annum for adults (three years and older) and 38-40% for juveniles (Horswill and Robinson 2015; rates based on population studies in Sweden and Alaska published respectively in 2002 and 2014). These rates will include mortality in the breeding and non-breeding season due to 'natural' factors such as weather or predation, as well as mortality (if any) from anthropogenic impacts such as disturbance and displacement by ships. As ships are mobile and red-throated divers will often fly away from approaching vessels (e.g., Schwemmer *et al*. 2011, Jarrett *et al*. 2018) the energy costs of displacement from moving vessels may be considerably greater than those of avoiding static structures; and the impact (if any) of disturbance by ships must already be incorporated in the existing estimates of survival.

4.10.35 Evidence strongly indicates that red-throated divers are limited by competition for safe breeding sites within range of foraging waters (Merrie 1978, Nummi *et al*. 2013, Rizzolo *et al*. 2014, Dahlen and Eriksson 2016), but they are probably not in competition for resources during the nonbreeding season (Dierschke *et al*. 2012, 2017). This would suggest that their population size will be limited by breeding habitat suitability and not by wintering habitat (Newton 1998). Loss of wintering habitat would, therefore, have little or no impact on red-throated diver numbers unless habitat loss was so extensive that nonbreeding season habitat became a limiting factor for the population because their density increased so much that interference competition or prey depletion became a driving factor. East Anglia ONE North and East Anglia TWO Offshore Windfarms Ltd (2021) concluded that 1% mortality is an appropriately precautionary estimate for displacement for red-throated diver, and that in reality the additional morality rate may be closer to zero.

4.10.36 However, based on previous advice from Natural England for other offshore wind farm projects, this assessment has assumed the precautionary maximum mortality rate associated with the displacement of red-throated diver in the wintering period is 1-10% (i.e., 1-10% of displaced individuals suffer mortality as a direct consequence). At this level of mortality then, when assuming 23 to 142 divers may be displaced, <1 to 15 birds would be expected to be lost across the entire winter period (September to April) as a result of any potential displacement effects from the offshore cable installation activities. The average annual mortality rate for red-throated diver, across age classes, is estimated as 0.228 (based on species specific data from Horswill and Robinson (2015); see Table 4.11). Based on this, 2,320 birds would be expected to die each year from the winter BDMPS for this species (10,177; Furness 2015). The addition of a maximum of 15 birds to this would increase the mortality rate by 0.6%.

4.10.37 For the reasons outlined above, this value is considered to be an overestimate of mortality. This is because (i) the mitigation via the Volume 9, Report 9.18: Outline PEMP and Volume 9, Report 18.1: Working in Proximity to Wildlife protocol would include measures to coordinate and schedule vessel movements and activities within the Outer Thames SPA, in a manner that would reduce disturbance impacts in areas of highest diver densities; (ii) red-throated diver densities along most of the offshore ECC, in shipping lanes, are likely to be lower than the mean density used from within the 'northern (large)' SPA area; (iii) cable laying vessels are likely to be relatively close together and so the overall displacement extent is likely to be much lower than a 3 x 2 km radius area considered here; and (iv) mortality rates due to displacement are unlikely to be as high as 10%.

4.10.38 The construction works, specifically offshore cable laying, are temporary and localised in nature, and so a **negligible** impact magnitude is predicted (Table 4.6).

4.10.39 As the species is of high sensitivity to disturbance, the effect significance is **minor adverse**, which is **not significant** in EIA terms (Table 4.7).

ARRAY AREAS

4.10.40 Red-throated divers were infrequently recorded in the northern array area in January and in the buffers in January to March, May, September, October and December. The array peak abundance estimate was three individuals in January (see Volume 6, Part 5, Annex 4.6: Seasonal Peak Abundance).

4.10.41 In the south array, red-throated divers were recorded in the wind farm in February and in the buffers in January to April and December. The estimated array peak abundance was three individuals in February.

4.10.42 There is potential for disturbance and displacement of red-throated divers due to construction activities, including the construction of WTGs and other infrastructure (offshore electrical platforms, construction operation and maintenance platforms) and associated vessel traffic. However, construction will not occur across the whole of the array areas simultaneously or every day but will be phased, with activity focused on a particular WTG, offshore platform or cable locations at any time (assumed to be a worst-case three discrete locations for the purposes of this assessment). Consequently, until WTGs (and other structures) are placed on foundations, the effects will occur only in the areas where vessels are operating at any given point and not the entire array areas. At such time as WTGs (and other infrastructure) are installed onto foundations the impact of displacement would increase incrementally to the same levels as operational impacts (Section 4.11 below).

4.10.43 During the winter period in the north array, a seasonal peak density of 0.05/km^2 was estimated. Although strictly considered to be within the spring migration period, based on local conditions described by Irwin *et al.* (2019) it has been assumed that the seasonal peak density within the south array (0.06/km^2) in February more closely reflects the species' winter period (see also RSPB consultation comment in Table 4.2 which advises this).

4.10.44 With a highly precautionary 2km radius of disturbance around three construction areas (WTGs or other infrastructure), up to two individual birds (0.06 x 12.56 x 3) could be at risk of displacement, of which the mortality would be <1 bird (0-0.2 birds).

4.10.45 This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of impact is assessed as **negligible**. As the species is of high sensitivity to disturbance, the significance of effect is **minor adverse** and **not significant** in EIA terms.

OFFSHORE EXPORT CABLE CORRIDOR AND ARRAY AREAS

4.10.46 Throughout the year, the estimated number of red-throated divers subject to construction disturbance/displacement would be up to 144 (assuming construction works in both the offshore ECC, and the array areas overlap in time), of which the resultant mortality would be between 1 and 14 individuals.

4.10.47 At the average baseline mortality rate of 0.228, the number of individuals expected to be lost from the largest BDMPS population throughout the year is 3,027 (13,277 x 0.228). The addition of a maximum of 14 individuals to this increases the mortality rate by 0.5%. This magnitude of impact is assessed as **negligible**. As the species is of high sensitivity to disturbance, the significance is **minor adverse** and not significant in EIA terms.

COMMON SCOTER

SENSITIVITY

4.10.48 Common scoters have been reported as having an 804m median flush distance from ships, and a maximum flush distance of 3.2km (Schwemmer *et al*. 2011). Kaiser *et al*. (2006) reported that common scoter had flush distances of 1,000-2,000m.

4.10.49 For the purposes of this assessment, it is assumed that common scoters are of **high sensitivity** to disturbance from vessels at similar distances as red-throated diver (up to 2km), and therefore the assessment methodology for that species is again applicable here.

4.10.50 Whilst the best practice protocol for reducing construction disturbance is primarily for red-throated diver, non-breeding common scoters have in some ways quite comparable ecology and behaviour and so the mitigation is also likely to benefit this species.

OFFSHORE EXPORT CABLE CORRIDOR

4.10.51 Common scoter is dependent on shallow feeding grounds (10-20m) with shellfish banks where molluscs are available (Forrester *et al*. 2007), and so distribution is likely to be relatively coastal in the vicinity of the offshore ECC. During the 2018 aerial surveys, common scoter numbers were low in the first survey, with no clear spatial pattern to the records. In the second survey numbers were slightly higher with two small groups recorded near Aldeburgh and another at the far east of the survey area (where they associated with a surf scoter, Irwin *et al*. 2019).

4.10.52 Irwin *et al*. (2019) recorded low densities of common scoters in the southern SPA area in 2018 at 0.23 birds/km² and 0.07 birds/km² in Survey 1 and Survey 2 respectively. This equated to 515 birds (± 95% CI 0 – 1480) and 161 birds (± 95% 0 – 466). Within the large northern SPA area, common scoters were only recorded at 0.42 birds/km² in Survey 2 equating to 509 birds (± 95% CI 0 – 1466).

4.10.53 The ‘worst case’ area from which birds could be displaced was defined as a circle with a 2km radius around each vessel aggregation, which is 37.71km^2 (3 x 12.57km^2). This is considered to be precautionary because densities are likely to be lower along the majority of the offshore ECC outside of the SPA, identified as a high activity shipping channel, and because vessel aggregations are likely to be closer together than 2km. If 100% displacement is assumed to occur within this area, then based on densities of up to 0.42 birds per km^2, up to 16 common scoters would be displaced at any given time. It is considered reasonable to assume that birds will reoccupy areas following passage of the vessel.

4.10.54 A precautionary maximum mortality rate associated with the displacement of common scoter in the wintering period is assumed to be 1-10% (i.e., 1-10% of displaced individuals suffer mortality as a direct consequence). At this level of mortality then up to two birds (out of a population of c.509 birds within the Outer Thames SPA) would be expected to be lost across the entire winter period as a result of any potential displacement effects from the offshore cable installation activities. The construction works, specifically offshore cable laying, are temporary and localised in nature, and it is likely that the best practice protocol for red-throated divers would also benefit common scoter. Therefore, this highly precautionary assessment generates a worst-case impact of **negligible** magnitude (Table 4.6).

4.10.55 As the species is of high sensitivity to disturbance, the effect significance is at worst **minor adverse**, which is **not significant** in EIA terms.

ARRAY AREAS

4.10.56 No common scoters were recorded within the study area during baseline aerial surveys (see Volume 6, Part 5, Annex 4.1: Offshore Ornithology Technical Report). As noted above, the array areas are in deeper water than preferred by common scoter, and therefore are likely to be outside the species’ distribution range. As such, it can be reasonably concluded that there would be no impacts associated with construction within the array areas, and the effect significance is **negligible**, which is **not significant** in EIA terms.

OFFSHORE EXPORT CABLE CORRIDOR AND ARRAY AREAS

4.10.57 Throughout the year, the estimated number of common scoters subject to construction disturbance/displacement would be up to 16 (assuming construction works in both the offshore ECC, and the array areas overlap in time), of which the resultant mortality would be up to two individuals (associated with the offshore ECC only).

4.10.58 Out of a population of c.509 birds within the Outer Thames SPA, this magnitude of impact is assessed as **negligible**. As the species is of high sensitivity to disturbance, the significance is **minor adverse** and **not significant** in EIA terms.

GUILLEMOT

SENSITIVITY

4.10.59 Guillemots are considered to have a **medium sensitivity** to disturbance and displacement, based on their sensitivity to ship and helicopter traffic noted in Garthe and Hüppop (2004), Furness and Wade (2012), Furness *et al*. (2013) and Bradbury *et al*. (2014).

OFFSHORE EXPORT CABLE CORRIDOR

4.10.60 Irwin *et al.* (2019) calculated the non-breeding guillemot density within the southern area of the SPA at 0.02 birds per km² in Survey 1, and 0.95 birds per km² in Survey 2. This equated to 2,091 birds (± 95% CI 1180 – 3131) in Survey 2. In the northern (large) SPA area, guillemot density was calculated at 0.04 birds per km² in Survey 1 and increased to 0.24 birds per km² in Survey 2. These equated to 51 birds (± 95% CI 19 – 91) and 288 birds (± 95% CI 151 – 438) respectively.

4.10.61 Following the same worst-case assumptions on construction activities as red-throated diver and common scoter (i.e., a 2km radius around three vessel aggregations, totaling 37.71km^2 (3 x 12.57km^2), then based on a peak density of 0.95 birds per km^2, up to 36 guillemots could be displaced at any given time. It is considered reasonable to assume that birds will reoccupy areas following passage of the vessel.

4.10.62 For this assessment, it has been assumed that a mortality of 1-10% of displaced individuals could result from displacement by construction vessels (as for displacement from the operational windfarm – see Impact 3 in section 4.11 below). In such a case, 0-4 guillemots would be lost to the population over a winter period.

4.10.63 Although data on guillemot densities along much of the offshore ECC are unavailable for the breeding season, the mean maximum foraging range for breeding guillemot is 73km (Woodward *et al*, 2019) which places the offshore ECC considerably beyond the range of any guillemot breeding colonies. The nearest breeding colony is Flamborough Head, 265km from the offshore ECC (the minimum distance to the Flamborough and Filey Coast SPA, Table 4.14). It can therefore be stated with confidence that there are no breeding colonies for guillemot within foraging range of the array areas, therefore it is reasonable to assume that any individuals seen during the breeding season are nonbreeding and that they are largely sub-adult birds.

4.10.64 As outlined in the following section assessing array areas, the estimated loss of guillemots during the breeding season due to construction within the array areas (up to 18 individuals) is relatively low within the context of the large sub-adult component of the winter UK North Sea and English Channel BDMPS for this species, and losses due to offshore ECC works are likely to be lower still, based on the likelihood of similarly low densities of non-breeders during the breeding season.

4.10.65 Overall, therefore the annual magnitude of impact of temporary construction works associated with the offshore ECC has been determined as **negligible**. As the species is of medium sensitivity to disturbance, the effect significance is **minor adverse**, which is **not significant** in EIA terms.

ARRAY AREAS

4.10.66 Guillemots were recorded in the array areas year-round, with abundance estimates peaking at 326 individuals (density of 4.88 birds per km^2) in the north array in March, and 1,413 in the south array in February (density of 23.1 birds per km^2) and being at their lowest from June to August (e.g., no records from both array areas in August).

4.10.67 There is potential for disturbance and displacement of guillemots due to construction activities, including the construction of WTGs and other infrastructure and associated vessel traffic. However, construction will not occur across the whole of the proposed array areas simultaneously or every day but will be phased and assumed to occur at three discrete locations for the purposes of this assessment. Consequently, the effects will occur only in the areas where vessel aggregations are operating at any given point and not the entire array areas.

4.10.68 For this precautionary assessment, it has been assumed that a mortality of 1-10% of displaced individuals could result from displacement by construction vessels (as for displacement from the operational windfarm – see Impact 3 in section 4.11 below).

Non-breeding

4.10.69 During the nonbreeding season, at a mean peak density of 4.67 birds per km^2 (north array) and 23.1 birds per km^2 (south array) and with a highly precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), up to 870 individual birds (23.1 x 12.56 x 3) could be at risk of displacement, of which a mortality of 8-87 birds would be expected at a 1-10% range. The average annual mortality rate for guillemot, across age classes, is estimated as 0.14 (based on species specific data from Horswill and Robinson (2015); see Table 4.11). Based on this, 226,423 birds would be expected to die each year from the non-breeding season BDMPS for this species (1,617,306 individuals; UK North Sea and English Channel, Furness 2015). The addition of 8-87 birds to this would increase the mortality rate by up to 0.04%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable.

4.10.70 The construction works are temporary and localised in nature and the magnitude of effect has been determined as **negligible**. As guillemot is of medium sensitivity to disturbance, the effect significance is **minor adverse**, which is **not significant** in EIA terms.

Breeding

4.10.71 During the breeding season, the maximum mean peak density in the array areas was 4.88 birds per km^2 (north array) and 3.14 birds per km^2 (south array) which suggests that up to 184 individuals (4.88 x 12.56 x 3) could be at risk of displacement, of which a mortality of 2-18 birds would be expected.

4.10.72 As there are no major breeding colonies for guillemot within foraging range of the array areas, it is reasonable to assume that individuals seen during the breeding season are nonbreeding and that they are largely sub-adult birds. Since sub-adult seabirds are known to remain in wintering areas, the the relevant population during the breeding season may be taken as 661,446 individuals, based on the figure for the UK North Sea and English Channel sub-adult estimate in Furness (2015).

4.10.73 Based on the average mortality for the species of 0.14 (use of the average mortality produces a conservative estimate of % change, as the mortality of birds less than 3 years old is higher than (survival is lower than) that of adult birds, Table 4.11), a total of 92,602 birds would be expected to die each year from the sub-adult component of the winter BDMPS for this species. The addition of a maximum mortality of 18 birds from construction disturbance and displacement would increase the mortality rate by 0.02%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable.

4.10.74 The construction works are temporary and localised in nature and the magnitude of effect has been determined as **negligible**. As the species is of medium sensitivity to disturbance, the effect significance is **minor adverse**, which is **not significant** in EIA terms.

Year round

4.10.75 The estimated number of guillemots subject to construction disturbance/ displacement mortality throughout the year is between 10 and 105 individuals.

4.10.76 At the average baseline mortality rate for guillemot of 0.14, the number of individuals expected to die from the largest BDMPS population throughout the year is 226,423 (1,617,306 x 0.14). The addition of a maximum of 105 individuals to this increases the mortality rate by 0.05%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect significance is **minor adverse**, which is **not significant** in EIA terms.

OFFSHORE EXPORT CABLE CORRIDOR AND ARRAY AREAS

4.10.77 The estimated number of guillemots subject to construction disturbance/ displacement mortality throughout the year is up to 131 individuals (at worst, 26 associated with the offshore ECC and 105 associated with the array areas). This increases the mortality rate within the largest BDMPS population throughout the year (see above) by 0.06%.

4.10.78 This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect significance is **minor adverse**, which is **not significant** in EIA terms.

RAZORBILL

SENSITIVITY

4.10.79 Razorbills are considered to have a **medium sensitivity** to disturbance and displacement, based on their sensitivity to ship and helicopter traffic noted in Garthe and Hüppop (2004), Furness and Wade (2012), Furness *et al*. (2013) and Bradbury *et al*. (2014).

OFFSHORE EXPORT CABLE CORRIDOR

4.10.80 Irwin *et al.* (2019) recorded relatively low numbers of razorbills across the surveys with the lowest density estimate at 0.02 birds per km^2 in the large northern SPA area during Survey 2 and the highest density estimate at 0.13 birds per km^2 in the southern area of the SPA on Survey 2. This equated to 291 birds (± 95% CI 171 – 419) in Survey 2 in the southern SPA area.

4.10.81 Following the same worst-case assumptions on construction activities as red-throated diver and common scoter (i.e., a 2km radius around three vessel aggregations, totaling 37.71km^2 (3 x 12.57km^2), then based on a peak density of 0.13 birds per km^2, up to five razorbills could be displaced at any given time. It is considered reasonable to assume that birds will reoccupy areas following passage of the vessel.

4.10.82 For this assessment, it has been assumed that a mortality of 1-10% of displaced individuals could result from displacement by construction vessels (as for displacement from the operational windfarm – see Impact 3 in section 4.11 below). In such a case, it is unlikely that any razorbills would be lost to the population over a winter period.

4.10.83 Although data on razorbill densities along much of the offshore ECC are unavailable for the breeding season, the mean maximum foraging range for breeding razorbill 88.7km (Woodward *et al*, 2019) which places the offshore ECC considerably beyond the range of any breeding colonies (the nearest being Flamborough Head, 265km from the offshore ECC). It is reasonable to assume that any individuals seen during the breeding season are nonbreeding and that they are largely sub-adult birds.

4.10.84 As outlined in the following section for the array areas, the estimated loss of razorbills during the breeding season due to construction within the array areas is low (likely up to one individual), and losses due to offshore ECC works are also likely to be low, based on the assumption of similarly low densities of non-breeders during the breeding season.

4.10.85 Overall, therefore the annual magnitude of impact of temporary construction works associated with the offshore ECC has been determined as **negligible**. As the species is of medium sensitivity to disturbance, the effect significance is **minor adverse**, which is **not significant** in EIA terms.

ARRAY AREAS

4.10.86 Razorbills were recorded in the array areas throughout the non-breeding season, but were largely absent from June to September, overlapping with the species' post-breeding season and autumn migratory period. Estimated densities peaked within the north array in December (4.34 birds per km^2) and in the south array in March (2.64 birds per km^2).

4.10.87 For this precautionary assessment it has been assumed that a mortality of 1-10% of displaced individuals could result from displacement by construction vessels (as for displacement from the operational windfarm – see Impact 3, section 4.11 below).

Autumn Migration

4.10.88 During the autumn migration season, with a mean peak density of 1.07 birds per km^2 (north array) and 0.28 birds per km^2 (south array) and with a highly precautionary 2km radius of disturbance around each of three construction areas, up to 40 individual birds (1.07 x 12.56 x 3) could be at risk of displacement, of which a mortality of up to four birds (0-4 birds) would be predicted at a 1-10% range. The average annual mortality rate for razorbill, across age classes, is estimated as 0.174 (based on species specific data from Horswill and Robinson (2015); see Table 4.11). Based on this, 102,986 birds would be expected to die each year from the winter BDMPS for this species (591,874; Furness 2015). The addition of four birds to this would increase the mortality rate by 0.004%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable.

4.10.89 The construction works are temporary and localised in nature and the magnitude of impact has been determined as **negligible**. As razorbill is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms in EIA terms.

Winter

4.10.90 During the winter period, at a mean peak density of 4.34 birds per km^2 (north array) and 1.98/km^2 (south array) and with a highly precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), up to 164 individual birds (4.34 x 12.56 x 3) could be at risk of displacement, of which a mortality of 2-16 birds would be expected.

4.10.91 Based on the average mortality for the species, a total of 38,040 birds would be expected to die each year from the winter BDMPS for this species (218,622; Furness 2015). The addition of a maximum of 16 birds would increase the mortality rate by 0.04%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable.

4.10.92 The construction works are temporary and localised in nature and the magnitude of impact has been determined as **negligible**. As razorbill is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Spring migration

4.10.93 During the spring migration season, at a mean peak density of 2.97 birds per km^2 (north array) and 2.64 birds per km^2 (south array) and with a highly precautionary 2km radius of disturbance around each of three construction areas, up to 99 individual birds (2.64 x 12.56 x 3) could be at risk of displacement, of which 1-10 would be expected to be lost. Based on the average mortality for the species, a total of 102,986 birds would be expected to die each year from the spring migration BDMPS for this species (591,874; Furness 2015). The addition of a maximum of ten birds would increase the mortality rate by 0.01%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable.

4.10.94 The construction works are temporary and localised in nature and the magnitude of impact has been determined as **negligible**. As razorbill is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Breeding Season

4.10.95 During the breeding season, the maximum mean peak density was 0.21 birds per km^2 (north array) and 0.23 birds per km^2 (south array) which suggests that up to nine individuals (0.23 x 12.56 x 3) could be at risk of displacement, of which a mortality of 0-1 birds would be expected at 1-10% range.

4.10.96 The mean maximum foraging range for breeding razorbill is 88.7km (Woodward *et al*. 2019) which places the array areas considerably beyond the range of any razorbill breeding colonies. The nearest major breeding colony is Flamborough Head, 275km from the array areas (the minimum distance to the Flamborough and Filey Coast SPA, Table 4.14).

4.10.97 On the basis of the above evidence, and the relatively very low numbers recorded during the breeding season surveys, it can be stated with certainty that there are no breeding colonies for razorbill within normal foraging range of the array areas, therefore it is reasonable to assume that the few individuals seen during the breeding season are nonbreeding (e.g. immature birds). Since immature seabirds are known to remain in wintering areas, the number of immature birds in the relevant population during the breeding season is taken to be 112,439, as per the value given for the UK North Sea and Channel immature population in Furness (2015).

4.10.98 Based on the average mortality for the species (0.174), a total of 19,564 birds would be expected to die each year from the sub-adult component of the winter BDMPS. The addition of a maximum of one bird predicted to be lost from construction disturbance and displacement would increase the mortality rate by <0.01%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable.

4.10.99 The construction works are temporary and localised in nature and the magnitude of impact has been determined as **negligible**. As the species is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Year Round

4.10.100 The estimated number of razorbills subject to construction disturbance/displacement mortality throughout the year is up to 31 individuals.

4.10.101 At the average baseline mortality rate for razorbill of 0.174, the number of individuals expected to die from the largest BDMPS population throughout the year is 102,986 (591,874 x 0.174). The addition of a maximum of 31 individuals to this increases the mortality rate by 0.03%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the significance of effect is **minor adverse**, which is **not significant** in EIA terms.

OFFSHORE EXPORT CABLE CORRIDOR AND ARRAY AREAS

4.10.102 The estimated number of razorbills subject to construction disturbance/ displacement mortality throughout the year is up to 32 individuals (31 associated with the array areas and up to one associated with the offshore ECC). This increases the mortality rate within the largest BDMPS population throughout the year by 0.03%.

4.10.103 This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect significance is **minor adverse**, which is **not significant** in EIA terms.

IMPACT 2: INDIRECT IMPACTS THROUGH EFFECTS ON HABITATS AND PREY SPECIES

4.10.104 Indirect disturbance and displacement of seabirds may occur during the construction phase within the offshore ECC and array areas if there are impacts on prey species or on the habitats of prey species. These indirect impacts include those resulting from the production of underwater noise (e.g., during piling), the generation of suspended sediments (e.g., during preparation of the seabed for foundations) or accidental pollution events that may alter the behaviour or availability of bird prey species.

4.10.105 Underwater noise may cause fish and mobile invertebrates to avoid the construction area and also affect their physiology and behaviour. Suspended sediments may cause fish and mobile invertebrates to avoid the construction area and may smother and hide immobile benthic prey. Accidental spillage of chemicals and substances from vessels may result in behavioural effects such as avoidance of affected areas and prevention of spawning. Chemical spills may also have sub-lethal to lethal effects dependent on the spatial and temporal extent of the exposure and the level of toxicity.

4.10.106 These mechanisms may result in less prey being available within the construction area for foraging seabirds.

4.10.107 Such potential effects on benthic invertebrates and fish have been assessed in Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology and Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology and the conclusions of those assessments inform this assessment of indirect effects on IOFs.

NOISE IMPACTS

ARRAY AREAS

4.10.108 With regard to noise impacts, Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology assesses the potential impacts upon fish relevant to ornithology as prey species of seabirds.

4.10.109 It is stated in that chapter that general construction noise, arising from vessel movements, dredging and seabed preparation works will generate low levels of continuous sounds (i.e., from the vessels themselves and/or the sounds from dredging tools) throughout the construction phase. The study area is currently subject to high levels of shipping activity, and it is expected that the vessel activity would be no greater than the baseline during construction activities (due to construction exclusion zones reducing current shipping activity and the number of construction vessels expected to be much lower than that which currently transit the area).

4.10.110 The main prey items of seabirds such as gannet and auks are considered to be species such as sandeels, herring and sprat. Sandeels have been categorized as Group 1 (least sensitive to noise) whereas herring and sprat are considered to be Group 3 (most sensitive).

4.10.111 Sandeels are thought to be affected by vibration through the seabed, particularly when buried in the seabed during hibernation. They are however, anticipated to recover from noise impacts shortly after noise disturbance, with normal behaviours resuming, and the chapter concludes that the species would be of low sensitivity.

4.10.112 Herrings possess a swim bladder that is involved in hearing, and therefore are known to be sensitive to underwater noise. Taking this into account, and considering the low intensity spawning across the array areas, the sensitivity of spawning herring to noise impacts is considered to be medium.

4.10.113 Sprat is a pelagic spawner and is therefore not limited to specific sedimentary areas for spawning, and consequently are considered likely to move away from injurious effects. Based on their mobile nature, sprats are expected to recover quickly, return to normal behaviours, recolonizing areas shortly after disturbance. Therefore, their sensitivity to noise impacts is considered to be low.

4.10.114 Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology concludes that the potential for mortality is likely to only occur in extreme proximity to piling activities, and the risk of this occurring will be reduced by soft start techniques at the start of the piling sequence (mitigation). This means that fish in close proximity will move outside the impact range before noise levels reach a level likely to cause irreversible injury.

4.10.115 On the basis that shellfish do not possess swim bladders or other gas filled organs, it is considered that shellfish are primarily sensitive to particle motion rather than sound pressure. The chapter concluded that the impact of mortality and potential mortal injury on shellfish, is considered to be of low magnitude, and the sensitivity of the receptors is considered to be low (resulting in minor adverse effects).

4.10.116 Underwater noise impacts (death, physical injury or behavioural changes) during construction in the array areas are therefore considered to be minor adverse at worst for all prey species.

4.10.117 It is therefore concluded that the indirect effect significance of noise on seabird IOFs occurring in or around the array areas during the construction phase is therefore at worst of low magnitude but in practice this can be reduced to **negligible** magnitude in most cases, due to the ability of birds to forage over a wide area. A **negligible or minor adverse** effect is therefore predicted for all IOFs, which is **not significant** in EIA terms.

OFFSHORE EXPORT CABLE CORRIDOR

4.10.118 With regard to noise impacts associated with the offshore ECC, Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology limits the scope of the assessment to the possible installation of five sheet piled exit pits for the trenchless installation techniques within the landfall. For all fish species assessed, impact magnitudes were considered to be **negligible**. A **negligible or minor adverse** effect is therefore predicted for all seabird IOFs in relation to the offshore ECC, which is **not significant** in EIA terms.

SUSPENDED SEDIMENT

4.10.119 With regard to changes to the seabed and to suspended sediment levels, Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology discuss the nature of any change and impacts on the seabed and benthic habitats. The impact on benthic habitats is predicted to be of local spatial extent (i.e., restricted to discrete areas, short-term duration (as it is limited to the duration of construction activities), intermittent and with high reversibility.

OFFSHORE EXPORT CABLE CORRIDOR

4.10.120 Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology notes that in the offshore ECC, temporary localised increases in suspended sediment concentration (SSC) and associated sediment deposition and smothering are expected from cable installation works (including HDD installation at landfall) and seabed preparation works (including sandwave clearance).

4.10.121 The chapter concludes that in relation to construction works in the offshore ECC, any sediment plume will disperse quickly with some smothering effects on fish and shellfish receptors potentially occurring within 50 m of construction activities. The impact of increased SSC and smothering from sediment deposition is expected to be short-term, intermittent and of localised extent and reversible.

4.10.122 Release of bentonite (a non-toxic, natural clay mineral) during the trenchless installation technique at landfall may result in a single, large plume of sediment in suspension into the water column, but the magnitude of the release of bentonite in the marine environment is assessed as negligible.

4.10.123 According to Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology, the secondary effects of increased concentrations of SSC in the water column and smothering have been shown to be inconsequential to sandeel species. Sandeel eggs are also likely tolerant to increases in SSC and smothering from sediment deposition, due to the nature of resuspension and deposition within their natural high energy environment. Based on the species reduced sensitivity to increased SSC and deposition, and the broadscale distribution of suitable habitats, sandeel are deemed to be of low sensitivity.

4.10.124 Potential sandeel spawning grounds and prime and sub-prime habitats are located within the offshore ECC. However, Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology concludes any impacts on this species are expected to be relatively small in the context of the spawning habitat available across the southern North Sea.

4.10.125 The impact of increased SSC and sediment deposition on spawning Blackwater herring, sandeel and all other fish and shellfish receptors is considered to be of low magnitude, and the maximum sensitivity of all receptors is considered to be **low**, which results in at worst minor adverse effects for seabird prey species. Based on this, the level of effects on seabird IOFs are considered to be **negligible or minor adverse**, which is **not significant** in EIA terms.

ARRAY AREAS

4.10.126 In the array areas temporary localised increases in SSC and associated sediment deposition and smothering are expected from foundation and cable installation works and seabed preparation works (including sandwave clearance).

4.10.127 Sediment plumes caused by seabed preparation and construction activities are expected to be restricted to within a single tidal excursion from the point of release and are expected to quickly dissipate after cessation of the construction activities, due to settling and wider dispersion with the concentrations reducing quickly over time to background levels (i.e., within a couple of tidal cycles). Sediment deposition will consist primarily of coarser sediments deposited close to the source (a few hundred meters), with a small proportion of silt deposition (reducing exponentially from source).

4.10.128 Potential sandeel spawning grounds and preferred habitats (as determined by sand content) are located across the array areas, however, as noted above, the sensitivity of the species is considered to be low.

4.10.129 Impacts from increased suspended sediment concentration and sediment deposition are considered to be of greater concern for herring eggs. There is a slight overlap with the Downs herring spawning ground lying to the east of the array areas, however, any impacts on this species will be relatively small in the context of the spawning habitat available across the southern North Sea and English Channel and therefore any impacts form suspended sediment concentration and deposition are not likely to have a population level effect. Adult herring are mobile and as such would be expected to avoid unfavourable areas. Herring is considered to be of low sensitivity to increases in suspended sediment concentration and sediment deposition from construction activity.

4.10.130 Pelagic spawning species such as sprat are mobile, widely spread across the southern North Sea, and will experience exposure to naturally high variability to suspended sediment concentration within their natural range.

4.10.131 For all prey species, a minor adverse effect was predicted in Volume 6, Part 2, Chapter 6 Fish and Shellfish Ecology. With regard to changes to the seabed and to suspended sediment levels, Volume 6, Part 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology discuss the nature of any change and impacts on the seabed and benthic habitats. The impact on benthic habitats is predicted to be of local spatial extent (i.e., restricted to discrete areas within array areas, short-term duration (as it is limited to the duration of construction activities), intermittent and with high reversibility. The consequent indirect impact is considered to be at worst a low impact magnitude for species which are the main prey items of seabirds.

4.10.132 Based on the above information, it is concluded that the indirect effect significance from increased suspended sediment concentration and sediment deposition on seabirds occurring in or around the array areas during the construction phase is a **negligible or minor adverse** effect for all IOFs, which is **not significant** in EIA terms.

ACCIDENTAL POLLUTION EVENTS

ARRAY AREAS

4.10.133 With regard to accidental pollution impacts, Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology assesses the potential impacts upon fish relevant to ornithology as prey species of seabirds.

4.10.134 It is stated that the likelihood of an incident will be reduced by the implementation of an Outline PEMP and Outline Marine Pollution Contingency Plan (MPCP), which will be approved by the relevant stakeholders and secured through DCO. Taking this into consideration, the magnitude of impact is therefore considered to be low for all prey species.

4.10.135 The sensitivity of the prey species will vary depending on a range of factors including species and life stage with adult fish less likely to be affected by marine pollution, due to their increased mobility, compared to fish eggs, larvae, juveniles and shellfish species. Any such pollution events will therefore have varying levels of effect dependent on the species present, and pollutants involved. However, as fuel and oil spills are likely to be dispersed on the surface, effects on seabird prey species are likely to be limited. The sensitivities of fish and shellfish to marine pollution were assessed as having a maximum sensitivity of medium, giving an overall minor adverse effect for all prey species.

4.10.136 Based on the above information, it is concluded that the indirect effect significance from accidental pollution on seabirds occurring in or around the array areas during the construction phase is a **negligible or minor adverse** effect for all IOFs, which is **not significant** in EIA terms.

OFFSHORE EXPORT CABLE CORRIDOR

4.10.137 Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology states that the magnitude of an accidental spill will be limited by the size of chemical or oil inventory on construction vessels. In addition, released hydrocarbons will be subject to rapid dilution, weathering and dispersion and will be unlikely to persist in the marine environment. The likelihood of an incident will be reduced by the implementation of an Outline PEMP and MPCP, which will be approved by the relevant stakeholders and secured through DCO. Taking this into consideration, the magnitude of impact is therefore considered to be low for all prey species.

4.10.138 The sensitivities of fish and shellfish receptors to marine pollution were assessed as having a maximum sensitivity of medium, giving an overall minor adverse effect for all prey species.

4.10.139 Based on the above information, it is concluded that the indirect effect significance from accidental pollution on seabirds occurring in or around the offshore ECC during the construction phase is a **negligible or minor adverse** effect for all IOFs, which is **not significant** in EIA terms.

OFFSHORE EXPORT CABLE CORRIDOR AND ARRAY AREAS

4.10.140 It is possible that noise, sediment deposition or accidental pollution impacts arising in the array areas and offshore ECC may overlap.

4.10.141 If separate vessel aggregations (up to three each in either area) occur within the offshore ECC and array areas at the same time, then the extent of noise impacts on prey species may temporarily increase.

4.10.142 Likewise, if the activities causing sediment disturbance to occur at the same time (to within a few minutes or hours at the most) and in locations that are closely aligned with respect to the ambient tidal currents so that a second plume is created within the footprint of effect of another plume, the effect on SSC is locally additive in the area of overlap. If activities causing sediment disturbance occur at any time in locations that are closely aligned with respect to direction of the ambient tidal currents, the total sediment thickness deposited is locally additive in the area of overlap. It is noted that measurable thicknesses of deposition are only expected within relatively small distances (tens of metres) from the site of the activity, extending in the direction of tidal current at the time of the work. Therefore, there is a very low likelihood of a large total area of overlapping measurable local thicknesses of deposition resulting from overlapping plume effects.

4.10.143 Accidental pollution impacts may potentially occur within the array area and offshore ECC and may bridge or transition between the two areas. The impacts will be localised with no additive spatial overlap.

4.10.144 For all indirect impacts it is however the case that, as described above in Impact 1: Direct Disturbance and Displacement, it is unlikely that the most sensitive IOFs (red-throated diver, common scoter, guillemot and razorbill) would be present in important numbers in both the offshore ECC and array areas, based on observed distribution and abundances and known habitat preference within the study area. As such there is unlikely to be an additive indirect effect on any IOF at a population level, and a **negligible or minor adverse** effect is therefore predicted for all IOFs, which is **not significant** in EIA terms.

4.11 ENVIRONMENTAL ASSESSMENT: OPERATIONAL PHASE

IMPACT 3: DIRECT DISTURBANCE AND DISPLACEMENT

OFFSHORE EXPORT CABLE CORRIDOR

4.11.1 Following installation of the offshore cable, the required operational and maintenance activities in relation to the offshore export cable may have short-term and localised disturbance and displacement impacts on birds. However, disturbance from operational activities would be relatively infrequent (estimated nine repairs during 40-year lifespan of project, see MDS, Table 4.15) temporary and localised, and are unlikely to result in detectable effects at either the local or regional population level.

4.11.2 As outlined in section 4.4.3, it was agreed during the consultation process (Table 4.2) that impacts associated with displacement within the offshore ECC during the operational phase could therefore be scoped out due to a lack of likely significant effect.

ARRAY AREAS

4.11.3 The presence of WTGs and associated infrastructure and operational activities have the potential to directly disturb and displace birds from within and around the array areas. This can be interpreted as an indirect habitat loss, as it has the potential to reduce the area available to birds for feeding, loafing and moulting, and may result in reduction in survival rates of displaced birds. The presence of WTGs associated ancillary structures, vessel activity and factors such as the lighting of WTGs could also attract (or repel) certain species of birds and affect migratory behaviour on a local scale.

4.11.4 As offshore windfarms are relatively new features in the marine environment, there is limited robust empirical evidence about the disturbance and displacement effects of the operational infrastructure in the long term, although the number of available studies of post-construction monitoring is increasing (e.g., JNCC 2015, Dierschke *et al*. 2016, Vallejo *et al*. 2017, MMO 2018; MacArthur Green, 2019b). Dierschke *et al*. (2016) reviewed evidence from 20 operational offshore windfarms in European waters. They found strong avoidance by divers, gannet, great crested grebe, and fulmar; less consistent displacement by razorbill, guillemot, little gull and sandwich tern; no evidence of any consistent response by kittiwake, common tern and Arctic tern, evidence of weak attraction to operating offshore windfarms for common gull, black-headed gull, great black-backed gull, herring gull, lesser black-backed gull and red-breasted merganser, and strong attraction for shags and cormorants. Thaxter *et al*. (2018) also found no evidence of macro-avoidance of offshore windfarms by lesser black-backed gulls. For cormorants and shags the presence of structures for roosting and drying plumage is a factor in attraction, while other species appear to benefit from increases in food abundance within operational offshore windfarms.

4.11.5 During operation, the WTGs and offshore platforms will have lights for air safety and navigational safety. There would be other lighting for personnel working at night, however these would not be as bright as air and navigational safety lighting. Air safety lights will be placed high on the WTG structures, and as a minimum on WTGs at the periphery of the arrays. Navigational lights for shipping will be placed lower on WTG structures and other offshore structures.

4.11.6 A review by Furness (2018b) of the potential effects of operational lighting on birds considered eight categories of potential effect on birds: disruption of photoperiod physiology; extension of daytime activity; phototaxis of seabirds; phototaxis of nocturnal migrant birds; ability of birds to use artificial light to feed at night or to feed on prey aggregating under artificial lights; increased predation risk for nocturnal migrant birds; birds better able to avoid collision when structures are illuminated; displacement of birds due to avoidance of artificial lights. The available evidence suggests that lights on offshore wind turbines in European shelf seas are extremely unlikely to have any detectable effect on birds as a consequence of any of the processes listed above. The effects of operational lighting are therefore not assessed separately.

4.11.7 There is currently no empirical evidence that birds displaced from windfarms, or exposed to barrier effects, suffer increased mortality. Any mortality due to displacement would most likely be a result of increased densities of foraging birds in locations outside the affected area, resulting in increased competition for food. This would be unlikely for seabirds that have large areas of alternative habitat available but would be more likely to affect seabirds with highly specialised habitat requirements that are limited in availability (Furness and Wade 2012; Bradbury *et al*. 2014). Impacts of displacement are also likely to be dependent on other environmental factors such as food supply and are expected to be greater in years of low prey availability (e.g., as could result from unsustainably high fisheries pressures or effects of climatic changes on fish populations). Furthermore, modelling of the consequences of displacement for fitness of displaced birds suggests that even in the case of breeding seabirds that are displaced on a daily basis, there is likely to be little or no impact on survival unless the offshore windfarm is close to the breeding colony (Searle *et al*. 2014, 2017).

DISPLACEMENT ASSESSMENT METHODOLOGY

4.11.8 The assessment of displacement impacts is based on the guidance note from the UK Statutory Nature Conservation Bodies (SNCB 2017; updated 2022), which is endorsed by Parker *et al.* (2022c).

4.11.9 Displacement is defined as '*a reduced number of birds occurring within or immediately adjacent to an offshore windfarm*' (Furness *et al*. 2013) and can act upon birds present in the air and on the water (SNCB 2017; updated 2022). Birds that do not intend to utilise a windfarm area but would have previously flown through the area on the way to a feeding, resting or nesting area, and which either stop short or detour around a development, are subject to barrier effects (SNCB 2017; updated 2022).

4.11.10 Birds are considered to be most at risk from operational disturbance and displacement effects when they are resident in an area, for example during the breeding season or wintering season, as opposed to passage or migratory seasons.

4.11.11 Resident birds may regularly encounter and be displaced by an offshore windfarm for example during daily commuting trips to foraging areas from nest sites, whereas birds on passage may encounter (and potentially be displaced from) a particular offshore windfarm only once during a given migration journey.

4.11.12 For the purposes of assessment of displacement for resident birds, it is usually not possible to distinguish between displacement and barrier effects - for example to define where individual birds may have intended to travel to, or beyond an offshore windfarm, even when tracking data are available. Parker *et al.* (2022c) notes that "*at present there is insufficient evidence to quantitively separate these impacts* [displacement and barrier effects] *out and apportion to the two groups. Therefore, for the purposes of environmental assessments, it is assumed that total numbers of birds on site (flying and on water) are subject to displacement impacts*." Therefore, in this assessment the impacts of displacement and barrier effects on the key resident seabird species are considered together.

4.11.13 The small risk of impact to migrating birds resulting from flying around rather than through, the wind turbine array of an offshore windfarm is considered a potential barrier effect but has been scoped out of the assessment. Masden *et al*. (2010, 2012) and Speakman *et al*. (2009) calculated that the costs of one-off avoidances during migration were small, accounting for less than 2% of available fat reserves. A recent tracking study on guillemots and razorbills (Buckingham *et al*. 2022) found that some birds make hitherto unknown lengthy moult migrations (round trips of up to 4,000km), which suggests that flying a few extra kilometres around an offshore wind farm is very unlikely to reduce their body condition enough to increase their risk of death. Therefore, the impacts on birds that only migrate seasonally through the region (including seabirds, waders and waterbirds on passage) are considered negligible and these have been scoped out of detailed assessment.

4.11.14 The focus of this section is on the disturbance and displacement of birds due to the presence and operation of WTGs, other offshore infrastructure and any maintenance operations associated with them. The extent of displacement used in the assessment is considered to be the worst-case scenario for all types of disturbance and displacement working together – i.e., it estimates the reaction and impacts of birds due to the presence of operational WTGs and ongoing operational maintenance activities simultaneously. The worst-case is based on the Small WTGs scenario MDS outlined in Table 4.15.

4.11.15 The methodology presented in the updated SNCB Advice Note (SNCB 2017; updated 2022) and endorsed by Parker *et al.* (2022c) recommends a matrix is presented for each key species showing bird losses at differing rates of displacement and mortality. This assessment uses the range of predicted losses, in association with the scientific evidence available from post-construction monitoring studies, to quantify the level of displacement and the potential losses as a consequence of the proposed project. These losses are then placed in the context of the relevant population (e.g. BDMPS) to determine the magnitude of impact.

4.11.16 In order to focus the assessment, a screening exercise was undertaken to identify those species most likely to be at risk (Table 4.18). These species were then assessed within the biological seasons to which effects were potentially likely to occur. Any species with a low sensitivity to displacement and/or recorded only in very small numbers within the study area during the breeding and wintering seasons, was screened out of further assessment. Table 4.18 presents the general sensitivity to disturbance and displacement for each species, and rationale for scoping in/out.

Table 4.18: Operational Disturbance and Displacement Screening.

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Season(s)	Rationale
Red-throated diver	High	IN	Midwinter, Spring migration	Recorded occasionally outside the breeding season but sensitive to disturbance and displacement
Common scoter	High	OUT	N/A	Not recorded during baseline surveys.
Fulmar	Considered Low in some studies, but possibly high according to Dierschke *et al*. (2016)	OUT	N/A	The species has a maximum habitat flexibility score of 1 in Furness and Wade (2012), suggesting it utilises a wide range of habitats over a large area.
Gannet	Considered Low in some studies, but possibly high according to Dierschke *et al*. (2016), and has a high macro-avoidance rate for windfarms	IN	Breeding, Autumn and Spring migration	Potentially susceptible to displacement from WTGs and can be abundant
Cormorant	Considered high in some studies but species is attracted to offshore windfarm structures	OUT	N/A	Recorded on only one baseline survey (south array)
Arctic skua	Low	OUT	N/A	Single individuals occasionally in buffers only

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Season(s)	Rationale
Great skua	Low	OUT	N/A	Recorded in low numbers during passage migration periods
Puffin	Medium	OUT	N/A	Single individuals recorded in 4km buffers only on two surveys
Razorbill	Medium	IN	Year round	Potentially susceptible to displacement from WTGs and abundant
Guillemot	Medium	IN	Year round	Potentially susceptible to displacement from wind turbines and abundant
Common tern	Low	OUT	N/A	Recorded in low numbers and not very susceptible to displacement
Sandwich tern	Low	OUT	N/A	Recorded in low numbers and not very susceptible to displacement
Kittiwake	Low	OUT	N/A	No clear evidence of displacement from wind turbines
Black-headed gull	Low	OUT	N/A	No clear evidence of displacement from wind turbines

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Season(s)	Rationale
Little gull	Low	OUT	N/A	No clear evidence of displacement from wind turbines
Common gull	Low	OUT	N/A	No clear evidence of displacement from wind turbines
Lesser black-backed gull	Low	OUT	N/A	No clear evidence of displacement from wind turbines
Herring gull	Low	OUT	N/A	No clear evidence of displacement from wind turbines
Great black-backed gull	Low	OUT	N/A	No clear evidence of displacement from wind turbines
1. With reference to Garthe and Hüppop, 2004; Furness and Wade, 2012, Furness *et al*., 2013, Wade *et al*., 2016, Dierschke *et al*., 2016)				

4.11.17 Displacement rates to be considered in the matrices are based on observations of macro-avoidance, that is avoidance at the level of the whole windfarm rather than the WTG, and are derived from a review of monitoring reports at constructed windfarms (Krijgsveld *et al*., 2011, Leopold *et al*., 2011, Vanermen *et al*. 2013, Walls *et al*., 2013, Mendel *et al*. 2014, Braasch *et al*. 2015, Skov *et al*. 2018, Cook *et al*. 2018).

4.11.18 The reference population estimate used for each species to assess the magnitude of displacement impacts was the relevant seasonal peak mean (i.e., the highest mean value for the months within each season, detailed in Volume 6, Part 5, Annex 4.6: Seabird Peak Seasonal Abundances). The seasonal peaks were calculated as follows: first the density for each calendar month was calculated (as the average of the density in each survey undertaken in that month), then the highest value from the months within each season extracted.

4.11.19 The appropriate buffer is used to assess displacement effects, following the guidance set out in joint SNCB advice, noting updated advice for red-throated diver (SNCBs, 2017; updated 2022). As per the updated SNCB (2017; updated 2022) guidance for assessing displacement impacts on divers, where more than 10km from an SPA, the assessment used all data recorded within the 4km buffer, for all other scoped-in species the assessment used all data recorded within the 2km buffer. Seasonal site population estimates for species included in the displacement assessment are included in Table 4.19.

4.11.20 Although birds are considered to be most at risk from operational disturbance and displacement effects when they are resident (e.g., during the breeding season or wintering season), SNCB (2017; updated 2022) suggests that migration periods should also be assessed using the matrix approach and this has been undertaken where appropriate.

4.11.21 For each species and season assessed, the predicted mortality due to displacement was determined and the impact of this assessed in terms of the change in the baseline mortality rate of the relevant population. It has been assumed that all age classes are equally at risk of displacement in proportion to their presence in the population.

4.11.22 As no information on seasonal population age structure is available from site data, it is necessary to calculate an average baseline mortality rate for all age classes for each species screened in for assessment. These were calculated using empirical information on the survival rates for each age class and their relative proportions in the population. The demographic rates and the age class proportions, and average mortality rates calculated from them are presented in

4.11.23 Table 4.20.

Table 4.19: Seasonal Peak Mean Populations (and 95% confidence intervals) for Species Assessed for Displacement from the arrays during operation.

Species	Area considered for displacement	Breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
Red-throated diver	North Array + 4km buffer	6.82 (0-13.64) *	3.52 (0-10.55)	6.75 (0-13.5)	16.8 (3.36-36.96)	-
	South Array + 4km buffer	6.83 (0-20.48)	-	10.1 (3.37-16.83)	13.41 (0-23.45)	-
Gannet	North Array + 2km buffer	112.62 (49.31-186.42)	393.78 (200.34-604.82)	-	26.95 (0-64)	-
	South Array + 2km buffer	120.39 (10.62-258.49)	245.97 (122.9-361.9)	-	40.14 (6.68-80.31)	-
Razorbill	North Array + 2km buffer	66.03 (19.13-126.36)	121.62 (29.57-221.14)	749.48 (445.27-1066.68)	502.34 (314.51-698.91)	749.48 (445.27-1066.68)
	South Array + 2km buffer	24.42 (0-52.2)	162 (29.37-320.03)	296.55 (94.98-526.09)	254.13 (118.33-402.81)	377.85 (216.15-552.5)
Guillemot	North Array + 2km buffer	776.35 (509.63-1057.38)	117.7 (52.31-187.44)	275.54 (148.32-402.76)	806.11 (425.3-1157.32)	806.11 (425.3-1157.32)
	South Array + 2km buffer	424.22 (242.04-605.94)	62.81 (14.02-127.68)	319.99 (128.86-521.91)	2891.87 (1963.73-3834.24)	2891.87 (1963.73-3834.24)

* The array areas are not within foraging range of any breeding colonies of red-throated diver. Although birds were recorded during the full breeding season (March to August), this overlaps with the spring migration period (February to April). The peak

Species	Area considered for displacement	Breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
number of birds recorded in the overlapping period (February in north array) is considered to comprise birds on spring migration. During the migration free breeding season (May until August) birds were only recorded in May (north array); these are considered likely to be birds migrating late to breeding areas and/or sub-adult birds.						

Table 4.20: Average Annual Mortality Across Age Classes Calculated Using Age-Specific Demographic Rates and Age Class Proportions.

Species	Parameter	Age class						Productivity	Average mortality
		0-1	1-2	2-3	3-4	4-5	Adult		
Red-throated diver	Survival	0.6	0.62	-	-	-	0.84	0.571	0.228
	Proportion in population	0.179	0.145	-	-	-	0.678		
Gannet	Survival	0.424	0.829	0.891	0.895	-	0.912	0.7	0.191
	Proportion in population	0.191	0.081	0.067	0.06	-	0.6		
Guillemot	Survival	0.56	0.792	0.917	0.939	0.939	0.939	0.672	0.14
	Proportion in population	0.168	0.091	0.069	0.062	0.056	0.552		
Razorbill	Survival	0.63	0.63	0.895	0.895	-	0.895	0.57	0.174
	Proportion in population	0.159	0.102	0.065	0.059	-	0.613		

4.11.24 Parker *et al.* (2022c) advise that displacement effects estimated in different seasons should be combined to provide an annual effect for assessment which should then be assessed in relation to the largest of the component BDMPS populations. Natural England has acknowledged that summing impacts in this manner almost certainly over-estimates the number of individuals at risk through double counting (i.e., some individuals may potentially be present in more than one season) and assessing against the BDMPS almost certainly under-estimates the population from which they are drawn (which must be at least this size and is likely to be considerably larger as a consequence of turnover of individuals). However, at the present time there is no agreed alternative method for undertaking assessment of annual displacement and therefore the above approach is presented, albeit with the caveat that the results are anticipated to be highly precautionary.

RED-THROATED DIVER

Sensitivity

4.11.25 Red-throated divers are considered to have a **high sensitivity** to disturbance and displacement, and they are prone to avoiding disturbed areas such as shipping lanes, as well as offshore windfarms (Garthe and Hüppop 2004; Bellebaum *et al*. 2006; Petersen *et al*. 2006; Schwemmer *et al*. 2011; Furness and Wade 2012; Furness *et al*. 2013; Bradbury *et al*. 2014; Percival 2014; Dierschke *et al*. 2017; Mendell *et al*. 2019; Irwin *et al*. 2019). This is consistent with the SNCB (2017; updated 2022) guidance.

4.11.26 A detailed review of the evidence for displacement of red-throated divers from offshore windfarms, and the likely effects on displacement on population mortality rates, is included in Norfolk Vanguard Ltd (2019a). That review found that most studies found a marked decrease (around 90%) in red-throated diver densities within operational windfarms when compared to pre-construction data, however the distance outside the windfarm over which diver densities were reduced was more variable. At the extremes, Percival (2013) found no reduction in diver density outside Thanet offshore windfarm even within 500m of the outer wind turbines, whereas Mendel *et al*. (2019) found a statistically detectable reduction in density up to 12km from the outer wind turbines. This variation is unexplained. It might relate to ecological conditions or to the seascape/landscape of the site. Behaviour may vary seasonally, for example, depending on ecological constraints at different times of year, such as may arise during flight-feather moult when birds may become flightless. Birds might show greater avoidance distances where they are unconstrained. At sites where suitable or optimal habitat is limited, birds might show lower displacement distances because of constraints imposed by habitat availability. Alternatively, divers may show stronger avoidance of visible structures at sea where these are against an ‘empty’ background seascape.

4.11.27 Where structures are in front of a cluttered background of coast, perhaps especially a coast with industrial development, wind turbines may appear less prominent and/or may be seen by divers as less threatening.

4.11.28 Two aerial surveys of red-throated divers in the Outer Thames Estuary SPA in February 2018 (Irwin *et al*. 2018) found that densities were notably increased in waters either side of shipping lanes and the London Array windfarm, indicative of displacement behaviour. There were significant differences in the mean density of birds within areas of the SPA outside the footprints of windfarms (>3 birds per km^2), and those within wind farm footprints (<1 bird per km^2), however these displacement effects were not quantified in any further detail in the survey report.

4.11.29 The largest distances from offshore windfarms over which diver densities were reduced were in the German Bight, a very large area of open sea far from the coast. The smallest displacement distances from offshore windfarms were at sites close to the UK coast where anthropogenic influences on the coastal scenery are high (Thanet, Kentish Flats) (MacArthur Green 2019a).

4.11.30 Displacement rates of 60% to 80% were reported for Egmond aan Zee offshore windfarm (OWEZ) (Leopold *et al*. 2011). The Offshore Renewables Joint Industry Programme (ORJIP) bird avoidance study at Thanet offshore windfarm (Skov *et al*. 2018) reported records of 82 radar tracks and 42 laser rangefinder tracks of red-throated divers. This would appear to provide an adequate sample size to assess macro-avoidance of that windfarm, although avoidance behaviour of this species is not assessed in the report, as it was not one of the key species in that study.

4.11.31 Monitoring studies of red-throated divers at the Kentish Flats offshore windfarm found an observable shift of birds away from the wind turbines, particularly within 500m of the site (Percival 2010). Further pre-construction and post-construction abundance and distribution studies have provided displacement values for both the site footprint and within distance bands away from the site boundary. Percival (2014) reported that while displacement within the windfarm boundary was around 80% (compared to pre-construction), this declined to 10% at 1km from the windfarm and was 0% beyond 2km. A similar within windfarm reduction in density was reported at Thanet, but there was no detectable displacement beyond the windfarm boundary (Percival 2013).

4.11.32 A study of pre-construction and post-construction abundance and distribution of birds conducted at Horns Rev offshore windfarm, Denmark, found that red-throated divers avoided areas of sea that were apparently suitable (favoured habitat, suitable depth and abundant food sources) following the construction of an offshore windfarm, and that this effect remained for a period of three years (Peterson *et al*. 2006).

4.11.33 A large-scale and long-term analysis of the distribution of red-throated divers in the German North Sea found decreases in abundance detectable as far as about 12km from the closest operational offshore wind farm (Mendel *et al*. 2018).

4.11.34 If red-throated divers were to habituate over time to offshore windfarms, then habitat loss might reduce to negligible in the long term. There is no clear evidence, however, for habituation (Norfolk Vanguard Ltd 2019a).

4.11.35 Modelling of data from pre-construction, construction and post-construction for the London Array Windfarm considered 1km buffers extending around the wind farm up to 15km. Red-throated diver density close to the windfarm was found to decline significantly between the pre-construction and construction periods; preliminary data from the post-construction period, however, may suggest that divers recolonised the windfarm and surrounding areas after construction had been completed (APEM 2016). It was noted that the densities of divers in the study area may vary to a large extent between years, and, as well as the presence of offshore wind farms and shipping activities, the total numbers of birds present as well as changes in other environmental conditions will influence the distribution of birds in a given year.

4.11.36 Displacement could influence the survival of individual red-throated divers through increased energy costs and/or decreased energy intake. The former could arise if birds had to fly more to avoid offshore windfarms or to reach more distant foraging areas. The latter could arise if birds were displaced to lower quality habitat where food capture rates were reduced, and/or if displacement resulted in an increase in the density of divers and an increase in intra-specific competition. Alternatively, displacement may have no effect on individuals if birds are displaced into equally good habitat so that their energy budget is unaffected, or if birds could buffer any impact on energy budget by adjusting their time budget (for example by spending a higher proportion of the time foraging rather than resting in order to compensate for an increase in energy budget) (Norfolk Vanguard Ltd 2019a).

4.11.37 SNCB (2017; updated 2022) guidance advises for red-throated diver that the assessment for displacement is based on a displacement rate of 100% within the offshore wind farm site and a 4km buffer (being >10km from the Outer Thames SPA), and a mortality rate of up to 10% for displaced birds.

4.11.38 In relation to the degree of displacement from a windfarm and 4km buffer, it is noted that displacement has been demonstrated to decline with distance from a site. Norfolk Vanguard Ltd (2019a) used a precautionary rate of 90% displacement from an offshore windfarm and a 4km buffer based on a detailed review of available evidence, and this is considered to be a more realistic but still precautionary assumption.

4.11.39 At VE, the largest numbers of red-throated divers were recorded during the early spring migration period, at which time there is likely to be a turnover of individuals passing through the area, rather than a wholly resident population. Thus, a given individual might only be displaced once from the array area(s), as opposed to being displaced multiple times if it was resident over the three-month spring migration period. Taking this into account, and the review above of the likely impacts of displacement during the non-breeding season on survival rates of red-throated divers it is considered that 1% mortality is a more appropriate precautionary estimate.

4.11.40 The displacement matrices in Table 4.21 through

4.11.41 Table 4.25 have been populated with data for red-throated diver during the autumn migration, nonbreeding and spring migration periods within the site and a 4km buffer in line with recommendations (SNCB 2017; updated 2022). The array areas are not within an area designated for high densities of red-throated divers, suggesting that the habitat is less important to this species than the nearby Outer Thames Estuary SPA (about 17km from the array areas at the nearest point), or within foraging range of any breeding areas for red-throated divers.

Autumn Migration

4.11.42 During the autumn migration, red-throated divers were recorded within the north array study area (4km buffer) but were absent in the south array study area. Within the range of 100% displacement and 1-10% mortality, the number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement from the north array during the autumn migration period has been estimated as zero individuals (Table 4.21). This would not increase the background mortality rate of the autumn BDMPS for red-throated diver (13,277; Furness, 2015), and so the effect is **negligible** and **not significant** in EIA terms.

Table 4.21: North Array displacement matrix for red-throated diver during the autumn migration period. The cells show the predicted mortality (rounded to the nearest integer) at a given rate of displacement and mortality.

Autumn migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	0	0	0	0	0	0	0
	20%	0	0	0	0	0	0	0	0	0	1	1
	30%	0	0	0	0	0	0	0	0	1	1	1
	40%	0	0	0	0	0	0	0	0	1	1	1
	50%	0	0	0	0	0	0	0	1	1	1	2
	60%	0	0	0	0	0	0	0	1	1	2	2
	70%	0	0	0	0	0	0	0	1	1	2	2
	80%	0	0	0	0	0	0	1	1	1	2	3
	90%	0	0	0	0	0	0	1	1	2	3	3
	100%	0	0	0	0	0	0	1	1	2	3	4

Midwinter

4.11.43 Red-throated divers were recorded in both the north and south array study areas during the midwinter period.

4.11.44 Within the range of 100% displacement and 1-10% mortality, the number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement from the north and south array areas combined during the midwinter period has been estimated as 0-2 individuals (Table 4.22 and Table 4.23). The BDMPS for red-throated diver in winter is 10,177 (Furness 2015).

4.11.45 At the average baseline mortality rate for red-throated diver of 0.228, the number of individuals expected to die in the midwinter BDMPS is 2,320 (10,177 x 0.228). The addition of a maximum of two to this increases the mortality rate by 0.09%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the midwinter period, the magnitude of impact is assessed as **negligible**. As the species is of high sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Table 4.22: North array displacement matrix for red-throated diver during the Midwinter Period.

Midwinter		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	0	0	0	0	0	1	1
	20%	0	0	0	0	0	0	0	0	1	1	1
	30%	0	0	0	0	0	0	0	1	1	2	2
	40%	0	0	0	0	0	0	1	1	1	2	3
	50%	0	0	0	0	0	0	1	1	2	3	3
	60%	0	0	0	0	0	0	1	1	2	3	4
	70%	0	0	0	0	0	0	1	1	2	4	5
	80%	0	0	0	0	0	1	1	2	3	4	5
	90%	0	0	0	0	0	1	1	2	3	5	6
	100%	0	0	0	0	0	1	1	2	3	5	7

Table 4.23: South array displacement matrix for red-throated diver during the Midwinter Period.

Midwinter		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	0	0	0	0	1	1	1
	20%	0	0	0	0	0	0	0	1	1	2	2
	30%	0	0	0	0	0	0	1	1	2	2	3
	40%	0	0	0	0	0	0	1	1	2	3	4
	50%	0	0	0	0	0	1	1	2	3	4	5
	60%	0	0	0	0	0	1	1	2	3	5	6
	70%	0	0	0	0	0	1	1	2	4	6	7
	80%	0	0	0	0	0	1	2	2	4	6	8
	90%	0	0	0	0	0	1	2	3	5	7	9
	100%	0	0	0	0	1	1	2	3	5	8	10

Spring Migration

4.11.46 Red-throated divers were recorded in both the north and south array study areas during the spring migration period. With no breeding sites within foraging range of the array areas, birds present during the breeding season are also considered to be non-breeders that form part of the larger spring migration population, with records occurring in April and May.

4.11.47 Within the range of 100% displacement and 0-10% mortality, the number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement from the two array areas combined during the spring migration period (including the breeding season) has been estimated as 0-3 individuals (Table 4.24 and

4.11.48 Table 4.25). The BDMPS for red-throated diver in spring is 13,277 (Furness, 2015). The loss of a maximum of three birds to the spring BDMPS increases the mortality rate by 0.1%. This magnitude of increase in mortality is considered highly unlikely as during this period birds would be passing through the site during migration, and there is likely to be a turnover of individuals passing through the area, rather than a resident population. Thus, a given individual might only be displaced once from the array areas, as opposed to being displaced multiple times if it was resident over the three-month spring migration period. Therefore, during the spring migration period, the magnitude of impact is assessed as **negligible**. As the species is of high sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Table 4.24: North array displacement matrix for red-throated diver during the spring migration period (including birds recorded during breeding season).

Spring migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	0	0	0	1	1	1	2
	20%	0	0	0	0	0	0	1	1	2	3	3
	30%	0	0	0	0	0	1	1	2	3	4	5
	40%	0	0	0	0	0	1	1	2	3	5	7
	50%	0	0	0	0	0	1	2	3	4	7	9
	60%	0	0	0	0	1	1	2	3	5	8	10
	70%	0	0	0	0	1	1	2	4	6	10	12
	80%	0	0	0	1	1	1	3	4	7	11	14
	90%	0	0	0	1	1	2	3	5	8	12	15
	100%	0	0	1	1	1	2	3	5	9	14	17

Table 4.25: South array displacement matrix for red-throated diver during the spring migration period (including birds recorded during breeding season).

Spring migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100 %
Displacement	10%	0	0	0	0	0	0	0	0	1	1	1
	20%	0	0	0	0	0	0	1	1	1	2	3
	30%	0	0	0	0	0	0	1	1	2	3	4
	40%	0	0	0	0	0	1	1	2	3	4	5
	50%	0	0	0	0	0	1	1	2	3	5	7
	60%	0	0	0	0	0	1	2	2	4	6	8
	70%	0	0	0	0	0	1	2	3	5	7	9
	80%	0	0	0	0	1	1	2	3	5	8	10
	90%	0	0	0	0	1	1	2	4	6	9	12
	100%	0	0	0	1	1	1	3	4	7	10	13

Year Round

4.11.49 Considering the year-round effects, the maximum number of red-throated divers expected to be lost as a result of displacement from the two array areas, at a displacement rate of 100% and mortality of 1-10%, would be 0-5 (adding the numbers predicted to be displaced during autumn migration, winter, spring migration and breeding season, and noting that the totals in each table and the combined total are expressed to the nearest integer).

4.11.50 The biogeographic red-throated diver population with connectivity to UK waters is 27,000 (Furness 2015). At the average baseline mortality rate for red-throated diver of 0.228, the number of individuals expected to die over one year is 6,156 (27,000 x 0.228). The addition of 0-5 to this increases the mortality rate by up to 0.08%. Most of this mortality is predicted during the spring migration period, when birds would be passing through the site rather than resident in the area. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of impact is assessed as **negligible**. As the species is of high sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

GANNET

Sensitivity

4.11.51 Gannets show a low sensitivity to ship and helicopter traffic (Garthe and Hüppop 2004, Furness and Wade 2012, Furness *et al*. 2013), but appear to be of higher sensitivity to displacement from structures such as offshore WTGs (Wade *et al*. 2016; Dierschke *et al*. 2016) and on this basis SNCB (2017; updated 2022) guidance indicates that a detailed assessment of potential displacement should be carried out as standard.

4.11.52 Cook *et al*. (2018) review a number of studies of displacement of gannets from offshore windfarms. Where quantified, macro-avoidance rates (the percentage of birds taking action to avoid entering the wind turbine array) of 64% to 100% were reported. Some studies however reported no displacement response of gannets, possibly in areas where low densities of birds were present. Cook *et al*. (2018) recommended that the lowest of the quantified macro-avoidance rates, 64% for Egmond aan Zee offshore windfarm (Krijgsveld *et al* 2011) was appropriate for this species. A study of seabird flight behaviour at Thanet offshore windfarm, not included in the above review, found a macro-avoidance rate of 79.7% for gannets approaching within 3km of the windfarm (Skov *et al*. 2018).

4.11.53 Displacement impacts for gannets for the VE array areas were assessed during the autumn migration, spring migration and breeding periods, based on respective peak mean populations shown in Table 4.19, calculated for the array areas and a 2km buffer in line with the SNCB (2017; updated 2022) guidance. The inclusion of all birds within the 2km buffer, to determine the total number of birds subject to displacement, is precautionary, as in reality the avoidance rate is likely to fall with distance from the site. This has been demonstrated in a study of gannet distribution in relation to the nearby Greater Gabbard windfarm (APEM 2014).

4.11.54 Displacement matrices for gannets during the three periods (calculated for the site and a 2km buffer) are presented in Table 4.26 to Table 4.31, with values taken from the peak seasonal abundance estimates detailed in Volume 6, Part 5, Annex 4.6*: Seabird peak seasonal abundances.* Highlighted range of displacement rates are based on the recommendations of Cook *et al*. (2018) and also the findings of Skov *et al*. (2018). Mortality rates of displaced birds are assumed to be a maximum of 1%, as this species has high habitat flexibility (Furness and Wade 2012) indicating that displaced birds are predicted to readily find alternative habitats including foraging areas.

Autumn Migration

4.11.55 Based on displacement rates of 60% to 80% and a mortality rate of 1%, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from north and south array areas combined during the autumn migration period has been estimated as five individuals (cells highlighted in Table 4.26 and Table 4.27).

4.11.56 The BDMPS for gannet in autumn is 456,298 (Furness 2015). At the average baseline mortality rate for gannet of 0.191 (the number of individuals expected to die in the autumn BDMPS is 87,153 (456,298 x 0.191). The addition of a maximum of five to this increases the mortality rate by 0.005%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the autumn migration period, the magnitude of impact is assessed as **negligible**. As the species is of low to medium sensitivity to displacement, the effect is **minor adverse** at worst, which is **not significant** in EIA terms.

Table 4.26: North array displacement matrix for gannet during the autumn migration period.

Autumn migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	1	1	2	2	4	8	12	20	32	39
	20%	1	2	2	3	4	8	16	24	39	63	79
	30%	1	2	4	5	6	12	24	35	59	95	118
	40%	2	3	5	6	8	16	32	47	79	126	158
	50%	2	4	6	8	10	20	39	59	98	158	197
	60%	2	5	7	9	12	24	47	71	118	189	236
	70%	3	6	8	11	14	28	55	83	138	221	276
	80%	3	6	9	13	16	32	63	95	158	252	315
	90%	4	7	11	14	18	35	71	106	177	284	354
	100%	4	8	12	16	20	39	79	118	197	315	394

Table 4.27: South array displacement matrix for gannet during the autumn migration period.

Autumn migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	1	1	1	2	5	7	12	20	25
	20%	0	1	1	2	2	5	10	15	25	39	49
	30%	1	1	2	3	4	7	15	22	37	59	74
	40%	1	2	3	4	5	10	20	30	49	79	98
	50%	1	2	4	5	6	12	25	37	61	98	123
	60%	1	3	4	6	7	15	30	44	74	118	148
	70%	2	3	5	7	9	17	34	52	86	138	172
	80%	2	4	6	8	10	20	39	59	98	157	197
	90%	2	4	7	9	11	22	44	66	111	177	221
	100%	2	5	7	10	12	25	49	74	123	197	246

Spring Migration

4.11.57 Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement during the spring migration period has been estimated as zero (<1) individuals Table 4.28 and Table 4.29).

4.11.58 Therefore, during the spring migration period, the magnitude of effect is assessed as **negligible**. As the species is of low to medium sensitivity to displacement, the effect is **negligible**, which is **not significant** in EIA terms.

Table 4.28: North array displacement matrix for gannet during the spring migration period.

Spring migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	0	0	1	1	1	2	3
	20%	0	0	0	0	0	1	1	2	3	4	5
	30%	0	0	0	0	0	1	2	2	4	6	8
	40%	0	0	0	0	1	1	2	3	5	9	11
	50%	0	0	0	1	1	1	3	4	7	11	13
	60%	0	0	0	1	1	2	3	5	8	13	16
	70%	0	0	1	1	1	2	4	6	9	15	19
	80%	0	0	1	1	1	2	4	6	11	17	22
	90%	0	0	1	1	1	2	5	7	12	19	24
	100%	0	1	1	1	1	3	5	8	13	22	27

Table 4.29: South array displacement matrix for gannet during the spring migration period.

Spring migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	0	0	1	1	2	3	4
	20%	0	0	0	0	0	1	2	2	4	6	8
	30%	0	0	0	0	1	1	2	4	6	10	12
	40%	0	0	0	1	1	2	3	5	8	13	16
	50%	0	0	1	1	1	2	4	6	10	16	20
	60%	0	0	1	1	1	2	5	7	12	19	24
	70%	0	1	1	1	1	3	6	8	14	22	28
	80%	0	1	1	1	2	3	6	10	16	26	32
	90%	0	1	1	1	2	4	7	11	18	29	36
	100%	0	1	1	2	2	4	8	12	20	32	40

Breeding

4.11.59 The nearest gannet breeding colony to the proposed development is Bempton Cliffs within the Flamborough and Filey Coast SPA. The SPA is 275km from the VE array areas at the nearest point (Table 4.14). This is within the mean maximum foraging range of gannets, estimated as 315.2km (Woodward *et al*. 2019), the usual measure used to identify potential connectivity between a breeding seabird colony and foraging areas. Tracking data, however, suggest that breeding adults from that colony make very little, if any, use of the VE array areas during the breeding season (Langston *et al*. 2013).

4.11.60 A project that tagged breeding gannets at Alderney (Warwick-Evans et al, 2017) found that gannets were tracked foraging from the Alderney colony into the array areas and therefore it was agreed with Natural England to include the Alderney West Coast and Burhou Islands Ramsar site in the apportioning of impacts as part of the HRA assessment in the Volume 5, Report 4: RIAA.

4.11.61 Predicted displacement mortality of gannet during the breeding season has therefore been compared to the combined Flamborough and Filey Coast SPA and Alderney West Coast and Burhou Islands Ramsar site populations.

4.11.62 The Flamborough and Filey Coast SPA population at designation was 11,061 pairs, with a count of 13,125 pairs in 2022 (Clarkson *et al*. 2022). The Alderney West Coast and Burhou Islands Ramsar site population was estimated to be 17,078 breeding pairs in 2021 (Purdie *et al.* 2023) (compared to a citation population of 5,950 pairs in 2000-2001).

4.11.63 The 2021 and 2022 estimates of the two colonies have been used as a reference population here, being closer in time to baseline surveys. When including immatures, this equates to a total of 109,335 individuals, based on the immature per breeding adult ratio of 0.81 from Furness (2015).

4.11.64 At the average baseline mortality rate for gannet of 0.191 (Table 4.11) the number of individuals expected to die from the breeding season BDMPS is 20,883 (93,630 x 0.191). The addition of a maximum of two to this increases the mortality rate by <0.01%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the spring migration period, the magnitude of impact is assessed as **negligible**. As the species is of low to medium sensitivity to displacement, the effect is **minor adverse** at worst, which is **not significant** in EIA terms.

Table 4.30: North array displacement matrix for gannet during the breeding season.

Breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	1	1	2	3	6	9	11
	20%	0	0	1	1	1	2	5	7	11	18	23
	30%	0	1	1	1	2	3	7	10	17	27	34
	40%	0	1	1	2	2	5	9	14	23	36	45
	50%	1	1	2	2	3	6	11	17	28	45	56
	60%	1	1	2	3	3	7	14	20	34	54	68
	70%	1	2	2	3	4	8	16	24	39	63	79
	80%	1	2	3	4	5	9	18	27	45	72	90
	90%	1	2	3	4	5	10	20	30	51	81	101
	100%	1	2	3	5	6	11	23	34	56	90	113

Table 4.31: South array displacement matrix for gannet during the breeding season.

Breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	1	1	2	4	6	10	12
	20%	0	0	1	1	1	2	5	7	12	19	24
	30%	0	1	1	1	2	4	7	11	18	29	36
	40%	0	1	1	2	2	5	10	14	24	39	48
	50%	1	1	2	2	3	6	12	18	30	48	60
	60%	1	1	2	3	4	7	14	22	36	58	72
	70%	1	2	3	3	4	8	17	25	42	67	84
	80%	1	2	3	4	5	10	19	29	48	77	96
	90%	1	2	3	4	5	11	22	33	54	87	108
	100%	1	2	4	5	6	12	24	36	60	96	120

Year Round

4.11.65 Considering the year-round effects, the maximum number of gannets expected to be lost as a result of displacement from the two array areas, at a displacement rate of 60-80% and mortality of 1%, would be seven (adding the numbers predicted to be displaced during autumn migration, spring migration and breeding season for both array areas and noting that the totals in each table and the combined total are expressed to the nearest integer). The biogeographic gannet population with connectivity to UK waters is 1,180,000 (Furness 2015).

4.11.66 At the average baseline mortality rate for gannet of 0.191 the number of individuals expected to die over one year is 225,380 (1,180,000 x 0.191). The addition of a maximum of seven to this increases the mortality rate by 0.003%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of impact is assessed as **negligible**. As the species is of low to medium sensitivity to disturbance, the effect is **minor adverse** at worst, which is **not significant** in EIA terms.

AUKS (RAZORBILL AND GUILLEMOT)

Sensitivity

4.11.67 Auks are considered to have **medium** sensitivity to disturbance and displacement from operational offshore windfarms based on available monitoring data and information on their responses to man-made disturbance, for example for ship and helicopter traffic (Garthe and Hüppop 2004; Schwemmer *et al*. 2011; Furness and Wade 2012; Furness *et al*. 2013; Bradbury *et al*. 2014; MMO 2018).

4.11.68 Available pre- and post-construction data for offshore windfarms have yielded variable results; they indicate that auks may be displaced to some extent by some windfarms, but displacement is partial and apparently negligible at others (Dierschke *et al*. 2016).

4.11.69 Common guillemots were displaced at Blighbank (Vanermen *et al*. 2012, 2014) and only in a minority of surveys at two Dutch windfarms (OWEZ and PAWP; Leopold *et al*. 2011, Krijgsveld *et al*. 2011), but were not significantly displaced at Horns Rev (although the data suggest that slight displacement was probably occurring; Petersen *et al*. 2006) or Thornton Bank (Vanermen *et al*. 2012). Razorbills were displaced in one out of six surveys at two Dutch windfarms (OWEZ and PAWP; Leopold *et al*. 2011, Krijgsveld *et al*. 2011), but not at Horns Rev (Petersen *et al*. 2006) or Thornton Bank (Vanermen *et al*. 2012). At Blighbank, razorbills were found to be significantly displaced when considering the windfarm area and a buffer of 0.5km, but not when considering the windfarm area and a 3km buffer, or the buffer alone (0.5-3km from the windfarm; Vanermen *et al*. 2014).

4.11.70 Following statutory guidance (SNCB 2017; updated 2022) the abundance estimates for each auk species for the windfarm and a 2km buffer for the most relevant biological periods have been placed into individual displacement matrices. Each matrix displays displacement rates and mortality rates for each species.

4.11.71 For auks, Natural England has advised that a range of mortality rates of 1-10% and displacement rates of 30-70%, should be considered, with 70% displacement and 10% mortality as the worst case. Natural England has also stated (in relation to other wind farms in the southern North Sea, including East Anglia TWO and Norfolk Boreas) that they agree that the mortality for auks is likely to be at the low end of the range.

4.11.72 The worst-case scenario of 10% mortality would equate to a doubling of natural adult annual mortality for razorbill (10.5%; Horswill and Robinson 2015) and more than double that for guillemot (6%; Horswill and Robinson 2015).

4.11.73 A review of available evidence for auk displacement, prepared for the assessment of the Norfolk Vanguard Offshore Wind Farm (Norfolk Vanguard Ltd 2019b) concluded that displacement of guillemots and razorbills by offshore windfarms is incomplete, and may reduce with habituation, and that offshore windfarms may in the long-term increase food availability to guillemots and razorbills through providing enhanced habitat for fish populations. Mortality due to displacement might arise if displacement increased competition for resources in the remaining areas of auk habitat outside the windfarm. The increase in density of auks outside the windfarm area will be negligible (because the rest of the available habitat is vast), Thus the mortality rate due to displacement may well be 0% and is highly unlikely to represent levels of mortality anywhere near to the 6% or 10% total annual mortality that occurs due to the combination of many natural factors plus existing human activities. Norfolk Vanguard Ltd (2019b) suggested that precautionary rates of displacement and mortality from operational wind farms would be 50% and 1% respectively.

4.11.74 For the purpose of this assessment a displacement rate range of 30% to 70% and a mortality rate range of 1 to 10% are highlighted in each matrix, with the 70% / 10% combination representing a highly precautionary worst-case scenario.

4.11.75 As noted previously, there are no breeding colonies for guillemot or razorbill within foraging range of the VE array areas. Therefore, it is reasonable to assume that individuals seen during the breeding season are nonbreeding individuals (e.g., immature birds). Since immature seabirds are known to remain in wintering areas, the number of immature birds in the relevant populations during the breeding season may be estimated as 43% of the total wintering BDMPS population for guillemot and razorbill (based on modelled age structures for these species populations in Furness, 2015). This gives breeding season populations of non-breeding individuals of 663,095 guillemots (BDMPS for the UK North Sea and Channel, 1,617,306 x 41%), and 111,497 razorbills (BDMPS for the UK North Sea and Channel, 218,622 x 51%). For guillemot, there is only one defined nonbreeding season (August - February), while for razorbill there are three (August - October, November - December and January - March; Table 4.9). The number of birds which could potentially be displaced has been estimated for each species-specific relevant season.

Guillemot

Non-breeding

4.11.76 The estimated number of guillemots subject to mortality during the non-breeding period due to displacement from the combined VE array areas is between 11 and 258 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, Table 4.32 and Table 4.33).

4.11.77 The BDMPS for the UK North Sea and Channel is 1,617,306 (Furness 2015). At the average baseline mortality rate for guillemot of 0.140 (Table 4.11) the number of individuals expected to die in the non-breeding season is 226,423 (1,617,306 x 0.140). The addition of a maximum of 258 individuals to this increases the mortality rate by 0.11%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the non-breeding season, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Table 4.32: North array displacement matrix for guillemot during the non-breeding period.

Non-breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	1	2	2	3	4	8	16	24	40	64	81
	20%	2	3	5	6	8	16	32	48	81	129	161
	30%	2	5	7	10	12	24	48	73	121	193	242
	40%	3	6	10	13	16	32	64	97	161	258	322
	50%	4	8	12	16	20	40	81	121	202	322	403
	60%	5	10	15	19	24	48	97	145	242	387	484
	70%	6	11	17	23	28	56	113	169	282	451	564
	80%	6	13	19	26	32	64	129	193	322	516	645
	90%	7	15	22	29	36	73	145	218	363	580	725
	100%	8	16	24	32	40	81	161	242	403	645	806

Table 4.33: South array displacement matrix for guillemot during the non-breeding period.

Non-breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	3	6	9	12	14	29	58	87	145	231	289
	20%	6	12	17	23	29	58	116	174	289	463	578
	30%	9	17	26	35	43	87	174	260	434	694	868
	40%	12	23	35	46	58	116	231	347	578	925	1157
	50%	14	29	43	58	72	145	289	434	723	1157	1446
	60%	17	35	52	69	87	174	347	521	868	1388	1735
	70%	20	40	61	81	101	202	405	607	1012	1619	2024
	80%	23	46	69	93	116	231	463	694	1157	1851	2313
	90%	26	52	78	104	130	260	521	781	1301	2082	2603
	100%	29	58	87	116	145	289	578	868	1446	2313	2892

Breeding Season

4.11.78 The estimated number of guillemots subject to mortality during the breeding period due to displacement from the VE array areas is between three and 84 individuals (from 30%/1% to 70%/10%, Table 4.34 and Table 4.35).

4.11.79 The BDMPS is 663,095 non-breeding individuals. At the average baseline mortality rate for guillemot of 0.140, the number of individuals expected to die in the breeding season is 92,833 (663,095 x 0.140). The addition of a maximum of 84 to this increases the mortality rate by 0.09%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding period, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Table 4.34: North array displacement matrix for guillemot during the breeding season.

Breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	1	2	2	3	4	8	16	23	39	62	78
	20%	2	3	5	6	8	16	31	47	78	124	155
	30%	2	5	7	9	12	23	47	70	116	186	233
	40%	3	6	9	12	16	31	62	93	155	248	311
	50%	4	8	12	16	19	39	78	116	194	311	388
	60%	5	9	14	19	23	47	93	140	233	373	466
	70%	5	11	16	22	27	54	109	163	272	435	543
	80%	6	12	19	25	31	62	124	186	311	497	621
	90%	7	14	21	28	35	70	140	210	349	559	699
	100%	8	16	23	31	39	78	155	233	388	621	776

Table 4.35: South array displacement matrix for guillemot during the breeding season.

Breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	1	1	2	2	4	8	13	21	34	42
	20%	1	2	3	3	4	8	17	25	42	68	85
	30%	1	3	4	5	6	13	25	38	64	102	127
	40%	2	3	5	7	8	17	34	51	85	136	170
	50%	2	4	6	8	11	21	42	64	106	170	212
	60%	3	5	8	10	13	25	51	76	127	204	255
	70%	3	6	9	12	15	30	59	89	148	238	297
	80%	3	7	10	14	17	34	68	102	170	272	339

Breeding	Mortality rate										
	90%	4	8	11	15	19	38	76	115	191	305	382
	100%	4	8	13	17	21	42	85	127	212	339	424

Year Round

4.11.80 The estimated number of guillemots subject to displacement mortality throughout the year is between 14 and 342 individuals (summing the range of displacement/mortality of 30%/1% to 70%/10% from Table 4.32 through Table 4.35)

4.11.81 At the average baseline mortality rate for guillemot of 0.140, the number of individuals expected to die from the largest BDMPS population throughout the year is 226,423 (1,617,306 x 0.140). The addition of a maximum of 342 individuals to this increases the mortality rate by 0.15%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding season, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Razorbill

Autumn Migration

4.11.82 The estimated number of razorbills subject to mortality during the autumn migration period due to displacement from the VE array areas combined is between zero and 20 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, Table 4.36 and Table 4.37)

4.11.83 The BDMPS for the UK North Sea and Channel is 591,874 (Furness 2015). At the average baseline mortality rate for razorbill of 0.174 (Table 4.11) the number of individuals expected to die in the autumn migration period is 102,986 (591,874 x 0.174). The addition of a maximum of 20 individuals to this increases the mortality rate by 0.02%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the autumn migration period, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Table 4.36: North array displacement matrix for razorbill during the autumn migration period.

Autumn migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	1	1	2	4	6	10	12
	20%	0	0	1	1	1	2	5	7	12	19	24
	30%	0	1	1	1	2	4	7	11	18	29	36
	40%	0	1	1	2	2	5	10	15	24	39	49
	50%	1	1	2	2	3	6	12	18	30	49	61
	60%	1	1	2	3	4	7	15	22	36	58	73
	70%	1	2	3	3	4	9	17	26	43	68	85
	80%	1	2	3	4	5	10	19	29	49	78	97
	90%	1	2	3	4	5	11	22	33	55	88	109
	100%	1	2	4	5	6	12	24	36	61	97	122

Table 4.37: South array displacement matrix for razorbill during the autumn migration period.

Autumn migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	1	1	2	3	5	8	13	16
	20%	0	1	1	1	2	3	6	10	16	26	32
	30%	0	1	1	2	2	5	10	15	24	39	49
	40%	1	1	2	3	3	6	13	19	32	52	65
	50%	1	2	2	3	4	8	16	24	41	65	81
	60%	1	2	3	4	5	10	19	29	49	78	97
	70%	1	2	3	5	6	11	23	34	57	91	113
	80%	1	3	4	5	6	13	26	39	65	104	130
	90%	1	3	4	6	7	15	29	44	73	117	146
	100%	2	3	5	6	8	16	32	49	81	130	162

Winter

4.11.84 The estimated number of razorbills subject to mortality during the winter period due to displacement from the VE array areas is between three and 73 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, Table 4.38 and Table 4.39).

4.11.85 The BDMPS for the UK North Sea and Channel is 218,622 (Furness 2015). At the average baseline mortality rate for razorbill of 0.174 the number of individuals expected to die in the winter period is 38,040 (218,622 x 0.174). The addition of a maximum of 73 individuals to this increases the mortality rate by 0.2%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the winter period, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Table 4.38: North array displacement matrix for razorbill during the winter period.

Winter		Mortality rate										
Displacement		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
	10%	1	1	2	3	4	7	15	22	37	60	75
	20%	1	3	4	6	7	15	30	45	75	120	150
	30%	2	4	7	9	11	22	45	67	112	180	225
	40%	3	6	9	12	15	30	60	90	150	240	300
	50%	4	7	11	15	19	37	75	112	187	300	375
	60%	4	9	13	18	22	45	90	135	225	360	450
	70%	5	10	16	21	26	52	105	157	262	420	525
	80%	6	12	18	24	30	60	120	180	300	480	600
	90%	7	13	20	27	34	67	135	202	337	540	675
	100%	7	15	22	30	37	75	150	225	375	600	749

Table 4.39: South array displacement matrix for razorbill during the winter period.

Winter		Mortality rate										
Displacement		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
	10%	0	1	1	1	1	3	6	9	15	24	30
	20%	1	1	2	2	3	6	12	18	30	47	59
	30%	1	2	3	4	4	9	18	27	44	71	89
	40%	1	2	4	5	6	12	24	36	59	95	119
	50%	1	3	4	6	7	15	30	44	74	119	148
	60%	2	4	5	7	9	18	36	53	89	142	178
	70%	2	4	6	8	10	21	42	62	104	166	208
	80%	2	5	7	9	12	24	47	71	119	190	237

Winter	Mortality rate										
	90%	3	5	8	11	13	27	53	80	133	214	267
	100%	3	6	9	12	15	30	59	89	148	237	297

Spring Migration

4.11.86 The estimated number of razorbills subject to mortality during the spring migration period due to displacement from the VE array areas is between three and 53 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, Table 4.40 and Table 4.41.

4.11.87 The BDMPS for the UK North Sea and Channel is 591,874 (Furness 2015). At the average baseline mortality rate for razorbill of 0.174 the number of individuals expected to die in the spring migration period is 102,986 (591,874 x 0.174). The addition of a maximum of 53 individuals to this increases the mortality rate by 0.05%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the spring migration period, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Table 4.40: North array displacement matrix for razorbill during the spring migration period.

Spring migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	1	1	2	2	3	5	10	15	25	40	50
	20%	1	2	3	4	5	10	20	30	50	80	100
	30%	2	3	5	6	8	15	30	45	75	121	151
	40%	2	4	6	8	10	20	40	60	100	161	201
	50%	3	5	8	10	13	25	50	75	126	201	251
	60%	3	6	9	12	15	30	60	90	151	241	301
	70%	4	7	11	14	18	35	70	105	176	281	352
	80%	4	8	12	16	20	40	80	121	201	321	402
	90%	5	9	14	18	23	45	90	136	226	362	452
	100%	5	10	15	20	25	50	100	151	251	402	502

Table 4.41: South array displacement matrix for razorbill during the spring migration period.

Spring migration	Mortality rate										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	1	1	1	1	3	5	8	13	20	25
20%	1	1	2	2	3	5	10	15	25	41	51
30%	1	2	2	3	4	8	15	23	38	61	76
40%	1	2	3	4	5	10	20	30	51	81	102
50%	1	3	4	5	6	13	25	38	64	102	127
60%	2	3	5	6	8	15	30	46	76	122	152
70%	2	4	5	7	9	18	36	53	89	142	178
80%	2	4	6	8	10	20	41	61	102	163	203
90%	2	5	7	9	11	23	46	69	114	183	229
100%	3	5	8	10	13	25	51	76	127	203	254

Breeding Season

4.11.88 The estimated number of razorbills subject to mortality during the breeding period due to displacement from the VE array areas is between zero and seven individuals (from 30%/1% to 70%/10%, Table 4.42 and Table 4.43)

4.11.89 The BDMPS is 112,439 non-breeding individuals. At the average baseline mortality rate for razorbill of 0.174, the number of individuals expected to die in the breeding season is 19,564 (112,439 x 0.174). The addition of a maximum of seven to this increases the mortality rate by 0.04%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the nonbreeding migration period, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

Table 4.42: North array displacement matrix for razorbill during the breeding season.

Breeding	Mortality rate										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	0	0	0	0	0	1	1	2	3	5	7
20%	0	0	0	1	1	1	3	4	7	11	13
30%	0	0	1	1	1	2	4	6	10	16	20
40%	0	1	1	1	1	3	5	8	13	21	26
50%	0	1	1	1	2	3	7	10	17	26	33

Breeding	Mortality rate										
	60%	0	1	1	2	2	4	8	12	20	32	40
	70%	0	1	1	2	2	5	9	14	23	37	46
	80%	1	1	2	2	3	5	11	16	26	42	53
	90%	1	1	2	2	3	6	12	18	30	48	59
	100%	1	1	2	3	3	7	13	20	33	53	66

Table 4.43: South array displacement matrix for razorbill during the breeding season.

Breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	0	0	0	1	1	2	2
	20%	0	0	0	0	0	0	1	1	2	4	5
	30%	0	0	0	0	0	1	1	2	4	6	7
	40%	0	0	0	0	0	1	2	3	5	8	10
	50%	0	0	0	0	1	1	2	4	6	10	12
	60%	0	0	0	1	1	1	3	4	7	12	15
	70%	0	0	1	1	1	2	3	5	9	14	17
	80%	0	0	1	1	1	2	4	6	10	16	20
	90%	0	0	1	1	1	2	4	7	11	18	22
	100%	0	0	1	1	1	2	5	7	12	20	24

Year Round

4.11.90 The estimated number of razorbills subject to displacement mortality throughout the year is between six and 153 individuals (summing the range of displacement/mortality of 30%/1% to 70%/10% from Table 4.36 through Table 4.43).

4.11.91 At the average baseline mortality rate for razorbill of 0.174, the number of individuals expected to die from the largest BDMPS population throughout the year is 102,986 (591,874 x 0.174). The addition of a maximum of 153 individuals to this increases the mortality rate by 0.15%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of impact is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the effect is **minor adverse**, which is **not significant** in EIA terms.

IMPACT 4: INDIRECT IMPACTS THROUGH EFFECTS ON HABITATS AND PREY SPECIES

4.11.92 Indirect disturbance and displacement of birds may occur during the operational phase of the proposed VE project if there are impacts on prey species and their habitats. Potential indirect impacts associated with an offshore windfarm include those resulting from the production of underwater noise (e.g., the turning of the WTGs), electro-magnetic fields (EMF) associated with cables, and the generation of suspended sediments (e.g., due to scour or maintenance activities) that may alter the behaviour or availability of bird prey species. Underwater noise and EMF may cause fish and mobile invertebrates to avoid the operational area and affect their physiology and behaviour. Suspended sediments may cause fish and mobile invertebrates to avoid the operational area and may smother and hide immobile benthic prey. These mechanisms could result in less prey being available within the operational area to foraging seabirds.

4.11.93 Changes in fish and invertebrate communities due to changes in presence of hard substrate (resulting in colonisation by epifauna) may also occur, and changes in fishing activity could influence the communities present. The worst-case MDS in relation to operational factors that may indirectly impact on seabirds is presented in Table 4.15.

ARRAY AREAS

4.11.94 With regard to noise impacts on fish, Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology assesses the potential impacts upon fish species relevant to IOFs as prey. The assessment concludes that behavioural changes related to underwater noise impacts on fish and shellfish during the operation of the proposed VE project would be of negligible magnitude and at worst, minor adverse significance. With a non-significant unmitigated effect on fish species that are bird prey items, it can be concluded that the indirect effects on wide-ranging seabirds occurring in or around the array areas and offshore ECC during the operational phase would be **negligible or minor adverse** (**not significant** in EIA terms), occurring over a very limited extent compared to overall foraging areas.

4.11.95 With regard to changes to the seabed and to suspended sediment levels, Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology discusses the nature of any change and impact. It identifies that changes in physical processes and temporary habitat disturbance would be of negligible significance. Chapter 6: Fish and Shellfish Ecology also concludes a negligible impact and at worst, minor adverse effects for fish and shellfish. With unmitigated negligible impacts on benthic habitats and species, it can be concluded that the indirect impact on seabirds occurring in or around the array areas during the operational phase is similarly a **negligible or minor adverse** effect for all IOFs, which is **not significant** in EIA terms.

4.11.96 With regard to EMF impacts associated with inter-array cables, these are identified as localised with the majority of cables being buried to up to 3.5m depth, further reducing the effect of EMF. The magnitude of impact is considered negligible on benthic communities, and so it can be concluded that the indirect impact on seabirds occurring in or around the array areas during the operational phase is similarly a **negligible or minor adverse** effect, which is **not significant** in EIA terms.

4.11.97 Very little is known about potential long-term changes in invertebrate and fish communities due to colonisation of hard substrate and changes in fishing pressures associated with offshore windfarms. Whilst the impact of the colonisation of introduced hard substrate is seen as a minor adverse impact in terms of benthic ecology (as it is a change from the baseline conditions), the consequences for seabirds may be positive or negative locally but are not predicted to be significant (either beneficially or adversely) in EIA terms, at a population level (at worst, **negligible or minor adverse** effect, which is **not significant** in EIA terms).

OFFSHORE EXPORT CABLE CORRIDOR

4.11.98 Potential impacts on seabirds due to the offshore ECC would most likely be associated with EMF impacts or suspension of sediments due to cable maintenance activities. These are likely to be comparable, or smaller in extent or duration than those described for the array areas, and so it follows that the indirect impacts on seabirds occurring in or around the offshore ECC during the operational phase are similarly of a **negligible or minor adverse** effect for all IOFs, which is **not significant** in EIA terms.

IMPACT 5: COLLISION RISK

OFFSHORE EXPORT CABLE CORRIDOR

4.11.99 There are no predicted collision impacts associated with the offshore ECC and so the following assessment relates to WTGs within the array areas only.

ARRAY AREAS

4.11.100 Birds flying through the WTG arrays of offshore windfarms may collide with rotor blades, resulting in fatality or injury. This may occur whilst foraging for food, commuting between breeding sites and foraging areas, or during migration.

MIGRATORY (NON-SEABIRD) SPECIES

4.11.101 The potential collision risk to migratory bird species due to VE alone is modelled in Volume 6, Part 5, Annex 4.14: Migratory Collision Risk Modelling. The results of the modelling are primarily required to support the Volume 5, Report 4: RIAA, in relation to designated site populations.

4.11.102 A screening process identified the suite of designated sites and associated qualifying features within 100 km of the array areas. The qualifying/assemblage species that have <1% proportion of UK population at risk of collision within the array area were screened out at this stage.

4.11.103 A range of remaining migratory qualifying features were screened in for analysis using Migropath or 'Broad Front' modelling approaches. These included wildfowl, waders, terns and other migratory species such as marsh harrier and nightjar.

4.11.104 Results of the CRM showed that for most migratory species, fewer than one collision per year was predicted. The exceptions to these were: avocet (2.89 collisions), dark-bellied brent goose (14.78), gadwall (wintering, 2.18), redshank (8.35), shoveler (2.18) and common tern (4.28).

4.11.105 The assessment of the impacts of the resulting additional mortality to qualifying features on the designated site populations is presented in Volume 5, Report 4: RIAA.

4.11.106 For all designated sites a conclusion of 'no potential for adverse effect on integrity', either alone or in-combination with other projects was made, in relation to designated sites where migratory species (non-seabirds) are qualifying features. Based on these assessments of effects on smaller designated site populations, it can reasonably be concluded that either no, or negligible magnitudes of impact would occur to all non-seabird migratory species when assessing at a suitable geographic population scale (BDMPS or biogeographic). As such, a **negligible** or at worst, **minor adverse** effect is predicted for all migratory species, which is **not significant** in EIA terms.

SEABIRD SPECIES

4.11.107 CRM has been undertaken for this assessment to estimate the collision risk to seabirds associated with the turbines within the VE array areas. Deterministic and stochastic modelling was undertaken based on the two indicative WTG maximum design scenarios outlined in Table 4.15, i.e., the 79 Small WTG scenario (turbine parameter set 1) and the 41 Large WTG scenario (turbine parameter set 2).

4.11.108 The approach to CRM has taken into account Natural England (2022a) interim guidance and Parker *et al.* (2022c) guidance, and is summarised here, with further details provided in Volume 6, Part 5, Annex 4.8a: *Deterministic Collision Risk Modelling Inputs and Outputs*; and Annex 4.8b: Stochastic Collision Risk Modelling Inputs and Outputs. A comparison of the deterministic and stochastic models is also presented in Volume 6, Part 5, Annex 4.10: Collision Risk Modelling: comparison of model results, in response to discussions with Natural England (see Table 4.2).

4.11.109 The deterministic Band model (Band 2012) Option 2 has been used to produce predictions of collision rates for all species across biological seasons and annually. This option uses generic estimates of flight height for each species based on the percentage of birds flying at Potential Collision Height (PCH) derived from data from a number of offshore windfarm sites, presented in Johnston *et al*. (2014a, 2014b).

4.11.110 The deterministic outputs incorporated uncertainty around the mean values through the use of the upper and lower 95% confidence intervals in flight densities. While other model parameters can also be adjusted across ranges of values to provide further estimates of uncertainty (e.g., in stochastic simulations discussed below), variation in flight density typically accounts for the largest component of overall variation (by some margin) and thus only this parameter was varied in this assessment. Avoidance rates used for CRM (Table 4.44) were those advised by Natural England and proportions at collision height were based on the generic dataset in Johnston *et al*. (2014a, 2014b).

4.11.111 Stochastic modelling was also undertaken using the stochLAB R Package[3] for those species typically considered to be at greater collision risk (due to their flight behaviour; for the remaining species, for which very low deterministic collision estimates were obtained, it was considered there was little added benefit in providing stochastic collision modelling estimates). Justification for selection of this version of the stochastic CRM is presented in Volume 6, Part 5, Annex 4.10: Collision Risk Modelling: comparison of model results.

4.11.112 The nocturnal activity factor (NAF, Table 4.44) used in the CRM defines the level of nocturnal flight activity of each seabird species, expressed in relation to daytime flight activity levels. For example, a value of 50% for the nocturnal activity factor is appropriate for a species which is half as active at night as during the day. This factor is used to enable estimation of nocturnal collision risk from survey data collected during daylight, with the total collision risk the sum of those for day and night.

4.11.113 The nocturnal activity factors used here for each species are from Natural England's (2022a) Interim CRM guidance, which are based on Garthe and Hüppop (2004), except gannet which is from Furness *et al* (2018).

Table 4.44: Parameters used in Deterministic CRM.

Species	Avoidance Rate	Standard Deviation (SD)	Nocturnal activity factor (1 to 5 / %)
Black-headed gull	99.5	0.2%	3 / 50%
Common gull	99.5	0.2%	3 / 50%
Common tern	99.0	0.2%	5 / 100%
Fulmar	99.0	0.2%	4 / 75%
Gannet*	99.72	0.2%	1.32 / 8%
	99.88		
Great black-backed gull	99.4	0.1%	3 / 50%

[3] https://github.com/HiDef-Aerial-Surveying/stochLAB

Species	Avoidance Rate	Standard Deviation (SD)	Nocturnal activity factor (1 to 5 / %)
			2 / 25%
Great skua	99.0	0.2%	1 / 0%
Herring gull	99.4	0.1%	3 / 50%
			2 / 25%
Kittiwake	99.2	0.2%	3 / 50%
			2 / 25%
Lesser black-backed gull	99.4	0.1%	3 / 50%
			2 / 25%
Little gull	99.5	0.2%	2 / 50%
Sandwich tern	99.0	0.2%	5 / 100%

*Following Natural England (2022a) interim advice on CRM, macro-avoidance has been accounted for by reduction of density of birds in flight based on the level of macro-avoidance displayed by this species. A project has been commissioned by NE to inform this rate, but in the interim, NE advises the use of a range of macro avoidance rates between 65% - 85% or a single rate of 70%.

Table 4.45: Parameters used in Stochastic CRM.

Species	Avoidance Rate (%)	Nocturnal activity factor (%)
Gannet	99.3 (0.03; + macro avoidance at 70%)	8 (10)
Great black-backed gull	99.4 (0.04)	37.5 (6.37)
Herring gull	99.3 (0.03)	37.5 (6.37)
Kittiwake	99.3 (0.04)	37.5 (6.37)
Lesser black-backed gull	99.3 (0.03)	37.5 (6.37)

4.11.114 An overview of annual collision risk estimates for all species using the deterministic and stochastic models are presented in Table 4.46 and Table 4.47 respectively for the Small and Large WTG scenarios. These results were used to identify species to be scoped in for assessment in relation to collision risk, and to identify the worst-case MDS for each species scoped in. For all species, the worst-case is the 79-turbine Small WTG scenario.

4.11.115 Each species has also been assigned a sensitivity rating for collision risk, based on available data on the percentage of time spent flying at heights within the rotor diameter of offshore wind turbines, flight agility, the percentage of time flying, the extent of nocturnal flight activity and conservation importance (with reference to Garthe and Hüppop, 2004; Furness and Wade, 2012, Furness *et al*., 2013, Wade *et al*., 2016).

Table 4.46: Annual Collision Risk Estimates for North and South Arrays combined (deterministic Band model option 2, avoidance rates as per Table 4.44). Values are the mean number of birds and 95% confidence intervals.

Species (sensitivity to collision)	Model run type (NAF = Nocturnal Avoidance Factor)	79 Small WTG Scenario	41 Large WTG Scenario
Fulmar (Low)	Mean	0.16 (0.01-0.39)	0.12 (0.01-0.30)
Gannet (Low / medium)	Lower macro avoidance rate	5.36 (0.46-11.75)	3.65 (0.31-8.01)
	Higher macro avoidance rate	2.30 (0.20-5.04)	1.57 (0.13-3.43)
Kittiwake (Medium)	High NAF (50%)	32.22 (4.45-67.72)	22.89 (3.16-48.09)
	Reduced NAF (25%)	26.19 (3.51-55.26)	18.61 (2.50-39.24)
Black-headed gull (Medium)	Mean	0.91 (0-2.25)	0.65 (0-1.61)
Little gull (Low)	Mean	0.12 (0-0.37)	0.09 (0-0.27)
Common gull (Medium)	Mean	2.27 (0-5.05)	1.59 (0-3.54)
Lesser black-backed gull (Medium)	High NAF (50%)	41.47 (0-111.35)	28.36 (0-76.17)
	Reduced NAF (25%)	36.84 (0-98.72)	25.20 (0-67.53)
Herring gull (Medium)	High NAF (50%)	2.21 (0-5.97)	1.51 (0-4.07)
	Reduced NAF (25%)	1.82 (0-4.86)	1.24 (0-3.31)
Great black-backed gull (Medium)	High NAF (50%)	3.31 (0-9.92)	2.22 (0-6.67)
	Reduced NAF (25%)	1.45 (0-4.35)	0.97 (0-2.92)
Common tern	Mean	0.13 (0-0.38)	0.09 (0-0.28)
Great skua	Mean	0.13 (0-0.38)	0.09 (0-0.28)
Sandwich tern	Mean	0.21 (0-0.64)	0.16 (0-0.47)

Table 4.47: Annual Collision Risk Estimates for North and South Arrays combined (stochastic CRM, avoidance rates as per Table 4.45). Values are the mean number of birds with Standard Deviation and 95% confidence intervals.

Species (sensitivity to collision)	79 Small WTG Scenario	41 Large WTG Scenario
Gannet (Low / medium)	4.5 (5.04) 0 - 18.14	3.02 (3.35) 0 - 12.19
Kittiwake (Medium)	25.3 (22.96) 0.97 - 78.65	17.98 (16.33) 0.66 - 55.76
Lesser black-backed gull (Medium)	40.58 (57.44) 0 - 191.44	27.75 (38.98) 0 - 131.74
Herring gull (Medium)	2.05 (3.24) 0 - 10.52	1.4 (2.21) 0 - 7.24
Great black-backed gull (Medium)	1.84 (2.85) 0 - 9.22	1.24 (1.93) 0 - 6.22

4.11.116 Results show that most species have very low predicted annual collision rates within the combined VE array areas (i.e., worst case mean prediction was below approximately five birds per year). As the magnitudes of predicted impact were so small, even for the worst case, no further assessment is considered necessary for these species and **negligible or minor adverse** effects are predicted, which are **not significant** in EIA terms.

4.11.117 The species scoped into the collision risk assessment, with collision rates greater than approximately five birds per year are kittiwake and lesser black-backed gull. The predicted annual collision rates for gannet, great-black backed gull and herring gull were very low, but these species were taken forward to assessment on a precautionary basis, and for use in the cumulative assessment (see section 4.13) at the request of Natural England.

4.11.118 For lesser black-backed gull, the VE array areas are 37km from the Alde-Ore Estuary SPA at the nearest point, and within the mean maximum foraging range (127 km, Woodward *et al*. 2019). Thus, lesser black-backed gulls breeding at the Alde-Ore Estuary SPA might forage within or pass through the array areas and be at risk of collision (impacts on the SPA are assessed in the Volume 5, Report 4: RIAA). Herring gull and great black-backed gull were scoped in, based on requests for inclusion by Natural England for other southern North Sea offshore windfarms, to ensure that this species was carried through to the cumulative assessment for collision risk.

Table 4.48: Seasonal Collision Risk Estimates. Values are the mean number of collisions, stochastic model, with 95% CI.

Species	Array	Spring	Breeding season	Autumn	Non-breeding/ winter	Annual
Gannet	North	0.04 (0.06) 0 - 0.23	0.68 (0.94) 0 - 3.21	1.12 (1.07) 0 - 3.97	-	1.82 (2.07) 0 - 7.41
	South	0.2 (0.23) 0 - 0.81	1.33 (1.51) 0 - 5.52	1.14 (1.22) 0 - 4.41	-	2.67 (2.97) 0 - 10.73
	Total (SD)	**0.24 (0.29)**	**2.01 (2.46)**	**2.26 (2.3)**	**-**	**4.5 (5.04)**
	95% c.i.	**0 - 1.04**	**0 - 8.73**	**0 - 8.38**	**-**	**0 - 18.14**
Kittiwake	North	1.74 (1.69) 0 - 5.76	4.11 (5.16) 0 - 16.03	2.14 (2.33) 0 - 7.81	-	7.99 (9.16) 0 - 29.59
	South	3.77 (2.39) 0.56 - 9.13	7.8 (6.89) 0 - 24.23	5.74 (4.51) 0.42 - 15.69	-	17.31 (13.8) 0.97 - 49.05
	Total (SD)	**5.52 (4.07)**	**11.91 (12.05)**	**7.88 (6.84)**	**-**	**25.3 (22.96)**
	95% c.i.	**0.56 - 14.9**	**0 - 40.26**	**0.42 - 23.5**	**-**	**0.97 - 78.65**
Great black-backed gull	North	0.59 (0.9) 0 - 2.93	0.68 (1.06) 0 - 3.38	0 (0) 0 - 0	0.57 (0.89) 0 - 2.91	1.84 (2.85) 0 - 9.22
	South	-	-	-	-	-
	Total (SD)	**0.59 (0.9)**	**0.68 (1.06)**	**0 (0)**	**0.57 (0.89)**	**1.84 (2.85)**
	95% c.i.	**0 - 2.93**	**0 - 3.38**	**0 - 0**	**0 - 2.91**	**0 - 9.22**
Herring gull	North	0 (0) 0 - 0	0.65 (1.03) 0 - 3.3	0 (0) 0 - 0	0.47 (0.74) 0 - 2.39	1.11 (1.77) 0 - 5.69

Species	Array	Spring	Breeding season	Autumn	Non-breeding/ winter	Annual
	South	0 (0) 0 - 0	0 (0) 0 - 0	0.94 (1.48) 0 - 4.84	0 (0) 0 - 0	0.94 (1.48) 0 - 4.84
	Total (SD)	**0 (0)**	**0.65 (1.03)**	**0.94 (1.48)**	**0.47 (0.74)**	**2.05 (3.24)**
	95% c.i.	**0 - 0**	**0 - 3.3**	**0 - 4.84**	**0 - 2.39**	**0 - 10.52**
Lesser black-backed gull	North	0 (0) 0 - 0	23.68 (35.25) 0 - 116.4	0.45 (0.78) 0 - 2.55	0.41 (0.69) 0 - 2.29	24.54 (36.71) 0 - 121.25
	South	0.82 (1.35) 0 - 4.47	11.42 (14.06) 0 - 48.17	1.71 (2.89) 0 - 9.3	2.08 (2.43) 0 - 8.25	16.05 (20.72) 0 - 70.2
	Total (SD)	**0.82 (1.35)**	**35.09 (49.3)**	**2.16 (3.67)**	**2.49 (3.12)**	**40.58 (57.44)**
	95% c.i.	**0 - 4.47**	**0 - 164.57**	**0 - 11.85**	**0 - 10.54**	**0 - 191.44**

4.11.119 The seasonal collision estimates for species scoped into the collision risk assessment are presented in Table 4.48. The collision risk assessment uses the outputs for the worst-case, Small WTG scenario, calculated using the stochastic Band model. The mean results (with SD and 95% confidence intervals) have been used in the assessment.

4.11.120 Impacts during the non-breeding periods have been assessed in relation to the relevant BDMPS (Furness 2015). Where there is potential for impacts during the breeding season, these have been assessed in relation to estimated reference populations as described in the following section.

BREEDING SEASON REFERENCE POPULATIONS FOR COLLISION ASSESSMENT

GANNET

4.11.121 As outlined for Impact 3: Direct Disturbance and Displacement, the reference breeding season gannet population is based on the combined Flamborough and Filey Coast SPA and Alderney West Coast and Burhou Islands Ramsar breeding populations of 13,125 pairs in 2022 (Clarkson et al. 2022) and 17,078 breeding pairs in 2021 (Purdie et al. 2023) respectively.

4.11.122 These estimates of the two colonies have been used as reference populations, being closest in time to baseline surveys. When including immatures, there is a total estimate of 109,335 individuals, based on the immature per breeding adult ratio of 0.81 from Furness (2015).

KITTIWAKE

4.11.123 The nearest large breeding concentration of kittiwakes to the VE array areas is the Flamborough and Filey Coast SPA, 275km to the northeast. The mean maximum foraging range of kittiwake from breeding colonies is estimated at 156km (Woodward *et al*. 2019). Using this as a guide to the likely distance that breeding birds travel from a colony indicates that the VE array areas are beyond the range of kittiwakes breeding at colonies at Flamborough and Filey Coast. A tracking study of kittiwakes breeding at Flamborough and Filey Coast SPA in 2017 found an average foraging range of 88.65km (range 3.2-324 km), with birds travelling into the North Sea northwest and southwest of the breeding colony (Wischnewski *et al*. 2017), although none as far south as the VE array areas.

4.11.124 While RSPB's Future of the Atlantic Marine Environments (FAME) studies have shown some extremely long foraging trips for this species (as reported in various publications such as Fair Isle Bird Observatory annual reports) those extreme values tend to occur at colonies where food supply is extremely poor and breeding success is low (for example Orkney and Shetland). Daunt *et al*. (2002) point out that seabirds, as central place foragers, have an upper limit to their potential foraging range from the colony, set by time constraints. For example, they assess this limit to be 73km for kittiwake based on foraging flight speed and time required to catch food, from observations of birds from the Isle of May. This means that kittiwakes would be unable to consistently travel more than 73km from the colony and provide enough food to keep chicks alive. Hamer *et al*. (1993) recorded kittiwake foraging ranges exceeding 40km in 1990 when sandeel stock biomass was very low and breeding success at the study colony in Shetland was 0.0 chicks per nest, but <5km in 98% of trips in 1991 when sandeel abundance was higher and breeding success was 0.98 chicks per nest. Kotzerka *et al*. (2010) reported a maximum foraging range of 59km, with a mean range of around 25km for a kittiwake colony in Alaska.

4.11.125 Consequently, the breeding season impact on kittiwake has been assessed against a reference population estimated using the same approach as that for auk species in *Impact 3: Direct Disturbance and Displacement*. This is based on the observation that immature birds tend to remain in wintering areas. Thus, the number of immature kittiwakes in the relevant populations during the breeding season may be estimated as the proportion of the relevant BDMPS (the one immediately preceding the breeding season) which are sub-adults. This is given as 252,001 individuals for the UK North Sea and Channel in Furness (2015).

LESSER BLACK-BACKED GULL

4.11.126 Lesser black-backed gulls breed at the Alde-Ore Estuary SPA on the Suffolk coast, which is within the 127km mean maximum foraging range of this species (Woodward *et al*. 2019) from the VE array areas. Thus, there is potential for connectivity with the VE array areas during the breeding season.

4.11.127 The Alde-Ore SPA lesser black-backed gull breeding population was about 2,000 pairs between 2007 and 2014 (minimum 1,580 pairs in 2011, maximum 2,769 pairs in 2008), with the most recent available counts in 2020 of 1,775 pairs (Green *et al*. 2021) and 1,533 pairs in 2022, plus an additional 20 pairs which nested nearby at Hollesley Marsh (Seabird Monitoring Programme, SMP database[4]).

[4] https://app.bto.org/seabirds/public/index.jsp

4.11.128 Tracking data for lesser black-backed gulls breeding at the Alde-Ore Estuary SPA indicated that birds sometimes travel as far as the VE array areas, but the core foraging areas for this breeding colony do not overlap with the proposed project (Thaxter *et al*. 2015). Green *et al*. (2021) assessed movements of lesser black-backed gulls from the SPA in 2019 and 2020 and found that in 2019, tagged birds had an average offshore foraging range of 31.5 ± 27.0 km, and an overall average foraging range (including onshore trips) of 12.4 ± 14.5 km, with trips covering an average total distance of 31.1 ± 47.6 km. In 2020 this was 21.3 ± 19.1 km, 8.3 ± 9.8 km, and 19.5 ± 26.8 km respectively. The study revealed that lesser black-backed gulls from the Alde-Ore Estuary SPA showed significant use of both the Galloper and Greater Gabbard OWFs and continued offshore usage into the proposed VE array areas.

4.11.129 An estimated breeding season reference population of 15,075 breeding adults has been agreed with Natural England for the Volume 5, Report 4: RIAA. Based on the ratio of 0.68 immatures per adult given in Furness (2015), the total number of individuals of all age classes would be 25,326.

4.11.130 This assumes it is likely that lesser black-backed gull present in the VE array areas during the breeding season will include breeding adults from the Alde-Ore Estuary SPA and from non-SPA colonies in East Anglia, mixed with nonbreeding / subadult birds from a variety of sources within foraging range.

4.11.131 Potential connectivity with breeding colonies of lesser black-backed gulls in the Netherlands, within foraging range, was considered. This was ruled out however based on tracking studies which indicate that breeding lesser black-backed gulls from the Netherlands normally remain on the continental side of the North Sea (e.g., Vanermen *et al.* 2022; van Bemmelen *et al.* 2023).

HERRING GULL

4.11.132 Herring gulls breed at the Alde-Ore Estuary SPA which is within the 58.8km mean maximum (92km maximum) foraging range (Woodward *et al*. 2019) of this species from the VE array areas. Thus, there is potential for connectivity with the VE array areas during the breeding season. However, this species was recorded within the array areas in July, October, and December only (Volume 6, Part 5, Annex 4.8), suggesting that herring gulls pass through the VE array areas only occasionally, and outside of the main breeding season.

4.11.133 The most recent colony counts available within the Alde-Ore Estuary SPA were 549 herring gull pairs in 2020 (Green *et al*. 2021) and 667 pairs in 2022 (plus seven pairs in nearby Hollesley Marsh, SMP database) which suggests that the total population (all age classes) is around 2,295 to 2,817 individuals (assuming that the ratio of immatures to breeding adults in the population is 1.09, Furness 2015). This is taken as a precautionary reference population, assuming birds present are from the SPA or adjacent.

GREAT BLACK-BACKED GULL

4.11.134 There are no breeding colonies for this species within foraging range of the VE array areas. Consequently, the breeding season impact on great black-backed gull has been assessed against a reference population estimated using the same approach as that for auk species in the *Impact 3: Direct Disturbance and Displacement* assessment. This is based on the observation that immature birds tend to remain in wintering areas. Thus, the number of immature birds in the relevant populations during the breeding season may be estimated as the proportion of the relevant BDMPS (the one immediately preceding the breeding season) which are sub-adults. Therefore, the breeding season reference population for the UK North Sea and Channel is taken to be 59,329 individuals, as estimated by Furness (2015). This value has also been used as the reference population for the spring migration period.

ADDITIONAL COLLISION MORTALITY EFFECTS

4.11.135 The effects of additional mortality caused by collisions on the populations are assessed in terms of the change in the baseline mortality rate which could result. It has been assumed that all age classes are equally at risk of collisions (i.e., in proportion to their presence in the population), therefore it is necessary to calculate an average baseline mortality rate for all age classes for each species assessed. These were calculated using the different survival rates for each age class and their relative proportions in the population.

4.11.136 The first step is to calculate an average survival rate. The demographic rates for each species were taken from reviews of the relevant literature (e.g., Horswill and Robinson, 2015) and recent examples of population modelling (e.g., EATL 2016). The demographic rates and the age class proportions, and average mortality rates calculated are presented in Table 4.49.

Table 4.49: Average Annual Mortality Across Age Classes Calculated Using Age-Specific Demographic Rates and Age Class Proportions.

Species	Parameter	Age class 0-1	1-2	2-3	3-4	Adult	Productivity	Average mortality
Gannet	Survival	0.424	0.829	0.891	0.895	0.912	0.7	0.191
	Proportion in population	0.191	0.081	0.067	0.06	0.6		
Kittiwake	Survival	0.79	0.854	0.854	0.854	0.854	0.69	0.156
	Proportion in population	0.155	0.123	0.105	0.089	0.527		
Lesser black-backed gull	Survival	0.82	0.885	0.885	0.885	0.885	0.53	0.126
	Proportion in population	0.134	0.109	0.085	0.084	0.577		
Herring gull	Survival	0.798	0.834	0.834	0.834	0.834	0.92	0.172
	Proportion in population	0.178	0.141	0.117	0.097	0.467		
Great black-backed gull	Survival	0.815	0.815	0.815	0.815	0.815	1.139	0.185
	Proportion in population	0.194	0.156	0.126	0.102	0.422		

4.11.137 The percentage increases in background mortality rates of seasonal and annual populations due to predicted collisions with the VE WTGs are shown in Table 4.50 for all species using avoidance rates recommended by Natural England (Table 4.44).

4.11.138 The mean and upper 95% confidence interval collision predictions for all species in all seasons and summed across the year resulted in increases in background mortality of up to 0.15% (0-0.7%) for lesser black-backed gull, when comparing against relevant annual BDMPS and biogeographic populations. For lesser black-backed gull, an increase in breeding season background mortality of 1.1% (0-5.1%) is predicted, which is considered within the context of the Alde-Ore Estuary SPA population in Volume 5, Report 4: RIAA.

4.11.139 Increases of such small magnitude within the context of annual BDMPS and biogeographic populations would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of impacts due to collision mortality for gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull are considered to be **negligible**. All IOFs are classed as low to medium (gannet), or medium (all others) sensitivity to collision with offshore wind farms (Table 4.4) resulting in **minor adverse** effects, which are **not significant** in EIA terms.

Table 4.50: Precautionary Estimates of Percentage Increases in the Background Mortality Rate of Seasonal and Annual Populations Due to Predicted Collisions.

Option 2 avoidance rates as per JNCC (2014) calculated with stochastic CRM for worst-case Small WTG scenario. Note that the annual mortalities have been assessed against both the biogeographic populations and the largest BDMPS (as advised by Natural England) in order to indicate the range of likely effects.

Species		Gannet			Kittiwake			Lesser black-backed gull			Herring gull			Great black-backed gull		
		Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.
Baseline average annual mortality		0.191			0.156			0.126			0.172			0.185		
Breeding season	Reference population	109,335			251,754			25,326			2,817			59,329		
	Seasonal mortality	2.01	0	8.73	11.91	0	40.26	35.09	0	164.57	0.65	0	3.3	0.68	0	3.38
	Increase in background mortality (%)	0.010	0.000	0.042	0.030	0.000	0.103	1.100	0.000	5.157	0.134	0.000	0.681	0.0062	0.0000	0.0308
Autumn	Reference population	456,298			829,937			209,007			466,511			N/A		
	Seasonal mortality	2.26	0	8.38	7.88	0.42	23.5	2.16	0	11.85	0.94	0	4.84	0	0	0
	Increase in background mortality (%)	0.003	0.000	0.010	0.006	0.000	0.018	0.008	0.000	0.045	0.001	0.000	0.006	0.0000	0.0000	0.0000
	Reference population	N/A			N/A			39,314			466,511			91,399		

Species		Gannet			Kittiwake			Lesser black-backed gull			Herring gull			Great black-backed gull		
Winter / non-breeding	Seasonal mortality	N/A	N/A	N/A	N/A	N/A	N/A	2.49	0	10.54	0.47	0	2.39	0.57	0	2.91
	Increase in background mortality (%)	N/A	N/A	N/A	N/A	N/A	N/A	0.050	0.000	0.213	0.001	0.000	0.003	0.0034	0.0000	0.0172
Spring	Reference population	248,835			627,816			197,483			N/A			52,829		
	Seasonal mortality	0.24	0	1.04	5.52	0.56	14.9	0.82	0	4.47	0	0	0	0.59	0	2.93
	Increase in background mortality (%)	0.001	0.000	0.002	0.006	0.001	0.015	0.003	0.000	0.018	0.000	0.000	0.000	0.0060	0.0000	0.0300
Annual largest BDMPS	Reference population	456,298			829,937			209,007			466,511			91,399		
	Seasonal mortality	4.5	0	18.14	25.3	0.97	78.65	40.58	0	191.44	2.05	0	10.52	1.84	0	9.22
	Increase in background mortality (%)	0.005	0.000	0.021	0.020	0.001	0.061	0.154	0.000	0.727	0.003	0.000	0.013	0.0109	0.0000	0.0545
Annual biogeo-graphic	Reference population	1,180,000			5,100,000			854,000			1,098,000			235,000		
	Seasonal mortality	4.5	0	18.14	25.3	0.97	78.65	40.58	0	191.44	2.05	0	10.52	1.84	0	9.22
	Increase in background	0.002	0.000	0.008	0.003	0.000	0.010	0.038	0.000	0.178	0.001	0.000	0.006	0.0042	0.0000	0.0212

Species		Gannet			Kittiwake			Lesser black-backed gull			Herring gull			Great black-backed gull		
	mortality (%)															

IMPACT 6: COMBINED OPERATIONAL COLLISION RISK AND DISPLACEMENT

4.11.140 With no identified operational collision risk or displacement impacts associated with the offshore ECC, this assessment considers impacts associated with operational WTGs within the array areas only.

GANNET

4.11.141 Being the only species that has been scoped in for both collision and displacement impacts from the VE project, it is possible that these impacts could combine to adversely affect gannet populations. Obviously, they would not act on the same individuals, as birds which do not enter a windfarm cannot be subject to mortality from collision, and vice versa. Avoidance rates for offshore windfarms, used in CRM, take account of macro-avoidance (where birds avoid entering a wind farm), meso-avoidance (avoidance of the rotor swept zone within a windfarm), and micro-avoidance (avoiding wind turbine blades). Thus, birds which exhibit macro-avoidance could be subject to mortality from displacement.

4.11.142 As noted above (Table 4.49), the estimated annual gannet collision mortality associated with VE is 4.5 (0 - 18.14). The estimated mortality for gannet displacement is up to seven birds at a displacement rate of 60-80% and mortality of 0-1% (Impact 3).

4.11.143 Based on the largest Annual BDMPS for the UK North Sea and Channel, of 456,298 (Furness 2015) and baseline mortality of 0.191 (Table 4.11), 87,153 individual gannets would be expected to die each year; the addition of a maximum of 12 individuals would represent an 0.01% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness 2015), 225,380 individuals would be expected to die; the addition of a maximum of seven individuals would represent an 0.003% increase in mortality. These magnitudes of increase would not materially alter the background mortality of the population and would be undetectable.

4.11.144 Thus, the combined impact of displacement and collision risk on gannet would be of negligible magnitude and the effect for a feature of medium sensitivity would be **minor adverse**, which is **not significant** in EIA terms.

4.12 ENVIRONMENTAL ASSESSMENT: DECOMMISSIONING PHASE

4.12.1 There are two potential impacts that may affect bird populations during the decommissioning phase of the proposed project that have been screened in. These are:

- Impact 7: Direct disturbance and displacement; and
- Impact 8: Indirect impacts through effects on habitats and prey species.

4.12.2 Any impacts generated during the decommissioning phase of the proposed VE project are expected to be similar, or of reduced magnitude, to those generated during the construction phase, as certain activities such as piling would not be required. This is because it would generally involve a reverse of the construction phase through the removal of some structures and materials installed.

4.12.3 It is anticipated that any future activities would be programmed in close consultation with the relevant statutory marine and nature conservation bodies, to allow any future guidance and best practice to be incorporated to minimise any potential impacts.

IMPACT 7: DIRECT DISTURBANCE AND DISPLACEMENT

4.12.4 Disturbance and displacement are likely to occur within the offshore ECC and array areas due to the presence of working vessels and crews and the movement, noise and light associated with these. Such activities have already been assessed for seabird IOFs in the construction section above and have been found to be of negligible or low magnitude.

4.12.5 Any impacts generated during the decommissioning phase of the proposed VE project are expected to be similar, but likely of reduced magnitude compared to those generated during the construction phase; therefore, the magnitude of impact is predicted to be negligible. The resultant effect on a range of IOFs of low to high sensitivity to disturbance is **negligible or minor adverse** for the offshore ECC and array areas combined, which is **not significant** in EIA terms.

IMPACT 8: INDIRECT IMPACTS THROUGH EFFECTS ON HABITATS AND PREY SPECIES

4.12.6 Indirect impacts such as displacement of seabird prey species are likely to occur within the offshore ECC and array areas as structures are removed. Such activities have already been assessed for relevant bird species in the construction section above and have been found to be of negligible magnitude.

4.12.7 Any impacts generated during the decommissioning phase of the proposed project are expected to be similar, but likely of reduced magnitude compared to those generated during the construction phase; therefore, the magnitude of impact is predicted to be negligible. The resultant effect on a range of IOFs of low to high sensitivity to disturbance is **negligible or minor adverse** for the offshore ECC and array areas combined, which is **not significant** in EIA terms.

4.13 ENVIRONMENTAL ASSESSMENT: CUMULATIVE EFFECTS

4.13.1 This cumulative impact assessment for offshore ornithology has been undertaken in accordance with the methodology provided in Volume 6, Part 1, Chapter 3, Annex 3.1: Cumulative Effects Assessment Methodology.

4.13.2 The methodology also follows the Natural England guidance on cumulative assessment (Parker *et al.* 2022c) specifically for offshore ornithology features and takes cognisance of the approach to the assessment of cumulative impacts for offshore ornithology that has been applied by the Secretary of State when consenting offshore windfarms and confirmed in the more recent consent decisions. It also considers the approach set out in guidance from the Planning Inspectorate (2019) and from the renewables industry (RenewableUK, 2013).

SCREENING FOR CUMULATIVE EFFECTS

4.13.3 The potential impacts arising from the proposed VE project that were screened in for assessment for the project alone have also been considered in Table 4.51 for the potential for cumulative effects with other projects (as defined below). This takes into account recommendations during the consultation process (Table 4.2).

Table 4.51: Screening for Potential Cumulative Effects.

Impact	Potential for cumulative impact	Data confidence[1]	Rationale
Construction			
Impact 1: Direct disturbance and displacement:	Yes (offshore ECC and array areas)	Medium	There is a possibility of temporal and spatial coincidence of disturbance / displacement from other plans or projects in the area acting on the same populations.
Impact 2: Indirect impacts through effects on habitats and prey species	No	Low	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is small and it is dependent on a temporal and spatial co-incidence of disturbance / displacement from other plans or projects.
Operation			
Impact 3: Direct disturbance and displacement	Yes (array areas)	High	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Impact 4: Indirect impacts through effects on habitats and prey species	No	Low	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is small

Impact	Potential for cumulative impact	Data confidence[1]	Rationale
Impact 5: Collision risk	Yes (array areas)	High	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Impact 6: Combined operational collision risk and displacement	Yes	Medium	There is a sufficient likelihood of a cumulative impact to justify quantitative cumulative impact assessment.
Decommissioning			
Impact 7: Direct disturbance and displacement	No	Low	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is small and it is dependent on a temporal and spatial co-incidence of disturbance / displacement from other plans or proposed projects.
Impact 8: Indirect impacts through effects on habitats and prey species	No	Low	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is small and it is dependent on a temporal and spatial co-incidence of disturbance / displacement from other plans or projects.
1. Indicates the degree of confidence; medium / low reflects lower confidence in older assessments which used variable methods.			

PROJECTS CONSIDERED FOR CUMULATIVE IMPACTS

4.13.4 The projects and plans selected as relevant to the assessment of impacts to 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 VE on offshore ornithology in the UK North Sea and Channel, the cumulative effect assessment technical note submitted through the EIA Evidence Plan (Volume 6, Part 1, Chapter 3, Annex 3.1: Cumulative Effects Assessment Methodology) screened in a number of projects and plans as presented in that report.

4.13.5 The classes of projects that could potentially be considered for the cumulative assessment of offshore ornithological receptors include:

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

4.13.6 With respect to the other activities listed above, 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, to avoid double-counting or exaggeration of potential impacts. This follows Parker *et al.* (2022c) guidance which advises that *'Built and operational projects should be included within the cumulative assessment where they have not been included within the environmental characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and/or any residual impact may not have yet fed through to and been captured in estimates of "baseline" conditions, such as "background" distribution or mortality rate for birds'*.

4.13.7 While other cable laying operations (e.g. interconnector cables) could take place at the same time as the VE offshore export cable construction, it is considered unlikely that this would contribute to a cumulative disturbance effect as the duration of cable laying operations within sensitive ornithological areas (such as the Outer Thames Estuary SPA) will last no more than a few weeks for any particular project, and the zone of effect is comparatively small e.g. up to a 2km radius around cable laying vessels, depending on species.

4.13.8 It is therefore not expected that VE will contribute to cumulative effects of the long-term activities in the above list (excluding offshore windfarms), and therefore these are scoped out and the cumulative assessment is focused on offshore windfarms.

WINDFARM PROJECTS

4.13.9 The windfarm projects listed in Table 4.53 are located within UK North Sea and Channel (equivalent to the BDMPS extent) and have been assigned to various Tiers (see Table 4.52) which are based on Natural England Parker *et al.* (2022c) guidance, but with additional sub-tiers added to provide a more accurate reflection of project status and applicability for particular impacts and species.

4.13.10 Projects within Tiers 6 and 7 have been excluded from this cumulative assessment because baseline data gathering is ongoing, and insufficient application information is available.

4.13.11 Some of the more recent OWF projects in the UK North Sea and Channel have required compensation measures to be implemented where significant project/cumulative effects have been predicted on particular species. These projects, which have been highlighted in Table 4.52, should technically be excluded from the cumulative assessment based on the assumption that the predicted effects have been removed due to compensation.

4.13.12 Following consultation, and in response to requests for closer coordination (in line with draft NPS EN-3), the neighbouring VE and North Falls projects have worked together to develop a shared export cable corridor, which keeps the potential impacts from the projects to a single area of sea and enables coordination during construction, which has the potential to significantly reduce the impacts associated with the construction phase (see Volume 6, Part 1, Chapter 3, Annex 3.1: Cumulative Effects Assessment Methodology).

Table 4.52: Description of Tiers of other windfarms considered for cumulative assessment (adapted from Parker *et al.* (2022)).

Tiers	Sub-tier	Development Stage
Tier 1	1a	Built and operational projects which may be judged as being included within the environmental characterisation survey, i.e., they were operational when baseline surveys were undertaken, and/or any residual impact has fed through to and been captured in estimates of “baseline” conditions, such as “background” distribution or mortality rate for birds.
	1b	Tier 1a + Built and operational projects which have not been included within the environmental characterisation survey, i.e. they were not operational when baseline surveys were undertaken, and/or any residual impact may not have yet fed through to and been captured in estimates of “baseline” conditions, such as “background” distribution or mortality rate for birds.* Projects built within five years of VE baseline surveys are included here (based on maximum age of first breeding for seabird species – see e.g., Table 4.11).
Tier 2	2a	Tier 1 + projects under construction.
	2b	Tier 2a + pre-construction projects (e.g., onshore works have commenced)
Tier 3		Tier 2 + projects that have been consented (but construction has not yet commenced).
Tier 4		Tier 3 + projects that have an application submitted to the appropriate regulatory body that have not yet been determined.
Tier 5		Tier 4 + projects that have produced a PEIR and have characterisation data within the public domain.

Tiers	Sub-tier	Development Stage
Tier 6		Tier 5 + projects that the regulatory body are expecting an application to be submitted for determination (e.g., projects listed under the Planning Inspectorate programme of projects).
Tier 7		Tier 6 + projects that have been identified in relevant strategic plans or programmes.

*Or if there are ongoing impacts that are greater than predicted where there is no evidence that the impacts will dissipate over the lifetime of the project, e.g. displacement of red-throated diver.

Table 4.53: Projects considered within the offshore ornithology cumulative effect assessment. Projects where compensation will be implemented, or where compensation may apply, have been shaded blue. Tier 6 projects scoped out of the assessment have been shaded grey.

Tier	Project	Year of Commissioning	Distance to Array Area (km)	Distance to Offshore ECC (km)
1a	Scroby Sands	2004	74	80
1a	Kentish Flats	2005	71	38
1a	Beatrice Demonstrator	2007	c.750	c.750
1a	Lynn and Inner Dowsing	2009	168	152
1a	Gunfleet Sands	2010	52	7
1a	Thanet	2010	43	36
1a	Greater Gabbard	2012	3	1
1a	Sheringham Shoal	2012	137	134
1a	Lincs	2013	167	152
1a	London Array	2013	35	14
1a	Methil	2013	574	559
1a	Teesside	2013	363	349
1b	Humber Gateway	2015	218	206
1b	Kentish Flats Extension	2015	71	39
1b	Westermost Rough	2015	238	226
1b	Blyth Demonstration Project	2017	416	404
1b	Dudgeon	2017	143	146
1b	Hywind	2017	649	645
1b	European Offshore Wind Deployment Centre (Aberdeen Bay)	2018	638	631
1b	Galloper ‡	2018	0	0
1b	Race Bank	2018	160	152

Tier	Project	Year of Commissioning	Distance to Array Area (km)	Distance to Offshore ECC (km)
1b	Rampion	2018	195	158
1b	Beatrice	2019	759	752
1b	East Anglia ONE	2020	23	29
1b	Hornsea Project One	2020	203	209
1b	Kincardine	2021	611	604
1b	Moray East	2022	746	740
1b	Hornsea Project Two	2022	207	214
1b	Triton Knoll	2022	175	171
1b	Seagreen A and B	2023 (Phase 1)	557	550
2a	Neart na Gaoithe	Under construction	546	535
2a	Moray West	Under construction	748	741
2a	Dogger Bank Creyke Beck Projects A and B	Under construction (A); Pre-construction (B)	296	302
2a	Dogger Bank Teesside Projects A (now Dogger Bank C) and B (now Sofia)	Under construction (Sofia); Pre-construction (C)	330	337
2b	East Anglia THREE	Pre-construction	69	75
2b	Hornsea Project Three - revised *	Pre-construction	193	198
2b	Inch Cape	Pre-construction	565	555
3	Pentland Floating Offshore Wind	Consented (variation in progress)	831	823
3	Norfolk Vanguard (East & West) * ‡	Consented	91	97
3	Norfolk Boreas * ‡	Consented	105	110
3	East Anglia ONE North * ‡ §	Consented	36	41
3	East Anglia TWO * ‡	Consented	5	12
3	Hornsea 4 *	Consented	210	215
4	Berwick Bank *	Application	508	500
4	Dudgeon Offshore Extension Project *	Application	136	139
4	Sheringham Shoal Extension Project *	Application	135	132
4	Rampion 2	Application	206	167

Tier	Project	Year of Commissioning	Distance to Array Area (km)	Distance to Offshore ECC (km)
4	ForthWind Offshore Wind Demonstration Project - phase 1	Application	572	558
4	West of Orkney	Application	855	846
5	Outer Dowsing	PEIR	176	176
5	Dogger Bank South (East & West combined)	PEIR	319	325
5	North Falls	PEIR	6	0
6	Dogger Bank D	Scoping	c.350	c350
6	Morven	Scotwind	528	525
6	Ossian	Scotwind	526	525
6	Bowdun	Scotwind	590	585
6	Bellrock	Scotwind	550	551
6	Campion	Scotwind	579	583
6	Muir Mhor	Scotwind	618	619
6	MarramWind	Scotwind	689	691
6	Buchan	Scotwind	728	727
6	Broadshore	Scotwind	726	723
6	Caledonia	Scotwind	729	723
6	Stromar	Scotwind	760	757
6	Ayre	Scotwind	798	795
6	BP North East	Innovation and Targeted Oil & Gas (INTOG)	646	643
6	Simply Blue Energy	INTOG	657	655
6	Scaraben	INTOG	729	726
6	Sinclair	INTOG	738	735

* = projects with compensation to be implemented for kittiwake (Dudgeon and Sheringham Offshore Extension projects have submitted compensation and is likely to be required).
‡ = projects with compensation to be implemented for lesser black-backed gull. Dudgeon and Sheringham Offshore Extension projects and Galloper are to be confirmed.
§ = red-throated diver displacement within the Outer Thames Estuary SPA will be compensated for by East Anglia ONE North.

CUMULATIVE ASSESSMENT OF CONSTRUCTION: DIRECT DISTURBANCE AND DISPLACEMENT

4.13.13 Cumulative construction disturbance and displacement impacts may occur when the construction phase of VE overlaps with that of one or more other Tier 3 (consented), Tier 4 (application) or Tier 5 (PEIR stage) projects listed in Table 4.53. Within the array area(s) of a project, at any one time, the physical extent of disturbance due to construction activities is likely to be relatively small. Until WTGs (and other structures) are placed on foundations, the impacts will occur only in the areas where vessels are operating at any given point and not the entire array area(s). At such time as WTGs (and other infrastructure) are installed onto foundations the impact of displacement would increase incrementally to the same levels as operational impacts (see Cumulative Assessment of Operational Displacement section below (4.13.37)).

4.13.14 Cumulative operational displacement could therefore effectively be seen as a worst-case WTG construction disturbance scenario, when considering Tier 3-5 projects only, albeit the duration of impact is extended, starting in the construction phase.

4.13.15 Effort should therefore be made to identify any cumulative construction disturbance impacts that are not covered by the operational displacement worst-case. For VE, the most likely separate cumulative impact will be cumulative disturbance to birds due to construction of offshore export cables which may occur at the same time as other Tier 3-5 projects.

4.13.16 Table 4.17 provided a screening of potential construction disturbance impacts on each species due to VE alone, and identified four species that were to be taken forward for assessment: red-throated diver, common scoter, razorbill and guillemot.

4.13.17 Of these four species, razorbill and guillemot numbers predicted to be affected by construction disturbance within the array areas were very small (0.03% and 0.05% of BDMPS for razorbill and guillemot respectively) and non-breeding numbers recorded by Irwin *et al*. (2019) around the offshore ECC were similarly low, and the area is not within foraging range of breeding birds. As such these two species are scoped out of this cumulative construction assessment.

4.13.18 Common scoters were regularly recorded within the Outer Thames Estuary SPA areas overlapping and close to the offshore ECC, but densities were sufficiently low to result in a prediction of fewer than one bird being lost due to VE disturbance under Impact 1. This species can therefore also be scoped out of cumulative assessment.

4.13.19 Based on the screening exercise undertaken in Table 4.17, red-throated diver is therefore the only species requiring a cumulative assessment for construction impacts, due to potential disturbance associated with export cable construction. This is particularly relevant for red-throated divers, because of their distribution and preference for inshore shallow sandy bays around the southern North Sea in the non-breeding season (O'Brien *et al*., 2008, Stone *et al*., 1995), and so the main overlap with Tier 3-5 project footprints is likely to be associated with export cable corridors.

RED-THROATED DIVER

4.13.20 Predicted mortality numbers due to construction-related disturbance in Table 4.54 have been compiled from EIAs of Tier 3-5 projects within the North Sea, carried out in a largely consistent way with each other, and with the assessment for VE alone in this chapter (Impact 1), where it is assumed that an area of 2km around cable-laying associated vessels will be subject to displacement impacts on red-throated divers. The resultant mortality rate due displacement has mainly been considered as being at a range of 1-10%, but where this was not the case, values have been converted for consistency. One difference between projects is the number of cable laying vessels/vessel aggregations assumed to be on site at any particular time – this is either one or two for other projects, with the worst-case assumption for VE being three vessels/aggregations directly associated with cable laying, based on the offshore ECC MDS (a total of up to 2 x 6 vessel aggregations at any one time, including non-cable laying vessels such as tugs, but assuming not all vessels in an aggregation are clustered together) which is outlined in Volume 6, Part 2, Chapter 1: Offshore Project Description and Table 4.15.

Table 4.54: Red-throated diver: predicted mortality due to cumulative disturbance and displacement impacts associated with export cable constructions.

Tier	Project	Predicted mortality Range	Mortality rate assumptions in ES
3	Pentland Floating Offshore Wind	0 - 0	No quantitative assessment ('negligible' magnitude)
3	Norfolk Vanguard (East & West) (East & West)	0 - 9	2 - 4 at 5% mortality, converted to 1-10% mortality
3	Norfolk Boreas	0 – 9	1-10% mortality
3	East Anglia ONE North	0 - 10	1-10% mortality
3	East Anglia TWO	0 - 10	1-10% mortality
3	Hornsea Project 4	0 - 0	No losses even with 100% displacement
4	Berwick Bank	0 - 0	Species not assessed
4	Dudgeon Offshore Extension Project	0 - 0	1-10% mortality
4	Sheringham Shoal Extension Project	0 - 3	1-10% mortality
4	Rampion 2	0 – 0	Species not assessed
4	ForthWind Offshore Wind Demonstration Project - phase 1	0 - 0	Species not assessed
4	West of Orkney	0 - 0	Species not assessed
5	Outer Dowsing	0 - 3	1-10% mortality

Tier	Project	Predicted mortality Range	Mortality rate assumptions in ES
5	Dogger Bank South (East & West combined)	0 - 0	Species not assessed
5	North Falls	1 - 18	1% mortality, converted to 1-10% mortality
	Total (other projects)	**1 - 62**	
	VE	1 - 14	1-10% mortality (3 vessel aggregations)
	Total (all projects)	**2 - 76**	

4.13.21 In total, up to 62 red-throated divers are predicted to be lost as a result of other Tier 3-5 projects. Although this would rise to 76 if including VE (where three vessel aggregations were assumed), because offshore cable construction would take place simultaneously with North Falls (or alone, should North Falls not be constructed), there would be no additive mortality associated with the two projects. As such, 62 individuals is considered to be the worst-case estimate.

4.13.22 At the average baseline mortality rate of 0.228, the number of individuals expected to die from the largest BDMPS population throughout the year is 3,027 (13,277 x 0.228). The addition of a maximum of 62 individuals to this increases the mortality rate by up to 2.0%, which would be considered of low magnitude. When considering impacts on wintering birds within the southwest North Sea BDMPS (10,177, Furness 2015) (no Tier 3-5 projects outside of this area predicted any losses), this would increase the mortality rate by up to 2.7%, which is again low magnitude.

4.13.23 The cumulative red-throated diver displacement mortality total does however combine several sources of precaution:

- It does not quantify the results of mitigation during construction of VE, and commitment by other southern North Sea projects, to provide a best practice protocol to minimise disturbance to red-throated divers within the Outer Thames Estuary SPA;
- An evidence review of effects of displacement on red-throated divers (Norfolk Vanguard Ltd 2019a; see also Section 4.11 above) found that 90% displacement and 1% mortality are more appropriate (and still precautionary) than the 100% and 10% recommended by the SNCBs (2017; updated 2022). Displacement mortality may be less than 1% and could be as low as zero;
- It includes an unknown degree of double counting across seasons since some individuals will be present within more than one season and could also potentially move between sites (e.g., as may have been the case for VE and North Falls);
- Much of the total annual mortality for other projects is predicted to occur during the autumn and spring migration periods when the potential consequences of displacement are expected to be much lower due to the brief duration that birds spend in the area at this time; and
- It is probable that the Southwest North Sea BDMPS for spring and autumn migration (13,277) is an underestimate. Aerial surveys of the Outer Thames

Estuary SPA in 2013 and 2018 produced respective peak population estimates of 14,161 and 22,280 birds (Irwin *et al*. 2019). Based on these surveys, the SPA population estimate has recently been revised upwards to 18,079 individuals (Natural England 2019) compared with 6,446 when the site was first designated in 2010. Natural England (2019) commented that this change in the estimated SPA population – nearly a three-fold increase – is thought to reflect the use of digital aerial surveys which have provided more accurate counts and that previous counts (based on visual aerial and boat-based surveys) may have been significant underestimates. The SPA lies within the wider BDMPS region and is recognised as an important area for red-throated divers (hence the designation), but its extent is small compared with the wider BDMPS region (which also includes the Greater Wash SPA with a cited population of 1,407 red-throated divers overwinter during the period 2002-2006, Natural England 2018). If the revised population estimate for the Outer Thames Estuary SPA was taken as a minimum estimate of the BDMPS population during the spring migration period, 4,122 individuals would be expected to die each year (0.228 x 18,079). The predicted annual cumulative mortality from construction displacement (1 - 62), would represent up to 1.5%.

4.13.24 On the basis of the worst-case approach recommended by Natural England (100% displacement from the site and a 4km buffer and 10% mortality of displaced birds), the cumulative red-throated diver construction disturbance impact magnitude is assessed as low, which, for a high sensitivity, species, would result in a moderate adverse effect (significant in EIA terms, based on the matrix in Table 4.7).

4.13.25 On the basis of the evidence review (see Section 4.11 above and Norfolk Vanguard Ltd 2019a) it is considered that the most realistic (and still precautionary) combination of displacement and consequent mortality rates is 90% and 1%. This, combined with the various additive sources of precaution listed above suggests there is a very high likelihood that cumulative disturbance would be lower than the worst-case totals presented here, resulting in increases in background mortality below 1%, and thus the magnitude of cumulative disturbance is assessed as **negligible**. Therefore, as the species is of high sensitivity to disturbance, the cumulative effect would be **minor adverse**, which is **not significant** in EIA terms.

CUMULATIVE ASSESSMENT OF OPERATIONAL DISPLACEMENT

4.13.26 The species assessed for project alone operational displacement impacts (and the relevant seasons) were red-throated diver (autumn, winter, spring), gannet (autumn, spring), guillemot (breeding, nonbreeding) and razorbill (breeding, autumn, winter, spring).

4.13.27 A review of the UK North Sea and Channel BDMPS for each species indicated that for gannet, guillemot, and razorbill, all the windfarms identified for inclusion in the cumulative assessment in Table 4.53 have the potential to contribute a cumulative effect. For red-throated diver, the BDMPS is the southwest North Sea.

4.13.28 Thus, windfarms located in the north-west North Sea (all offshore windfarms located from the Northumbria coast northwards) and in the English Channel were not considered likely to contribute to a cumulative displacement effect for this species. In addition, as the species tends to be found in estuarine and near-shore shallow waters during the non-breeding season, offshore wind farms further from the coast (Hornsea, Dogger Bank) tended to scope the impact out of their assessment or predict zero losses.

RED-THROATED DIVER

4.13.29 Cumulative red-throated diver displacement mortality has been estimated for windfarms in the south-west North Sea BDMPS (Furness 2015) which have the potential to contribute to a cumulative effect. This has been conducted using the precautionary rates of displacement and mortality recommended by the SNCBs (2017; updated 2022) (100% displacement and up to 10% mortality within the 4km buffer) as well as those derived from a review of evidence for this species (see Section 4.11 above and MacArthur Green 2019a) (90% displacement and up to 1% mortality).

4.13.30 A review of the impact assessments for offshore windfarms in the south-west North Sea BDMPS with a potential to contribute to cumulative operational displacement is presented in Norfolk Boreas Ltd (2019). Four categories were identified with respect to red-throated divers: windfarms with no population estimates presented (Dogger Bank sites and Blyth demonstrator), coastal windfarms with low numbers of over-wintering birds reported (Teesside, Humber Gateway and Westernmost Rough), windfarms with sightings made during months considered to belong to the breeding season (Hornsea projects) and windfarms with quantitative information on over-wintering birds by season (Norfolk Vanguard, Norfolk Boreas). The estimated numbers of red-throated divers displaced from these Tier 1 to 3 projects (where quantitative information is available) is shown in Table 4.55.

4.13.31 The assessments for a number of offshore windfarms in the south-west North Sea BDMPS did not include the necessary level of detail to permit their inclusion in a quantitative cumulative assessment. In addition, baseline surveys for different projects were carried out over different timescales, during a period that the distribution of red-throated divers may have been changing as offshore windfarm projects were constructed and became operational.

Table 4.55: Red-throated diver cumulative displacement mortality for the Southwest North Sea BDMPS. The ranges presented for each season and annually are mortality estimated for a precautionary range of 90-100% displacement within 4km of the windfarm and 1% to 10% mortality of displaced individuals. Projects where compensation will be implemented, or where compensation may apply, have been shaded light blue.

Tier	Project	Autumn	Midwinter	Spring	Annual
1 to 3	Wider region (Norfolk Boreas Ltd 2019a)	N/A	N/A	N/A	6 – 56
1b	East Anglia ONE	0.4 - 5	1 - 10	1.4 - 15	2.8 - 30
2b	East Anglia THREE	0.4 - 5	0.2 – 2	2 - 20	2.6 - 27
3	Norfolk Vanguard (East & West) East	0.4 - 5	0.2 - 3	1 - 12	1.6 - 20
3	Norfolk Vanguard (East & West) West	0 – 3	3 - 36	2 – 20	5 – 59
3	Norfolk Boreas	0 - 1	1 - 15	5 - 62	6 – 78
3	East Anglia ONE North	0 - 1	1 - 3	3 - 17	4 - 21
3	East Anglia TWO	0	0 - 2	2 - 25	3 - 28
3	Hornsea Project 4	0	0	0	0
4	Dudgeon Offshore Extension Project	1 – 6	0 - 1	1 – 5	1 – 13
4	Sheringham Shoal Extension Project	1 – 8	0 - 1	2 – 18	3 - 26
5	Dogger Bank South (East & West combined)	Not assessed			
5	Outer Dowsing	0.1 - 1.3	0.1 - 1.2	1.1 - 10.9 (+ 0.1 - 0.8 breeding season)	1.3 - 14.1
5	North Falls	0 - 1	1- 6	5 - 49	6 - 56
	Total (other projects)	**3.3 - 36.3**	**7.5 - 80.2**	**25.6 - 254.7**	**42 - 428**
	VE	0 - 0	0 - 2	0-3	0 - 5
	Total (all projects)	**3.3 - 36.3**	**7.5 - 82.2**	**25.6 - 257.7**	**42 - 433**

4.13.32 Table 4.55 shows that for all other projects combined, an annual total of 42-433 individuals would be lost.

4.13.33 The largest BDMPS for red-throated diver is 13,277 during spring and autumn migration (Furness 2015). At the average baseline mortality rate for red-throated diver of 0.228 the number of individuals expected to die is 3,027 (13,277 x 0.228). The addition of 42-433 individuals to this would increase the mortality rate by 1.3-14.3%.

4.13.34 The biogeographic population for red-throated diver with connectivity to UK waters is 27,000 (Furness 2015). At the average baseline mortality rate for red-throated diver of 0.228 the number of individuals expected to die is 6,156 (27,000 x 0.228). The addition of 42-433 to this would increase the mortality rate by 0.7-7.0%.

4.13.35 Looking at the midwinter period alone, the BDMPS for the southwest North Sea is 10,177 (Furness 2015). At the average baseline mortality rate for red-throated diver of 0.228 the number of individuals expected to die is 2,320 (10,177 x 0.228). The addition of a maximum of 7.5-82 birds to this would increase the mortality rate by 0.3-3.5%.

4.13.36 The cumulative red-throated diver displacement mortality totals combine several sources of precaution, some of which were noted previously in paragraph 4.13.23:

- It does not quantify the mitigation during construction of VE, and commitment by other southern North Sea projects, to provide a best practice protocol to minimise disturbance to red-throated divers within the Outer Thames Estuary SPA;
- Compensation for displacement of red-throated divers within the Outer Thames Estuary SPA will be implemented for the East Anglia ONE North project, thereby theoretically removing the impacts of this project on the species' BDMPS population (4-21 individuals).
- An evidence review of effects of displacement on red-throated divers (Norfolk Vanguard Ltd 2019a; see also Section 4.11 above) found that 90% displacement and 1% mortality are more appropriate (and still precautionary) than the 100% and 10% recommended by the SNCBs (2017; updated 2022). Displacement mortality may be less than 1% and could be as low as zero;
- Each windfarm assessment has assumed that all birds within 4km of the windfarm lease boundary are potentially affected to the same extent, whereas there is evidence that displacement declines with distance from windfarm boundaries and in some cases has been reported as zero by 2km;
- It includes an unknown degree of double counting across seasons since some individuals will be present within more than one season and could also potentially move between sites;
- The Norfolk Boreas, Norfolk Vanguard East and East Anglia THREE 4km buffers overlap with each other therefore including the buffer for all three sites leads to double counting birds in the overlapping areas (by approximately 15%);
- 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 turbines across the two windfarm sites and the consequent reduction in developed area or increase in wind turbine spacing;
- Two thirds of the total annual mortality is predicted to occur during the autumn and spring migration periods when the potential consequences of displacement are expected to be much lower due to the brief duration that birds spend in the area at this time; and

- It is probable that the UK North Sea BDMPS for spring and autumn migration (13,277) is an underestimate, based on the Outer Thames SPA population estimate which has more recently been revised upwards to 18,079 individuals (Natural England 2019). If the revised population estimate for the Outer Thames Estuary SPA was taken as a minimum estimate of the BDMPS population during the spring migration period, 4,122 individuals would be expected to die each year (0.228 x 18,079). The predicted annual cumulative mortality from displacement (42-433), would represent 1.0% - 10.5%.

4.13.37 A further potential source of precaution is that the assessment methodology makes no allowance for the fact that WTG areas (and hence the negative stimulus to which the birds respond) of built windfarms may be much lower than the worst-case designs on which the projects were consented. For example, East Anglia ONE was originally assessed on the basis of 333 wind turbines, reduced to 240 for consent, which was further reduced to 102 in the final built design. Thus, the windfarm has less than one third the original number of proposed (and assessed) wind turbines and has a smaller footprint area. Similar reductions in WTG area are likely for other consented windfarms which have not yet been built. This will further reduce the magnitude of displacement.

4.13.38 Generally, based on findings from population viability analyses for bird species, it would be considered that increases in mortality rates of less than 1% would be undetectable in terms of changes in population size. Using a range of displacement mortality of 1–10% for displaced birds and different reference populations predicts changes in population mortality rates which are likely to be undetectable at the lower end and may be detectable at the upper end of the range.

4.13.39 On the basis of the worst-case approach recommended by Natural England (100% displacement from the site and a 4km buffer and 10% mortality of displaced birds), the cumulative red-throated diver operational displacement impact magnitude is assessed as low or medium, which, for a high sensitivity, species, would result in a moderate or major adverse effect (significant in EIA terms, based on the matrix in Table 4.7).

4.13.40 However, on the basis of the evidence review (see Section 4.11 above and Norfolk Vanguard Ltd 2019a) it is considered that the most realistic (and still precautionary) combination of displacement and consequent mortality rates is 90% and 1%. This, combined with the various additive sources of precaution in this assessment suggests there is a very high likelihood that cumulative displacement would be much lower than the worst-case totals presented here, and thus the magnitude of cumulative displacement is assessed as **low**. Therefore, as the species is of high sensitivity to disturbance, the cumulative effect would be **minor adverse**, which is **not significant** in EIA terms.

GANNET

4.13.41 There is increasing evidence that gannets avoid flying through windfarms (Krijgsveld *et al*. 2011; Skov *et al*. 2018, Cook *et al*. 2018; Irwin *et al*. 2019). If this prevents them accessing important foraging areas this could have an impact on displaced individuals.

4.13.42 Although the VE array areas are located within the 315km mean maximum foraging range of gannets from breeding colonies in the North Sea (Woodward *et al*. 2019), evidence from tagging data in Langston *et al*. (2013) has shown that there is very, if any, overlap with the range of breeding birds in this area. Therefore, displacement risk is primarily of concern outside of the breeding season. During autumn migration, very large numbers of gannets are migrating from breeding colonies in Northern Europe to wintering areas farther south, predominantly off the coast of West Africa (Kubetzki *et al*. 2009; Furness *et al*. 2018a). Spring migration routes differ from those in autumn and very few birds migrate through the southern North Sea during this period (Furness 2015). Thus, spatial displacement due to windfarms in the North Sea is trivial when compared with the range over which individuals of this species travel (Garthe *et al*. 2012, see also Masden *et al*. 2010, 2012).

4.13.43 As well as being wide-ranging, gannets are considered to be highly flexible in their foraging requirements, and exclusion from wind farms in the southern North Sea, is very unlikely to represent a habitat loss of any importance. Consequently, the potential for the proposed VE project to contribute to a significant cumulative displacement effect on gannets was assessed above as being negligible.

4.13.44 Table 4.56 shows the number of birds at risk of displacement from offshore wind farms in the UK North Sea and Channel BDMPS, which has been calculated as 62,273 individuals. When the estimated numbers at risk due to VE are included, this would increase to 63,213 individuals.

Table 4.56: Cumulative Numbers of Gannets at Risk of Displacement from Offshore Windfarms in the North Sea.

Tier	Project	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
1a	Scroby Sands	-	-	-	-	-
1a	Kentish Flats	-	-	-	-	-
1a	Beatrice Demonstrator	-	-	-	-	-
1a	Lynn & Inner Dowsing	-	-	-	-	-
1a	Gunfleet Sands	0	12	9	21	21
1a	Thanet	-	-	-	-	21
1a	Greater Gabbard	252	69	105	426	447

Tier	Project	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
1a	Sheringham Shoal	47	31	2	80	527
1a	Lincs	-	-	-	-	527
1a	London Array	-	-	-	-	527
1a	Methil	23	0	0	23	550
1a	Teesside	1	0	0	1	551
1b	Humber Gateway	-	-	-	-	551
1b	Kentish Flats Extension	0	13	0	13	564
1b	Westermost Rough	-	-	-	-	564
1b	Blyth Demonstration Project	-	-	-	-	564
1b	Dudgeon	53	25	11	89	653
1b	Hywind	10	0	4	14	667
1b	European Offshore Wind Deployment Centre (Aberdeen Bay)	35	5	0	40	707
1b	Galloper	360	907	276	1543	2250
1b	Race Bank	92	32	29	153	2403
1b	Rampion	0	590	0	590	2993
1b	Beatrice	151	0	0	151	3144
1b	East Anglia ONE	161	3638	76	3875	7019
1b	Hornsea Project One	671	694	250	1615	8634
1b	Kincardine	120	0	0	120	8754
1b	Moray East	564	292	27	883	9637
1b	Hornsea Project Two	457	1140	124	1721	11358
1b	Triton Knoll	211	15	24	250	11608
1b	Seagreen A and B	2956	664	332	3952	15560
2a	Neart na Gaoithe	1987	552	281	2820	18380
2a	Moray West	2827	439	144	3410	21790

Tier	Project	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
2a	Dogger Bank Creyke Beck Projects A and B	1155	2048	394	3597	25387
2a	Dogger Bank Teesside Projects A (now Dogger Bank C) and B (now Sofia)	2250	887	464	3601	28988
2b	East Anglia THREE	412	1269	524	2205	31193
2b	Hornsea Project Three - revised	1333	984	524	2841	34034
2b	Inch Cape	2398	703	212	3313	37347
3	Pentland Floating Offshore Wind	166	24	8	198	37545
3	Norfolk Vanguard (East & West)	271	2453	437	3161	40706
3	Norfolk Boreas	1229	1723	526	3478	44184
3	East Anglia ONE North	149	468	44	661	44845
3	East Anglia TWO	192	891	192	1275	46120
3	Hornsea 4	976	790	401	2167	48287
4	Berwick Bank	4735	1500	269	6504	54791
4	Dudgeon Offshore Extension Project	417	343	47	807	55598
4	Sheringham Shoal Extension Project	23	295	11	28	55626
4	Rampion 2	111	102	123	336	55962
4	ForthWind Offshore Wind Demonstration Project - phase 1	64	26	44	134	56096
4	West of Orkney	958	585	586	2129	58225

Tier	Project	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
5	Outer Dowsing	847	169	172	1187	59412
5	Dogger Bank South (East & West combined)	1038	1020	17	2075	61487
5	North Falls	68	453	245	786	62273
	Total (other projects)	**29770**	**25851**	**6934**	**62273**	
	VE	233	640	67	940	
	Total	**30003**	**26491**	**7001**	**63213**	

4.13.45 Table 4.57 shows that at displacement rates of 60-80%, and 1% mortality of displaced birds, between 379 and 506 gannets would be predicted to be lost due to cumulative displacement (including the seven associated with VE). Based on the largest Annual BDMPS of 456,298 (Furness 2015) and baseline mortality of 0.191, 87,153 individual gannets would be expected to die each year; the addition of a maximum of 506 individuals would represent a 0.6% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness 2015), 225,380 individuals would be expected to die; the addition of a maximum of 506 individuals would represent an 0.2% increase in mortality.

Table 4.57: Cumulative Annual Displacement Matrix for Gannet.

Annual cumulative		**Mortality rate**										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	63	126	190	253	316	632	1264	1896	3161	5057	6321
	20%	126	253	379	506	632	1264	2529	3793	6321	10114	12643
	30%	190	379	569	759	948	1896	3793	5689	9482	15171	18964
	40%	253	506	759	1011	1264	2529	5057	7586	12643	20228	25285
	50%	316	632	948	1264	1580	3161	6321	9482	15803	25285	31607
	60%	379	759	1138	1517	1896	3793	7586	11378	18964	30342	37928
	70%	442	885	1327	1770	2212	4425	8850	13275	22125	35399	44249
	80%	506	1011	1517	2023	2529	5057	10114	15171	25285	40456	50570
	90%	569	1138	1707	2276	2845	5689	11378	17068	28446	45513	56892
	100%	632	1264	1896	2529	3161	6321	12643	18964	31607	50570	63213

4.13.46 Thus, precautionary estimates of the gannet mortality as a result of cumulative displacement from offshore wind farms UK North Sea and Channel BDMPS represent a change in mortality rate of 0.6% or less, which would not be detectable at the population level. In reality, given the wide-ranging behaviour of gannets and their flexibility in foraging behaviour, displacement from offshore wind farms is considered unlikely to cause any increase in the population mortality rate.

4.13.47 The magnitude of cumulative displacement for gannet is considered to be **negligible** and the effect of cumulative displacement on a receptor of low to medium sensitivity is **minor adverse**, which is **not significant** in EIA terms.

RAZORBILL

4.13.48 The VE array areas are located beyond the mean maximum foraging range of any razorbill breeding colonies (see section 4.11). Outside the breeding season razorbills migrate southwards from their breeding colonies. Large numbers are found in the North Sea throughout the non-breeding seasons (the spring and autumn migration periods and winter, between August and March; Furness 2015).

4.13.49 The annual total of razorbills at risk of displacement from both VE array areas is estimated as 2,176 individuals (summing the seasonal peak means within the north and south arrays (and 2km buffer) for the migration-free breeding, autumn migration, winter, and spring migration periods; Table 4.58).

4.13.50 Estimates of the number of razorbills at risk of displacement from other offshore windfarms included in the cumulative assessment are given in Table 4.58. The cumulative totals omit windfarms for which no data are available (as indicated in table), but they are also likely to over-estimate the numbers present due to the precautionary use of seasonal peak numbers at each site rather than average numbers, which is likely to lead to double counting as birds move through the North Sea.

4.13.51 The estimated annual cumulative total of razorbills at risk of displacement from windfarms in the North Sea is 206,551 individuals, which rises to 208,727 individuals when including VE (Table 4.58). Considering a range of displacement of 30-70%, and mortality of displaced individuals from 1-10%, based on advice from Natural England, the estimated number of razorbills subject to mortality from displacement throughout the year is between 626 and 14,611.

Table 4.58: Cumulative Numbers of Razorbills at Risk of Displacement from Offshore Windfarms in the North Sea.

Tier	Windfarm	Breeding season	Autumn migration	Non-breeding season	Spring migration	Annual	Annual Running Total
1a	Scroby Sands	No estimate available					-
1a	Kentish Flats	No estimate available					-
1a	Beatrice Demonstrator	No estimate available					-
1a	Lincs & LID	45	34	22	34	134	134
1a	Gunfleet Sands	0	0	30	0	30	164
1a	Thanet	3	0	14	21	37	201
1a	Greater Gabbard	0	0	387	84	471	672
1a	Sheringham Shoal	106	1343	211	30	1690	2362
1a	London Array	14	20	14	20	68	2430
1a	Methil	4	0	0	0	4	2434
1a	Teesside	16	61	2	20	99	2533
1b	Humber Gateway	27	20	13	20	80	2613
1b	Kentish Flats Extension	No estimate available					2613
1b	Westermost Rough	91	121	152	91	455	3068
1b	Blyth Demonstration Project	121	91	61	91	364	3432
1b	Dudgeon	256	346	745	346	1693	5125
1b	Hywind	30	719	10		759	5884
1b	European Offshore Wind Deployment Centre (Aberdeen Bay)	161	64	7	26	258	6142
1b	Galloper	44	43	106	394	587	6729
1b	Race Bank	28	42	28	42	140	6869

Tier	Windfarm	Breeding season	Autumn migration	Non-breeding season	Spring migration	Annual	Annual Running Total
1b	Rampion	630	66	1244	3327	5267	12136
1b	Beatrice	873	833	555	833	3094	15230
1b	East Anglia ONE	16	26	155	336	533	15763
1b	Hornsea Project One	1109	4812	1518	1803	9242	25005
1b	Kincardine	22	-	-	-	22	25027
1b	Moray East	2423	1103	30	168	3724	28751
1b	Hornsea Project Two	2511	4221	720	1668	9119	37870
1b	Triton Knoll	40	254	855	117	1265	39135
1b	Seagreen A	5876	-	1103	-	6979	46114
1b	Seagreen B	3698	-	1272	-	4970	51084
2a	Neart na Gaoithe	331	5492	508		6331	57415
2a	Moray West	2808	3544	184	3585	10121	67536
2a	Dogger Bank Creyke Beck A	1250	1576	1728	4149	8703	76239
2a	Dogger Bank Creyke Beck B	1538	2097	2143	5119	10897	87136
2a	Dogger Bank Teesside A	834	310	959	1919	4022	91158
2a	Dogger Bank Teesside B	1153	592	1426	2953	6125	97283
2b	East Anglia THREE	1807	1122	1499	1524	5952	103235
2b	Hornsea Project Three - Revised	630	2020	3649	2105	8404	111639
2b	Inch Cape	1436	2870	651		4957	116596
3	Pentland Floating Offshore Wind	134	16	17	14	181	116777
3	Norfolk Vanguard (East & West)	879	866	839	924	3508	120285
3	Norfolk Boreas	630	263	1065	345	2303	122588

Tier	Windfarm	Breeding season	Autumn migration	Non-breeding season	Spring migration	Annual	Annual Running Total
3	East Anglia ONE North	403	85	54	207	749	123337
3	East Anglia TWO	281	44.1	136.4	230	692	124029
3	Hornsea 4	386	4311	455	449	5600	129629
4	Berwick Bank	4040	8849	1399	7480	21768	151397
4	Dudgeon Offshore Extension Project	3741	923	320	848	5829	157226
4	Sheringham Shoal Extension Project	759	316	144	686	1905	159131
4	Rampion 2	32	26	1193	6303	7554	166685
4	ForthWind Offshore Wind Demonstration Project - phase 1	57	40	58	41	196	166881
4	West of Orkney	69.8		143.9		213.7	167094.7
5	Outer Dowsing	5163	2339	2570	5229	15301	182395.7
5	Dogger Bank South (East & West combined)	5313	1238	4117	8628	19296	201691.7
5	North Falls	168	266	2565	1860	4859	206550.7
	Total (other projects)	**51986.8**	**53424.1**	**37077.3**	**64069**	**206551**	
	VE	90	284	1046	756	2176	
	Total	**52076.8**	**53708.1**	**38123.3**	**64825**	**208727**	

Table 4.59: Cumulative Annual Displacement Matrix for Razorbill.

Annual cumulative		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	209	417	626	835	1044	2087	4175	6262	10436	16698	20873
	20%	417	835	1252	1670	2087	4175	8349	12524	20873	33396	41745
	30%	626	1252	1879	2505	3131	6262	12524	18785	31309	50094	62618
	40%	835	1670	2505	3340	4175	8349	16698	25047	41745	66793	83491
	50%	1044	2087	3131	4175	5218	10436	20873	31309	52182	83491	104363
	60%	1252	2505	3757	5009	6262	12524	25047	37571	62618	100189	125236
	70%	1461	2922	4383	5844	7305	14611	29222	43833	73054	116887	146109
	80%	1670	3340	5009	6679	8349	16698	33396	50094	83491	133585	166981
	90%	1879	3757	5636	7514	9393	18785	37571	56356	93927	150283	187854
	100%	2087	4175	6262	8349	10436	20873	41745	62618	104363	166981	208727

4.13.52 The largest BDMPS for razorbill in UK North Sea waters is 591,874 (Furness 2015). At the average baseline mortality rate of 0.174 the number of individuals expected to die in a year is 102,986 (591,874 x 0.174). The addition of a maximum of 626 to 14,611 individuals to this increases the background mortality rate by respectively 0.6% and 14.1%.

4.13.53 Generally, based on findings from population viability analyses for bird species, it would be considered that increases in mortality rates of less than 1% would be undetectable in terms of changes in population size. Using a range of displacement of 30-70% and mortality of 1–10% for displaced birds predicts changes in population mortality rates which are unlikely to be detectable at the lower end and may be detectable at the upper end of the range.

4.13.54 This is a large range, so the assessment considers the most realistic value within this range.

4.13.55 Reviews of post-construction monitoring of auks at offshore windfarms have found evidence of avoidance behaviour, although avoidance was incomplete and variable between sites and was considered overall to be less than an average of 50% reduction in density compared to pre-construction data; it was also considered that auks might habituate to the presence of operational windfarms and there is some indication that displacement may decrease with wider spacing between turbines (Dierschke *et al*. 2016; Norfolk Vanguard Ltd 2019b).

4.13.56 The detailed review of the potential effects of displacement from offshore windfarms on auks in Norfolk Vanguard Ltd (2019b) acknowledged that that the impact of displacement of razorbills and guillemots by offshore windfarms is uncertain. The information studied indicated that annual mortality of razorbill and guillemot adults (including impacts of existing human activities) is very low (10% and 6% per annum respectively), and that displacement of by offshore windfarms is likely to be incomplete, may reduce with habituation, and offshore wind farms may in the long-term increase food availability to guillemots and razorbills through providing enhanced habitat for fish populations.

4.13.57 Most recently, post-construction monitoring over two breeding seasons of the Beatrice Wind Farm in Scotland has found little indication that guillemots and razorbills avoid wind turbines, with spatial distributions within the wind farm no different from those that might be expected by chance (MacArthur Green, 2023).

4.13.58 This suggests that impacts of displacement from offshore windfarms are unlikely to represent levels of mortality anywhere near to the 6% or 10% total annual mortality that occurs due to the combination of many natural factors plus existing human activities. This evidence-based review recommended a displacement rate of 50% for auks within an offshore windfarm and 30% within a 1km buffer, both combined with a highly precautionary maximum mortality of 1%.

4.13.59 Hornsea Project Four (APEM, 2021) used the Seabird PVA Tool to test the impacts of cumulative displacement on the razorbill for the biogeographic and North Sea & Channel BDMPS population scales. The range of annual mortality modelled was 406.5 to 9,485.3 individuals, based on various displacement scenarios.

4.13.60 For the North Sea & Channel BDMPS population, at the modelled values closest to the predicted cumulative range in Table 4.59 (677.5 to 9,485.3 individuals), the density-independent counterfactual of population growth rate (after 35 years) would range from 0.999 to 0.992 and the reduction in growth rate (per annum) would range from 0.14% to 1.90%. At a biogeographic scale, the corresponding ranges would be 1.000 to 0.993 and 0.05% to 0.66%.

4.13.61 On the basis of the worst-case approach recommended by Natural England (70% displacement and a maximum 10% mortality), the cumulative operational displacement impact on razorbill is assessed as of medium magnitude, which, for a species of medium sensitivity, would equate to a moderate adverse cumulative effect (significant in EIA terms, based on the matrix in Table 4.7).

4.13.62 However, on the basis of the evidence review (Norfolk Vanguard Ltd 2019b) and more recent evidence (MacArthur Green, 2023) it is considered that a more realistic (and still precautionary) combination of displacement and consequent mortality rates is 50% and 1%. This would result in a predicted total of 1,044 deaths annually from displacement (Table 4.59) and a 1.0% increase in mortality.

4.13.63 Using the Hornsea Project Four Seabird PVA Tool again as a basis, the loss of 1,044 birds would result in a counterfactual of population growth rate of 0.997-0.998 and reduction in growth rate (per annum) approximately midway within a range of 0.16-0.27%. At a biogeographic scale, the corresponding values would be 0.999 and 0.06-0.09%.

4.13.64 This, combined with the various additive sources of precaution in this assessment, indicates there is a very high likelihood that cumulative displacement would be lower than the worst-case totals presented here, resulting in increases in background mortality and reductions in annual growth rate below 1%. The magnitude of cumulative displacement is assessed as being **low**, at worst. Therefore, as the species is of medium sensitivity to disturbance, the cumulative effect would be **minor adverse**, which is **not significant** in EIA terms.

GUILLEMOT

4.13.65 The VE array areas are located beyond the mean maximum foraging range of guillemot breeding colonies. Outside the breeding season, guillemots disperse from their breeding sites and large numbers are found throughout the North Sea in the nonbreeding season (defined as August to February, Furness 2015).

4.13.66 The annual total of guillemots at risk of displacement from the VE north and south arrays is estimated as 4,899 individuals (summing the seasonal peak means within the arrays and 2km buffers) for the breeding and non-breeding periods (Table 4.19).

4.13.67 The estimates of the total numbers of guillemots at risk of displacement from other offshore windfarms in the North Sea are included in Table 4.60. These totals omit windfarms for which no data are available (as indicated in the table), but they are also likely to over-estimate the numbers present due to the precautionary use of seasonal peak numbers at each site rather than average numbers, which is likely to lead to double counting as birds move through the North Sea.

Table 4.60: Cumulative Numbers of Guillemots at Risk of Displacement from Offshore Windfarms in the North Sea.

Tier	Windfarm	Breeding season	Non-breeding season	Annual	Annual Running Total
1a	Scroby Sands	No estimate available			0
1a	Kentish Flats	0	3	3	3
1a	Beatrice Demonstrator	No estimate available			3
1a	Lincs & LID	582	814	1396	1399
1a	Gunfleet Sands	0	363	363	1762
1a	Thanet	18	124	142	1904
1a	Greater Gabbard	345	548	893	2797
1a	Sheringham Shoal	390	715	1105	3902
1a	London Array	192	377	569	4471
1a	Methil	25	0	25	4496
1a	Teesside	267	901	1168	5664
1b	Humber Gateway	99	138	237	5901
1b	Kentish Flats Extension	0	4	4	5905
1b	Westermost Rough	347	486	833	6738
1b	Blyth Demonstration Project	1220	1321	2541	9279
1b	Dudgeon	334	542	876	10155
1b	Hywind	249	2136	2385	12540
1b	European Offshore Wind Deployment Centre (Aberdeen Bay)	547	225	772	13312
1b	Galloper	305	593	898	14210
1b	Race Bank	361	708	1069	15279
1b	Rampion	10887	15536	26423	41702

Tier	Windfarm	Breeding season	Non-breeding season	Annual	Annual Running Total
1b	Beatrice	13610	2755	16365	58067
1b	East Anglia ONE	274	640	914	58981
1b	Hornsea Project One	9836	8097	17933	76914
1b	Kincardine	632	0	632	77546
1b	Moray East	9820	547	10367	87913
1b	Hornsea Project Two	7735	13164	20899	108812
1b	Triton Knoll	425	746	1171	109983
1b	Seagreen A	13606	4688	18294	128277
1b	Seagreen B	11118	4112	15230	143507
2a	Neart na Gaoithe	1755	3761	5516	149023
2a	Moray West	24426	38174	62600	211623
2a	Dogger Bank Creyke Beck A	5407	6142	11549	223172
2a	Dogger Bank Creyke Beck B	9479	10621	20100	243272
2a	Dogger Bank Teesside A	3283	2268	5551	248823
2a	Dogger Bank Teesside B	5211	3701	8912	257735
2b	East Anglia THREE	1744	2859	4603	262338
2b	Hornsea Project Three - Revised	13374	17772	31146	293484
2b	Inch Cape	4371	3177	7548	301032
3	Pentland Floating Offshore Wind	1146	650	1796	302828
3	Norfolk Vanguard (East & West)	4320	4776	9096	311924
3	Norfolk Boreas	7767	13777	21544	333468
3	East Anglia ONE North	4183	1888	6071	339539

Tier	Windfarm	Breeding season	Non-breeding season	Annual	Annual Running Total
3	East Anglia TWO	2077	1675	3752	343291
3	Hornsea 4	9382	36965	46347	389638
4	Berwick Bank	74154	44171	118325	507963
4	Dudgeon Offshore Extension Project	3839	14887	18726	526689
4	Sheringham Shoal Extension Project	1085	1095	2180	528869
4	Rampion 2	134	5723	5857	534726
4	ForthWind Offshore Wind Demonstration Project - phase 1	417	401	818	535544
4	West of Orkney	4860.9	4275	9135.9	544680
5	Outer Dowsing	23173	22248	45421	590101
5	Dogger Bank South (East & West combined)	31587	25342	56929	647030
5	North Falls	1103	4497	5600	652630
	Total (other projects)	**321501.9**	**331128**	**652630**	
	VE	1201	3698	4899	
	Total	**322702.9**	**334826**	**657529**	

4.13.68 The estimated annual cumulative total of guillemots at risk of displacement from windfarms in the North Sea is 652,630 individuals, which rises to 657,529 individuals when including VE (Table 4.60). Considering a range of displacement of 30 to 70%, and mortality of displaced individuals from 1 to 10%, based on advice from Natural England, the estimated number of guillemots subject to mortality from displacement throughout the year is between 1,973 and 46,027.

4.13.69 The largest BDMPS for guillemot in UK North Sea waters is 1,617,306 (Furness 2015). At the average baseline mortality rate of 0.14 the number of individuals expected to die in a year is 226,423 (1,617,306 x 0.14). The addition of between 1,973 and 46,027 individuals to this increases the background mortality rate by between 0.9% and 20.3%.

4.13.70 This is a large range, so the assessment considers the most realistic value within this range. Recommendations of an evidence-based review (Norfolk Vanguard Ltd 2019b), described above for razorbill, are for a displacement rate of 50% for auks within an offshore wind farm and 30% within a 1km buffer, both combined with a highly precautionary maximum mortality of 1%.

4.13.71 Population modelling, as described above for razorbill, was also undertaken for guillemot by Hornsea Project Four (APEM, 2021). The range of annual mortality modelled was 1,138.1 to 26,554.8 individuals, based on various displacement scenarios. This upper value falls short of the 46,027 individuals predicted under the most precautionary scenario here.

Table 4.61: Cumulative Annual Displacement Matrix for Guillemot. The cells show the predicted mortality (rounded to the nearest integer) at a given rate of displacement and mortality.

Annual cumulative		**Mortality rate**										
		1%	**2%**	**3%**	**4%**	**5%**	**10%**	**20%**	**30%**	**50%**	**80%**	**100%**
Displacement	**10%**	658	1315	1973	2630	3288	6575	13151	19726	32876	52602	65753
	20%	1315	2630	3945	5260	6575	13151	26301	39452	65753	105205	131506
	30%	1973	3945	5918	7890	9863	19726	39452	59178	98629	157807	197259
	40%	2630	5260	7890	10520	13151	26301	52602	78903	131506	210409	263012
	50%	3288	6575	9863	13151	16438	32876	65753	98629	164382	263012	328764
	60%	3945	7890	11836	15781	19726	39452	78903	118355	197259	315614	394517
	70%	4603	9205	13808	18411	23014	46027	92054	138081	230135	368216	460270
	80%	5260	10520	15781	21041	26301	52602	105205	157807	263012	420818	526023
	90%	5918	11836	17753	23671	29589	59178	118355	177533	295888	473421	591776
	100%	6575	13151	19726	26301	32876	65753	131506	197259	328764	526023	657529

4.13.72 For the North Sea & Channel BDMPS population, at the modelled values closest to the predicted cumulative range in Table 4.61 (1,896.8 to 26,554.8 individuals), the density-independent counterfactual of population growth rate (after 35 years) would range from 0.999 to 0.992 and the reduction in growth rate (per annum) would range from 0.13% to 1.85%. At a biogeographic scale, the corresponding ranges would be 0.999 to 0.993 and 0.05% to 0.72%. As noted, the upper values of these ranges would be higher when considering the higher predicted cumulative mortality here, compared to the range modelled by Hornsea Project Four.

4.13.73 On the basis of the worst-case approach recommended by Natural England (70% displacement and a maximum 10% mortality), the cumulative operational displacement impact on guillemot is therefore assessed as of medium magnitude which, for a medium sensitivity, species, would result in a moderate adverse effect (significant in EIA terms, based on the matrix in Table 4.7).

4.13.74 However, on the basis of the evidence review (Norfolk Vanguard Ltd 2019b) it is considered that a more realistic (and still precautionary) combination of displacement and consequent mortality rates is 50% and 1%. This would result in a predicted total of 3,288 deaths annually from displacement and 1.4% increase in mortality.

4.13.75 Using the Hornsea Project Four Seabird PVA Tool again as a basis, the loss of 3,288 birds would result in a counterfactual of population growth rate of 0.997-0.998 and reduction in growth rate (per annum) approximately midway within a range of 0.16-0.26%. At a biogeographic scale, the corresponding values would be 0.999 and 0.06-0.10%.

4.13.76 This, combined with the various additive sources of precaution in this assessment, indicates there is a very high likelihood that cumulative displacement would be lower than the worst-case totals presented here, resulting in increases in background mortality up to 1%. The magnitude of cumulative displacement is assessed as **low** at worst. Therefore, as the species is of medium sensitivity to disturbance, the cumulative effect would be **minor adverse**, which is **not significant** in EIA terms.

CUMULATIVE ASSESSMENT OF OPERATIONAL COLLISION RISK

4.13.77 Cumulative collision risk both annually and for key seasons is assessed for gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull.

4.13.78 It is considered that all of the UK North Sea and Channel windfarms identified for inclusion in the cumulative assessment in Table 4.47 have the potential to contribute to a cumulative effect.

GANNET

4.13.79 The cumulative gannet collision risk prediction is set out in Table 4.62. This collates collision predictions from other windfarms which may contribute to the cumulative total. Assessments at other windfarms have been conducted using a range of avoidance rates and alternative collision model options.

Table 4.62: Cumulative Collision Risk Assessment for Gannet.

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
1a	Scroby Sands	-	-	-	-	0
1a	Kentish Flats	1.4	0.8	1.1	3.3	3.3
1a	Beatrice Demonstrator	0.6	0.9	0.7	2.2	5.5
1a	Lynn and Inner Dowsing	0.2	0.1	0.2	0.5	6
1a	Gunfleet Sands	-	-	-	-	6
1a	Thanet	1.1	0	0	1.1	7.1
1a	Greater Gabbard	14	8.8	4.8	27.5	34.6
1a	Sheringham Shoal	14.1	3.5	0	17.6	52.2
1a	Lincs	2.1	1.3	1.7	5	57.2
1a	London Array	2.3	1.4	1.8	5.5	62.7
1a	Methil	6	0	0	6	68.7
1a	Teesside	4.9	1.7	0	6.7	75.4
1b	Humber Gateway	1.9	1.1	1.5	4.5	79.9
1b	Kentish Flats Extension	-	-	-	-	79.9
1b	Westermost Rough	0.2	0.1	0.2	0.5	80.4
1b	Blyth Demonstration Project	3.5	2.1	2.8	8.4	88.8
1b	Dudgeon	22.3	38.9	19.1	80.3	169.1
1b	Hywind	5.6	0.8	0.8	7.2	176.3
1b	European Offshore Wind Deployment Centre (Aberdeen Bay)	4.2	5.1	0.1	9.3	185.6
1b	Galloper	18.1	30.9	12.6	61.6	247.2

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
1b	Race Bank	33.7	11.7	4.1	49.5	296.7
1b	Rampion	36.2	63.5	2.1	101.8	398.5
1b	Beatrice	37.4	48.8	9.5	95.7	494.2
1b	East Anglia ONE	3.4	131	6.3	141	635.2
1b	Hornsea Project One	11.5	32	22.5	66	701.2
1b	Kincardine	3	0	0	3	704.2
1b	Moray East	80.6	35.4	8.9	124.9	829.1
1b	Hornsea Project Two	7	14	6	27	856.1
1b	Triton Knoll	26.8	64.1	30.1	121	977.1
1b	Seagreen A and B	800.8	49.3	65.8	915.9	1893
2a	Neart na Gaoithe	143	47	23	213	2106
2a	Moray West	10	2	1	13	2119
2a	Dogger Bank Creyke Beck Projects A and B	81.1	83.5	54.4	219	2338
2a	Dogger Bank Teesside Projects A (now Dogger Bank C) and B (now Sofia)	14.8	10.1	10.8	35.7	2373.7
2b	East Anglia THREE	6.1	33.3	9.6	49	2422.7
2b	Hornsea Project Three - revised	10	5	4	19	2441.7
2b	Inch Cape	336.9	29.2	5.2	371.3	2813
3	Pentland Floating Offshore Wind	2	0	0	2	2815

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
3	Norfolk Vanguard (East & West)	8.2	18.6	5.3	32.1	2847.1
3	Norfolk Boreas	14.1	12.7	3.9	30.7	2877.8
3	East Anglia ONE North	12.4	11	1.1	24.5	2902.3
3	East Anglia TWO	12.5	23.1	4	39.6	2941.9
3	Hornsea 4	14.3	0.3	0.1	14.6	2956.5
4	Berwick Bank	170	18	3	191	3147.5
4	Dudgeon & Sheringham Offshore Extension Projects	0.4	0.6	0	1.1	3148.6
4	Rampion 2	2.9	1.41	0.61	4.92	3153.52
4	ForthWind Offshore Wind Demonstration Project - phase 1	1	0	0	1	3154.52
4	West of Orkney	22.9	3.8	3.8	30.5	3185.02
5	Outer Dowsing	2.9	0.4	0.4	3.7	3188.72
5	Dogger Bank South (East & West combined)	26.76	9.53	0	36.29	3225.01
5	North Falls	6.55	8.07	4.75	19.36	3244.37
	Total (other projects)	**2042**	**865**	**338**	**3244**	
	VE	2.01	2.26	0.24	4.51	
	Total	**2044**	**867**	**338**	**3249**	

4.13.80 The annual cumulative total for estimated collision mortality is 3,249 of which VE contributes 4.5 birds. Based on the largest Annual BDMPS of 456,298 (Furness 2015) and baseline mortality of 0.191, 87,153 individual gannets would be expected to die each year; the addition of 3,249 individuals would represent a 3.7% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness 2015), 225,380 individuals would be expected to die; the addition of 3,249 individuals would represent a 1.3% increase in mortality.

4.13.81 The predicted cumulative mortality for gannet collisions therefore generates estimates of more than 1% additional mortality in relation to the Autumn migration BDMPS and approximately 1% additional mortality for the biogeographical population with connectivity to UK Waters (Furness 2015). These percentage increases could cause detectable effects on population sizes.

4.13.82 Rampion 2 (APEM, 2023) used the Seabird PVA Tool to test the impacts of cumulative mortality on gannet for the North Sea & Channel BDMPS population scale. The range of annual mortality modelled was 300 to 4,000 individuals.

4.13.83 At the modelled values of 3,200 and 3,300 individuals, closest to the predicted cumulative value in Table 4.62 (3,249 individuals), the density-independent counterfactual of population growth rate (after 30 years) would range from 0.992 to 0.991 and the reduction in growth rate (per annum) would range from 0.83% to 0.86%. The corresponding reductions in population size would be 0.772-0.766 (22.75-23.36%).

4.13.84 Note, however, that many of the collision estimates for other windfarms were calculated for designs with higher numbers of WTGs (and total rotor swept areas) than have been installed (or are planned), which is a key factor in collision risk. A method for updating collision estimates for changes in windfarm design such as this was presented in MacArthur Green (2017). This uses ratios of consented and as-built turbine parameters to adjust the collision risk mortality estimates for a consented wind farm. Updating the collision estimates for windfarms in the North Sea which have been built out with a smaller rotor swept area than the consented worst-case reduces the cumulative annual mortality by around 7% (see Appendix 12.3 of East Anglia TWO EIA submission).

4.13.85 It is also the case that some of the older projects, listed in Tier 1a (Table 4.53) would be included in the baseline characterization data through baseline surveys or other studies of the species in the North Sea, and so have already had an impact on the population, meaning that their associated collision rate values should theoretically be excluded (Table 4.52).

4.13.86 Interim Natural England (2022a) guidance advises that the gannet avoidance rate should now be 99.2%, which is higher than the previously recommended rate of 98.9%, which means that older collision rates for other offshore windfarms will be overestimated. While the difference seems small, this change in avoidance rate would reduce predicted collisions by nearly one third: at 98.9% avoidance 11 birds in 1,000 would be predicted to collide with a windfarm, whereas at 99.2% avoidance this would reduce to 8. Applying this change pro-rata would reduce the annual cumulative total from Table 4.62.

4.13.87 As outlined in Natural England's (2022a) Interim Guidance, it is acknowledged that there is clear evidence that gannets display macro-avoidance of WTGs. Because avoidance calculated have until now generally been 'within-windfarm' avoidance rates, Natural England thus advise that the collision model methodology requires the reduction of density of birds in flight by an agreed macro-avoidance rate as an input to the CRM, followed by using an 'all gulls' avoidance rate (99.2%) within the CRM.

4.13.88 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%. Therefore, taking the original 3,249 cumulative value, the amended collision rate can be reduced by 0.15 (85% macro-avoidance rate) to 0.35 (65% macro-avoidance rate).

4.13.89 The Natural England (2022a) Interim Guidance also advises that the gannet nocturnal activity factor should now be 8% (based on Furness, 2018 review), which is lower than the previously recommended rate of 25%. Application of the lower evidence-based rate would reduce estimates of collision mortality. It is straightforward to adjust existing mortality estimates using the new and old nocturnal activity rates and the monthly number of daytime and night-time hours (i.e., it is not necessary to rerun the collision model for this update). However, it is necessary to calculate a mortality adjustment rate for each month at each windfarm because 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 but would be expected to reduce the cumulative total by at least 10%. This further emphasises the precautionary nature of the current assessment.

4.13.90 On the basis of the worst-case (over-precautionary) values presented in Table 4.62, and PVA modelling results presented above, the cumulative gannet collision impact magnitude would be assessed as low, which, for a low to medium sensitivity, species, would result in a minor adverse effect (not significant in EIA terms, based on the matrix in Table 4.7).

4.13.91 Based on the above information and realistic reductions in predicted collision rates due to (i) post-consent windfarm design revisions; (ii) inclusion of older Tier 1a projects that form part of the baseline characterization (iii) increase in avoidance rate; (iv) inclusion of macro-avoidance in modelling; and (v) reduction in nocturnal activity factor, the cumulative impact on the gannet population due to collisions both year round and within individual seasons is likely to be much lower than the estimate in Table 4.62.

4.13.92 The predicted cumulative impact is therefore, at worst, of **low** magnitude, and the relative contribution of the proposed VE project to this cumulative total is very small. Gannets are considered to be of low to medium sensitivity to collision mortality and the effect is therefore **minor adverse**, which is **not significant** in EIA terms.

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Table 4.63: Cumulative Collision Risk Assessment for Kittiwake. Projects where compensation will be implemented, or where compensation may apply, have been shaded light blue.

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
1a	Scroby Sands	-	-	-	-	0
1a	Kentish Flats	0	0.9	0.7	1.6	1.6
1a	Beatrice Demonstrator	0	2.1	1.7	3.8	5.4
1a	Lynn and Inner Dowsing	-	-	-	-	5.4
1a	Gunfleet Sands	-	-	-	-	5.4
1a	Thanet	0.2	0.5	0.4	1.1	6.5
1a	Greater Gabbard	1.1	15	11.4	27.5	34
1a	Sheringham Shoal	-	-	-	-	34
1a	Lincs	0.7	1.2	0.7	2.6	36.6
1a	London Array	1.4	2.3	1.8	5.5	42.1
1a	Methil	0.4	0	0	0.4	42.5
1a	Teesside	38.4	24	2.5	64.9	107.4
1b	Humber Gateway	1.9	3.2	1.9	7	114.4
1b	Kentish Flats Extension	0	0	2.7	2.7	117.1
1b	Westermost Rough	0.1	0.2	0.1	0.5	117.6
1b	Blyth Demonstration Project	1.7	2.3	1.4	5.4	123
1b	Dudgeon	-	-	-	-	123
1b	Hywind	16.6	0.9	0.9	18.3	141.3
1b	European Offshore Wind Deployment Centre (Aberdeen Bay)	11.8	5.8	1.1	18.7	160

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
1b	Galloper	6.3	27.8	31.8	65.9	225.9
1b	Race Bank	1.9	23.9	5.6	31.4	257.3
1b	Rampion	54.4	37.4	29.7	121.5	378.8
1b	Beatrice	94.7	10.7	39.8	145.2	524
1b	East Anglia ONE	1.8	160.4	46.8	209	733
1b	Hornsea Project One	44	55.9	20.9	120.8	853.8
1b	Kincardine	22	9	1	32	885.8
1b	Moray East	43.6	2	19.3	64.9	950.7
1b	Hornsea Project Two	16	9	3	28	978.7
1b	Triton Knoll	24.6	139	45.4	209	1187.7
1b	Seagreen A and B	153.1	313.1	247.6	713.8	1901.5
2a	Neart na Gaoithe	32.9	56.1	4.4	93.4	1994.9
2a	Moray West	79	24	7	110	2104.9
2a	Dogger Bank Creyke Beck Projects A and B	288.6	135	295.4	719	2823.9
2a	Dogger Bank Teesside Projects A (now Dogger Bank C) and B (now Sofia)	136.9	90.7	216.9	444.5	3268.4
2b	East Anglia THREE	6.1	69	37.6	112.7	3381.1
2b	Hornsea Project Three – revised	77	38	8	123	3504.1
2b	Inch Cape	13.1	224.8	63.5	301.4	3805.5
3	Pentland Floating Offshore Wind	7	1	0	8	3813.5
3	Norfolk Vanguard (East & West)	21.8	16.4	19.3	57.5	3871

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual	Annual Running Total
3	Norfolk Boreas	13.3	32.2	11.9	57.5	3928.5
3	East Anglia ONE North	40.4	8.1	3.5	52	3980.5
3	East Anglia TWO	29.5	5.4	7.4	42.3	4022.8
3	Hornsea 4	74.5	13.9	4.6	93	4115.8
4	Berwick Bank	617	190	179	986	5101.8
4	Dudgeon & Sheringham Offshore Extension Projects	7.2	4.3	0.9	12.4	5114.2
4	Rampion 2	1.21	9.78	17.25	28.25	5142.45
4	ForthWind Offshore Wind Demonstration Project - phase 1	0	0	0	0	5142.45
4	West of Orkney	9.6	12.4	12.4	34.4	5176.85
5	Outer Dowsing	28.1	18.1	50.4	96.6	5273.45
5	Dogger Bank South (East & West combined)	173.07	50.38	31.12	254.57	5528.02
5	North Falls	21	12	19	52	5580.02
	Total (other projects)	**2214**	**1858**	**1508**	**5580**	
	VE	11.91	7.88	5.52	25.3	
	Total (all projects)	**2226**	**1866**	**1513**	**5605**	

KITTIWAKE

4.13.93 The cumulative collision risk predictions for kittiwake are set out in Table 4.63. This collates collision predictions from other UK North Sea and Channel windfarms which may contribute to the cumulative total.

4.13.94 Assessments at other windfarms have been conducted using a range of avoidance rates and alternative collision model options.

4.13.95 The estimated annual cumulative total is 5,605 birds of which VE contributes 25 birds. Based on the largest Annual BDMPS of 829,937 (Furness 2015) and baseline mortality of 0.156, 129,470 individual kittiwakes would be expected to die each year; the addition of 5,605 individuals would represent a 4.3% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 5,100,000 (Furness 2015), 795,600 individuals would be expected to die; the addition of 5,605 individuals would represent an 0.7% increase in mortality.

4.13.96 Based on findings from population viability analyses for bird species, it would be considered that increases in mortality rates of less than 1% would be undetectable in terms of changes in population size, whereas increases of more than 1% may cause detectable effects in population size. The cumulative collision mortality for kittiwakes therefore suggests changes in population mortality rates which may be detectable in relation to the largest BDMPS, but not in relation to the annual biogeographic population with connectivity to UK Waters.

4.13.97 Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher numbers of wind turbines (and total rotor swept areas) than have been installed (or are planned), which is a key factor in collision risk. Updating the collision estimates for windfarms which have been built out or are due to be built out with a smaller rotor swept area that the consented worst-case design (as per MacArthur Green 2017) achieves a reduction in the cumulative annual mortality by around 12% (see Appendix 12.3 of East Anglia TWO EIA submission). Therefore, the values presented in Table 4.63, as well as being based on precautionary calculation methods, can be seen to overestimate the total due to the reduced collision risks for projects which undergo design revisions post consent.

4.13.98 It is also the case that some of the older projects, listed in Tier 1a (Table 4.53) would be included in the baseline characterization data through baseline surveys or other studies of the species in the North Sea, and so have already had an impact on the population, meaning that their associated collision rate values should theoretically be excluded (Table 4.52).

4.13.99 Additionally, some more recent Tier 3 and 4 projects have committed to compensation measures to address cumulative effects on kittiwakes (see highlighted rows in Table 4.63) thereby theoretically removing the cumulative impacts of these projects on the species' BDMPS population. This would be up to approximately 1,535 collisions, or 27% of the cumulative annual collision rate.

4.13.100 Interim Natural England (2022a) guidance advises that the kittiwake avoidance rate should now be 99.2%, which is higher than the previously recommended rate of 98.9%, meaning that older collision rates for other offshore windfarms will be overestimated. Use of this higher rate would reduce the cumulative total proportionately.

4.13.101 A review of nocturnal activity in kittiwakes (Furness *et al*., in prep.) has found that the value previously used for this parameter (50%) to estimate flight activity at night is a considerable overestimate and has identified evidence-based rates of 20% during the breeding season and 17% during the nonbreeding season. Natural England has recognised this aspect of precaution and advised recent projects to undertake collision modelling with nocturnal activity set to both 25% and 50%. Reducing the nocturnal activity factor to 25% reduced collision estimates for kittiwake at VE by around 19% (Table 4.46).

4.13.102 Applying the same approach to other windfarms in Table 4.63 would reduce the cumulative collision estimate by a significant amount (e.g. between 7% and 25%; note the magnitude of reduction varies depending on the time of year and windfarm latitude due to the variation in day and night length). This further emphasises the precautionary nature of the current assessment.

4.13.103 For the assessment of the East Anglia THREE Windfarm, a kittiwake population model was developed to assess the potential effects of cumulative predicted mortality from collisions with offshore windfarms on the kittiwake BDMPS population (MacArthur Green, 2015). Both density independent and density dependent models were developed. For an annual mortality of 4,000 (i.e., lower than the predicted worst-case cumulative value in Table 4.63 of 5,605 individuals, but higher than the value of c.4,070 individuals when excluding projects that have committed kittiwake compensation), the density dependent models predicted the population after 25 years would be 2.5 to 2.8% smaller than that predicted in the absence of additional mortality from collisions with offshore wind farms (counterfactual of population size = 0.975-0.972), while the more precautionary density independent models predicted equivalent declines of 7.0-7.6% (cps = 0.930-0.924).

4.13.104 More recently, Hornsea Project Four (APEM, 2022) used the density-independent Seabird PVA Tool to test the impacts of cumulative mortality on kittiwake for the North Sea & Channel BDMPS population scale. At the upper modelled value of 4,500 individuals, the density-independent counterfactual of population growth rate (after 35 years) would be 0.996 and the reduction in growth rate (per annum) would be 0.43%.

4.13.105 There is evidence that kittiwake populations are limited by food supply and are subject to density-dependent regulation (Frederiksen *et al*. 2004, 2007; Cury *et al*. 2011; Sandvik *et al*. 2012; Trinder 2014, Carroll *et al*. 2017). Evidence for density dependent regulation of the North Sea kittiwake population was summarised in EATL (2015). Trinder (2014) explored a range of strengths of density dependence for this species and identified model parameters which produced population predictions consistent with patterns of seabird population growth which have been observed across a wide range of taxa (including kittiwake) worldwide (Cury *et al*. 2011). Thus, there is robust evidence for density dependent regulation of the North Sea kittiwake population (and for seabirds more widely) and consequently, the density dependent kittiwake model results in MacArthur Green (2015) are considered to be the more robust ones on which to base this assessment.

4.13.106 To place these predicted magnitudes of change in context, over three approximately 15 to 20-year periods (between censuses) the British kittiwake population changed by +24% (1969 to 1985), -25% (1985 to 1998), -42% (2000 to 2021) (JNCC, 2020; Burnell *et al.* 2023). Modelled density-dependent changes in population size of c.3% across a longer (25 year) period (based on PVA modelling of annual mortality of 4,000 individuals in MacArthur Green, 2015) set against a background of changes that have been nearly an order of magnitude larger will almost certainly be undetectable. It is possible that the longer-term decline will continue, and the population is unlikely to recover over this period. However even precautionary estimates of additional mortality from offshore windfarms are not predicted to significantly increase the rate of decline or to prevent the population from recovering should environmental conditions become more favourable.

4.13.107 Kittiwake is considered to be of low to medium sensitivity and the magnitude of worst-case cumulative collision mortality (a 4.3% additional increase in mortality) is considered to be low to medium, which would result in a minor to moderate adverse effect (potentially significant in EIA terms, based on the matrix in Table 4.7).

4.13.108 However, when the various sources of precaution are taken into account (compensation by other projects, precautionary avoidance rate estimates, reduction in construction versus consented windfarm sizes, over-estimated nocturnal activity), the results of the PVA modeling summarized above suggest that the cumulative collision risk impact magnitude is more likely to be **low**, resulting in a **minor adverse** effect, which is **not significant** in EIA terms.

LESSER BLACK-BACKED GULL

4.13.109 The cumulative collision risk prediction for lesser black-backed gull is set out in Table 4.64. This collates collision predictions from other windfarms which may contribute to the cumulative total.

4.13.110 The collision values presented in Table 4.64 include totals for breeding, nonbreeding and annual periods. However, not all projects provide a seasonal breakdown of collision impacts, therefore it is not possible to extract data from these periods for cumulative assessment. Natural England has previously noted that an 80:20 split between the nonbreeding and breeding seasons is appropriate for lesser black-backed gull in terms of collision estimates (Natural England 2013). Therefore, for those sites where a seasonal split was not presented the annual numbers in Table 4.64 have been multiplied by 0.8 to estimate the nonbreeding component and 0.2 to estimate the breeding component.

Table 4.64: Cumulative Collision Risk Assessment for Lesser black-backed Gull. Projects where compensation will be implemented, or where compensation may apply, have been shaded light blue.

Tier	Windfarm	Breeding season	Nonbreeding season	Annual	Annual Running Total
1a	Scroby Sands	-	-	-	0
1a	Kentish Flats	-	-	-	0
1a	Beatrice Demonstrator	-	-	-	0
1a	Lynn and Inner Dowsing	-	-	-	0
1a	Gunfleet Sands	1	0	1	1
1a	Thanet	3.2	12.8	16	17
1a	Greater Gabbard	12.4	49.6	62	79
1a	Sheringham Shoal	1.7	6.6	8.3	87.3
1a	Lincs	1.7	6.8	8.5	95.8
1a	London Array	-	-		95.8
1a	Methil	0.5	0	0.5	96.3
1a	Teesside	0	0	0	96.3
1b	Humber Gateway	0.3	1.1	1.4	97.7
1b	Kentish Flats Extension	0.3	1.3	1.6	99.3
1b	Westermost Rough	0.1	0.3	0.4	99.7
1b	Blyth Demonstration Project	0	0	0	99.7
1b	Dudgeon	7.7	30.6	38.3	138
1b	Hywind	0	0	0	138
1b	European Offshore Wind Deployment Centre (Aberdeen Bay)	0	0	0	138

Tier	Windfarm	Breeding season	Nonbreeding season	Annual	Annual Running Total
1b	Galloper	27.8	111	138.8	276.8
1b	Race Bank	43.2	10.8	54	330.8
1b	Rampion	1.6	6.3	7.9	338.7
1b	Beatrice	0	0	0	338.7
1b	East Anglia ONE	5.9	33.8	39.7	378.4
1b	Hornsea Project One	4.4	17.4	21.8	400.2
1b	Kincardine	0	0	0	400.2
1b	Moray East	0	0	0	400.2
1b	Hornsea Project Two	2	2	4	404.2
1b	Triton Knoll	7.4	29.6	37	441.2
1b	Seagreen A and B	2.1	8.4	10.5	451.7
2a	Neart na Gaoithe	0.3	1.2	1.5	453.2
2a	Moray West	0	0	0	453.2
2a	Dogger Bank Creyke Beck Projects A and B	2.6	10.4	13	466.2
2a	Dogger Bank Teesside Projects A (now Dogger Bank C) and B (now Sofia)	2.4	9.6	12	478.2
2b	East Anglia THREE	1.8	8.2	10	488.2
2b	Hornsea Project Three - revised	8	1	9	497.2
2b	Inch Cape	0	0	0	497.2
3	Pentland Floating Offshore Wind	0	0	0	497.2
3	Norfolk Vanguard (East & West)	8.4	3.6	12	509.2

Tier	Windfarm	Breeding season	Nonbreeding season	Annual	Annual Running Total
3	Norfolk Boreas	6.2	8.1	14.3	523.5
3	East Anglia ONE North	0.9	0.6	1.5	525
3	East Anglia TWO	4.2	0.5	4.7	529.7
3	Hornsea 4	0.3	0.1	0.42	530.12
4	Berwick Bank	9	0	9	539.12
4	Dudgeon & Sheringham Offshore Extension Projects	1.9	0.3	2.2	541.32
4	Rampion 2	1.51	2.86	4.37	545.69
4	ForthWind Offshore Wind Demonstration Project - phase 1	0	0	0	545.69
4	West of Orkney	0	0	0	545.69
5	Outer Dowsing	1.5	2.1	3.7	549.39
5	Dogger Bank South (East & West combined)	0.46	0	0.46	549.85
5	North Falls	12	7	19	568.85
	Total (other projects)	**185**	**384**	**569**	
	VE	35.09	5.47	40.58	
	Total (all projects)	**220**	**389**	**609**	

4.13.111 The cumulative predicted annual total is 609 of which VE contributes up to 41 birds. Based on the largest Annual BDMPS of 209,007 (Furness 2015) and baseline mortality of 0.126, 26,335 individual lesser black-backed gulls would be expected to die each year; the addition of 609 individuals would represent a 2.3% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 854,000 (Furness 2015), 107,604 individuals would be expected to die; the addition of 609 individuals would represent an 0.6% increase in mortality.

4.13.112 Based on findings from population viability analyses for bird species, it would be considered that increases in mortality rates of less than 1% would be undetectable in terms of changes in population size, whereas above 1% there could be detectable effects. Comparison of cumulative collision mortality for lesser black-backed gulls predicts changes in population mortality rates which may be detectable in relation to the largest BDMPS, but not in relation to the annual biogeographic population with connectivity to UK Waters.

4.13.113 Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher numbers of wind turbines (and total rotor swept areas) than have been installed (or are planned), which is a key factor in collision risk. Updating the collision estimates for windfarms which have been built out or are due to be built out with a smaller rotor swept area that the consented worst-case design (as per MacArthur Green, 2017) achieves a reduction in the cumulative annual mortality by 28% (see Appendix 12.3 of East Anglia TWO EIA application). Therefore, the values presented in Table 4.64, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 28% due to the reduced collision risks for projects which undergo design revisions post consent.

4.13.114 It is also the case that some of the older projects, listed in Tier 1a (Table 4.53) would be included in the baseline characterization data through baseline surveys or other studies of the species in the North Sea, and so have already had an impact on the population, meaning that their associated collision rate values should theoretically be excluded (Table 4.52).

4.13.115 Additionally, some more recent Tier 3 projects (plus Galloper, if confirmed) have committed to compensation measures to address cumulative effects on lesser black-backed gull (see highlighted rows in Table 4.64 & Table 4.63) thereby theoretically removing the cumulative impacts of these projects on the species' BDMPS population. This would be up to approximately 171 collisions, or 28% of the cumulative annual collision rate.

4.13.116 In contrast to gannet and kittiwake described above, Natural England's (2022a) Interim Guidance has recommended a reduced avoidance rate of large gulls from 99.5% to 99.4%, which would increase the estimated collision rate of a project by around 17% if the new rate is applied. This would therefore increase the cumulative total in Table 4.64 by a similar proportion, although this may be roughly cancelled out by the application of a reduced nocturnal activity factor, now advised by Natural England as 25-50%, rather than 50% used previously.

4.13.117 A review of nocturnal activity in seabirds (EATL 2015) has indicated that the 50% estimate for lesser black-backed gull is almost certainly an overestimate, possibly by as much as a factor of two (i.e., study data suggest that 25% is more appropriate. Reducing the nocturnal activity factor to 25% reduced the collision estimate for VE by around 11% (Table 4.46). A similar correction applied to the other windfarms would further reduce the overall collision estimate for all windfarms by a significant amount (e.g., between 7% and 25%; note the magnitude of reduction varies depending on the time of year and windfarm latitude due to the variation in day and night length). This suggests that any increase in collision rates due to lower avoidance may be balanced by a lower nocturnal activity factor.

4.13.118 As part of the Norfolk Boreas OWF application process, Natural England requested that PVA modelling was undertaken using Natural England's PVA tool (Searle *et al.* 2019) to test cumulative impacts on the largest BDMPS UK North Sea & Channel lesser black-backed gull population (MacArthur Green, 2019c). The reduction in the BDMPS population growth rate at an adult mortality of 600 using a precautionary density independent model was estimated to be 0.33% (0.9967), with a reduction in population size of 9.6% (0.9035). At an adult mortality rate of 500 individuals, the reduction in population growth rate was predicted to be 0.27% (0.9973) and the reduction in population size was 8.1% (0.9191). Excluding the Tier 3 projects with committed compensation for lesser black-backed gull, the cumulative total would be 438 individuals (down from 609 individuals), and so reductions in growth rate and population size would be lower still.

4.13.119 In conclusion, the current cumulative total is considerably lower than previously consented cumulative totals, and yet this total still includes some of precaution (e.g., compensation by other projects, consented vs. built impacts and overestimated nocturnal activity), despite a now reduced avoidance rate being recommended by Natural England. Therefore, the cumulative impact on the lesser black-backed gull population due to collisions both year-round and within individual seasons is considered to be of **low** magnitude. Lesser black-backed gull is considered to be of medium sensitivity; therefore, the effect is **minor adverse**, which is **not significant** in EIA terms.

HERRING GULL

4.13.120 The cumulative herring gull collision risk prediction is set out in Table 4.65. Assessments at other windfarms have been conducted using a range of avoidance rates and alternative collision model options.

4.13.121 The annual cumulative total for estimated herring gull collision mortality is 885 of which VE contributes two birds. Based on the largest Annual BDMPS of 466,511 (Furness 2015) and baseline mortality of 0.172, 80,240 individual herring gulls would be expected to die each year; the addition of 885 individuals would represent a 1.1% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,098,000 (Furness 2015), 188,856 individuals would be expected to die; the addition of 885 individuals would represent a 0.5% increase in mortality.

4.13.122 Based on findings from population viability analyses for bird species, it would be considered that increases in mortality rates of less than 1% would be undetectable in terms of changes in population size, whereas above 1% there could be detectable effects. Comparison of cumulative collision mortality for herring gulls predicts changes in population mortality rates which are up to c.1% when considering the reference populations (Furness 2015).

4.13.123 A review of nocturnal activity in seabirds (EATL 2015) has indicated that the value currently used to estimate collision risk at night for herring gull (50%) is almost certainly an overestimate, possibly by as much as a factor of two (i.e. empirical data from logger deployments suggest that 25% is more appropriate). Natural England has recognised this aspect of precaution and advise in their Interim Guidance to undertake collision modelling with nocturnal activity set to both 25% and 50%. Reducing the nocturnal activity factor to 25% reduced collision estimates for herring gull at VE by around 18% (Table 4.46). Applying the same approach to other wind farms in Table 4.65 would reduce the cumulative collision estimate by a significant amount (e.g. between 7% and 25%; note the magnitude of reduction varies depending on the time of year and wind farm latitude due to the variation in day and night length). This emphasises the precautionary nature of the current assessment.

4.13.124 On the basis of the worst-case approach, the cumulative herring gull collision risk impact magnitude would be assessed as low, which, for a low to medium sensitivity, species, would result in a minor adverse effect (not significant in EIA terms, based on the matrix in Table 4.7).

4.13.125 The cumulative assessment, both year-round and within individual seasons does however include precaution and the impact is therefore considered to be of **negligible** magnitude; with the relative contribution of the proposed VE project to this cumulative total being very small. Herring gulls are considered to be of low to medium sensitivity to collision mortality and the effect is therefore **minor adverse**, which is **not significant** in EIA terms.

Table 4.65: Cumulative Collision Risk Assessment for Herring Gull.

Tier	Windfarm	Breeding season	Nonbreeding season	Annual	Annual Running Total
1a	Scroby Sands	-	-	-	0
1a	Kentish Flats	0	0	0	0
1a	Beatrice Demonstrator	0		0	0
1a	Lynn and Inner Dowsing	0		0	0
1a	Gunfleet Sands	-	-	-	0
1a	Thanet	4.9	19.6	24.5	24.5
1a	Greater Gabbard	0		0	24.5
1a	Sheringham Shoal	0		0	24.5
1a	Lincs	0		0	24.5
1a	London Array	-	-	-	24.5
1a	Methil	5.8	3.7	9.5	34
1a	Teesside	8.7	34.5	43.2	77.2
1b	Humber Gateway	0.4	1.1	1.5	78.7
1b	Kentish Flats Extension	0.5	1.7	2.2	80.9
1b	Westermost Rough	0.1	0	0.1	81
1b	Blyth Demonstration Project	0.5	2.2	2.7	83.7
1b	Dudgeon	-	-	-	83.7
1b	Hywind	0.6	7.8	8.4	92.1
1b	European Offshore Wind Deployment Centre (Aberdeen Bay)	4.8		4.8	96.9
1b	Galloper	27.2		27.2	124.1
1b	Race Bank	0		0	124.1

Tier	Windfarm	Breeding season	Nonbreeding season	Annual	Annual Running Total
1b	Rampion	155		155	279.1
1b	Beatrice	49.4	197.4	246.8	525.9
1b	East Anglia ONE	0	28	28	553.9
1b	Hornsea Project One	2.9	11.6	14.5	568.4
1b	Kincardine	1	0	1	569.4
1b	Moray East	52		52	621.4
1b	Hornsea Project Two	23.8		23.8	645.2
1b	Triton Knoll	0		0	645.2
1b	Seagreen A and B	10	21	31	676.2
2a	Neart na Gaoithe	5	12.5	17.5	693.7
2a	Moray West	12	1	13	706.7
2a	Dogger Bank Creyke Beck Projects A and B	0		0	706.7
2a	Dogger Bank Teesside Projects A (now Dogger Bank C) and B (now Sofia)	0		0	706.7
2b	East Anglia THREE	0	23	23	729.7
2b	Hornsea Project Three - revised	1	4	5	734.7
2b	Inch Cape	0	13.5	13.5	748.2
3	Pentland Floating Offshore Wind	0	0	0	748.2
3	Norfolk Vanguard (East & West)	0.4	7.1	7.5	755.7
3	Norfolk Boreas	1.5	5.4	6.9	762.6
3	East Anglia ONE North	0	0	0	762.6
3	East Anglia TWO	0	0.5	0.5	763.1

Tier	Windfarm	Breeding season	Nonbreeding season	Annual	Annual Running Total
3	Hornsea 4	0.5	0.3	0.79	763.89
4	Berwick Bank	43	7	50	813.89
4	Dudgeon & Sheringham Offshore Extension Projects	0.25	0	0.25	814.14
4	Rampion 2	34.52	28.11	62.62	876.76
4	ForthWind Offshore Wind Demonstration Project - phase 1	0	0	0	876.76
4	West of Orkney	0	0	0	876.76
5	Outer Dowsing	2.7	0.2	3	879.76
5	Dogger Bank South (East & West combined)	0.51	0.87	1.38	881.14
5	North Falls	0.5	1.1	1.6	882.74
	Total (other projects)	**449**	**433**	**883**	
	VE	0.65	1.41	2.05	
	Total (all projects)	**450**	**435**	**885**	

GREAT BLACK-BACKED GULL

4.13.126 The cumulative predicted collision risk for great black-backed gull is set out in Table 4.66. Assessments for other windfarms have been conducted using a range of avoidance rates and alternative collision model Options.

4.13.127 The collision values presented in Table 4.66 include breeding, nonbreeding and annual collision totals. However, not all projects provide a seasonal breakdown of collision impacts, therefore it is not possible to extract data from these periods for cumulative assessment. Natural England has previously noted that an 80:20 split between the nonbreeding and breeding seasons is appropriate for lesser black-backed gull in terms of collision estimates (Natural England, 2013). This ratio is considered to also be appropriate for great black-backed gull, therefore for those sites where a seasonal split was not presented the annual numbers in Table 4.66 have been multiplied by 0.8 to estimate the nonbreeding component and 0.2 to estimate the breeding component.

Table 4.66: Cumulative Collision Risk Assessment for Great Black-backed Gull.

Tier	Windfarm	Breeding season	Nonbreeding season	Annual	Annual Running Total
1a	Scroby Sands	-	-	-	0
1a	Kentish Flats	-	-	-	0
1a	Beatrice Demonstrator	0	0	0	0
1a	Lynn and Inner Dowsing	0	0	0	0
1a	Gunfleet Sands	-	-		0
1a	Thanet	0.1	0.4	0.5	0.5
1a	Greater Gabbard	15	60	75	75.5
1a	Sheringham Shoal	0	0	0	75.5
1a	Lincs	0	0	0	75.5
1a	London Array	-	-	-	75.5
1a	Methil	0.8	0.8	1.6	77.1
1a	Teesside	8.7	34.8	43.6	120.7
1b	Humber Gateway	1.3	5.1	6.3	127
1b	Kentish Flats Extension	0.1	0.2	0.3	127.3
1b	Westermost Rough	0	0	0.1	127.4
1b	Blyth Demonstration Project	1.3	5.1	6.3	133.7
1b	Dudgeon	0	0	0	133.7
1b	Hywind	0.3	4.5	4.8	138.5
1b	European Offshore Wind Deployment Centre (Aberdeen Bay)	0.6	2.4	3	141.5
1b	Galloper	4.5	18	22.5	164
1b	Race Bank	0	0	0	164

Tier	Windfarm	Breeding season	Nonbreeding season	Annual	Annual Running Total
1b	Rampion	5.2	20.8	26	190
1b	Beatrice	30.2	120.8	151	341
1b	East Anglia ONE	0	46	46	387
1b	Hornsea Project One	17.2	68.6	85.8	472.8
1b	Kincardine	0	0	0	472.8
1b	Moray East	9.5	25.5	35	507.8
1b	Hornsea Project Two	3	20	23	530.8
1b	Triton Knoll	24.4	97.6	122	652.8
1b	Seagreen A and B	13.4	53.4	66.8	719.6
2a	Neart na Gaoithe	0.9	3.6	4.5	724.1
2a	Moray West	4	5	9	733.1
2a	Dogger Bank Creyke Beck Projects A and B	5.8	23.3	29.1	762.2
2a	Dogger Bank Teesside Projects A (now Dogger Bank C) and B (now Sofia)	6.4	25.5	31.9	794.1
2b	East Anglia THREE	4.6	34.4	39	833.1
2b	Hornsea Project Three - revised	8	28	36	869.1
2b	Inch Cape	0	36.8	36.8	905.9
3	Pentland Floating Offshore Wind	0	0	0	905.9
3	Norfolk Vanguard (East & West)	4.5	21.5	26	931.9
3	Norfolk Boreas	6.9	28.7	35.6	967.5
3	East Anglia ONE North	3.7	1.2	5	972.5
3	East Anglia TWO	3.5	3.4	6.9	979.4
3	Hornsea 4	0.5	5.2	5.7	985.1

Tier	Windfarm	Breeding season	Nonbreeding season	Annual	Annual Running Total
4	Berwick Bank	0	0	0	985.1
4	Dudgeon & Sheringham Offshore Extension Projects	5.7	0.3	6	991.1
4	Rampion 2	6.25	13.59	19.84	1010.9
4	ForthWind Offshore Wind Demonstration Project - phase 1	0	0	0	1010.9
4	West of Orkney	0.1	6	6.1	1017
5	Outer Dowsing	0.5	4.2	4.7	1021.7
5	Dogger Bank South (East & West combined)	1.24	4.79	6.04	1027.8
5	North Falls	0	6	6	1033.8
	Total (other projects)	**198**	**835**	**1034**	
	VE	0.68	0.57	1.84	
	Total (all projects)	**199**	**836**	**1036**	

4.13.128 The annual cumulative total of predicted collisions is 1,036 of which VE contributes up to two birds. Based on the largest Annual BDMPS of 91,399 (Furness 2015) and baseline mortality of 0.185, 16,909 individual greater black-backed gulls would be expected to die each year; the addition of 1,036 individuals would represent a 6.1% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 235,000 (Furness 2015), 43,475 individuals would be expected to die; the addition of 996 individuals would represent a 2.4% increase in mortality.

4.13.129 Based on findings from population viability analyses for bird species, it would be considered that increases in mortality rates of less than 1% would be undetectable in terms of changes in population size, whereas above 1% there could be detectable effects.

4.13.130 Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher numbers of wind turbines (and total rotor swept areas) than have been installed (or are planned), which is a key factor in collision risk. Updating the collision estimates for windfarms which have been built out or are due to be built out with a smaller rotor swept area that the consented worst-case design (as per MacArthur Green 2017) achieves a reduction in the cumulative annual mortality by around 24% (see Appendix 12.3 of East Anglia TWO EIA submission). Therefore, the values presented in Table 4.66, as well as being based on precautionary calculations, can be seen to overestimate the total risk by around 24% due to the reduced collision risks for projects which undergo design revisions post consent.

4.13.131 It is also the case that some of the older projects, listed in Tier 1a (Table 4.53) would be included in the baseline characterization data through baseline surveys or other studies of the species in the North Sea, and so have already had an impact on the population, meaning that their associated collision rate values should theoretically be excluded (Table 4.52).

4.13.132 As with lesser black-backed gull described above, the avoidance rate for great black-backed gull has reduced from 99.5% to 99.4% on the advice from Natural England, leading to an increase in collision rates for projects by around 17% if they have used that previous avoidance rate. This is likely to be offset by implementation of a lower nocturnal activity factor from 50% to 25%. Reducing the nocturnal activity factor to 25% reduced collision estimates for great black-backed gull at VE by around 56% (Table 4.46). A similar correction applied to the other windfarms would further reduce the overall collision estimate for all windfarms by a significant amount (note the magnitude of reduction varies depending on the time of year and windfarm latitude due to the variation in day and night length). This emphasises the precautionary nature of the current assessment.

4.13.133 A population model for great black-backed gull was developed to inform the East Anglia THREE assessment (EATL 2016a). Four versions of the model were presented, using two different sets of demographic rates (from the scientific literature) and with and without density dependent regulation of reproduction. Comparison of the historical population trend with the outputs from these models indicated that the density dependent versions generated population predictions which were much more closely comparable to the population trend. The density dependent models were also less sensitive to which set of demographic rates was used. The density dependent versions were therefore considered to provide a more reliable predictive tool.

4.13.134 Using the density dependent model, application of an additional annual mortality of 1,000 to the great black-backed gull BDMPS (similar to the cumulative total of 1,036 birds predicted here) resulted in impacted populations after 25 years which were 6.8% to 8.9% smaller than predicted populations in the absence of collision risk impact from offshore wind farms. The equivalent density independent predictions generated population reductions of 22.6% to 23%. Based on the modelling, Natural England concluded that whilst a significant cumulative effect could not be ruled out, the contribution of East Anglia THREE was so small that it would not materially affect the overall cumulative impact magnitude. The final East Anglia THREE annual collision impact for great black-backed gull was 39, compared with only three for the proposed VE project.

4.13.135 Great back-backed gull population modelling was carried out on behalf of Hornsea Project Four (APEM, 2021) at a North Sea BDMPS scale at a range of mortality rates up to 964.3 individuals. This density independent modelling predicted that the counterfactual of population growth rate (after 35 years) would be 0.987, a reduction in growth rate per annum of 1.27%.

4.13.136 On the basis of the worst-case approach, the cumulative great black-backed gull collision risk impact magnitude would be assessed as medium, which, for a low to medium sensitivity, species, would result in a minor to moderate adverse effect (potentially significant in EIA terms, based on the matrix in Table 4.7).

4.13.137 The cumulative assessment, both year-round and within individual seasons does however include precaution and the impact is therefore considered to be of **low** magnitude; with the relative contribution of the proposed VE project to this cumulative total being very small. Great black-backed gulls are considered to be of low to medium sensitivity to collision mortality and the effect is therefore **minor adverse**, which is **not significant** in EIA terms.

CUMULATIVE ASSESSMENT OF OPERATIONAL COLLISION RISK AND DISPLACEMENT

GANNET

4.13.138 As a species which has been scoped in for collision and displacement from offshore wind farms, it is possible that the impacts of cumulative collision risk and cumulative displacement could combine to adversely affect gannet populations. Obviously, they would not act on the same individuals, as birds which do not enter a windfarm cannot be subject to mortality from collision, and vice versa. Avoidance rates for offshore windfarms, used in collision risk monitoring, take account of macro-avoidance (where birds avoid entering a windfarm), meso-avoidance (avoidance of the rotor swept zone within a windfarm), and micro-avoidance (avoiding wind turbine blades). Thus, birds which exhibit macro-avoidance could be subject to mortality from displacement.

4.13.139 As noted above, the estimated cumulative annual total for gannet collision mortality is 3,249. The estimated cumulative total for gannet displacement is 379-506 birds.

4.13.140 Based on the largest Annual BDMPS for the UK North Sea and Channel, of 456,298 (Furness 2015) and baseline mortality of 0.191, 87,153 individual gannets would be expected to die each year; the addition of 3,628-3,755 individuals would represent a 4.1–4.3% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness 2015), 225,380 individuals would be expected to die; the addition of 3,628-3,755 individuals would represent 1.6-1.7% increase in mortality.

4.13.141 The estimated cumulative impacts of collision are an order of magnitude higher than those of displacement, and addition of the precautionary 1% estimated mortality of displaced birds to the collision mortality results in a very small change in the estimated increased in population mortality rates due to collision. As discussed in the cumulative assessment sections above, it is considered that the mortality of displaced gannets would in reality be at or very close to zero, and there would therefore be no increase in the mortality rate increases estimated for cumulative collision risk.

4.13.142 Thus, the combined impact of cumulative displacement and collision risk would be of **low** magnitude (as for the assessment of cumulative collision risk alone), and the effect would be **minor adverse**, which is **not significant** in EIA terms.

4.14 CLIMATE CHANGE

4.14.1 The information provided in this section will be drawn upon and summarised in Volume 6, Part 4, Chapter 1: Climate change. As outlined in Volume 6, Part 4, Chapter 1: Climate Change, the operational phase of VE would enable the use of renewable electricity which would result in a positive greenhouse gas impact, resulting in a significant beneficial effect.

EFFECT OF CLIMATE CHANGE ON THE LOCAL ENVIRONMENT

4.14.2 Climate change has the potential to affect seabird distribution, abundance and demography in the local environment, although the impacts are likely to vary in magnitude and form, between species.

4.14.3 A review of the main drivers on the populations of IOFs, including the possible negative or positive impacts of climate change, is presented in section 4.7, Evolution of the Baseline.

4.14.4 A literature review by Searle et al. (2022) identified two sets of climate variables which may indicate impacts on seabirds in the North Sea: terrestrial and marine, which can be summarised as follows:

TERRESTRIAL VARIABLES

- Minimum air temperature: at nest sites this has the potential to affect hatching success, chick growth and chick survival. Adult survival rates over winter may also be affected;
- Summed daily/maximum precipitation: impacts as above; and
- Mean wind speed: at nest sites this has the potential to affect hatching success, chick growth and chick survival. Adult survival rates over winter and foraging effort may also be affected.

MARINE VARIABLES

- Sea surface temperature: changes in sea temperature may affect the distribution, abundance and demography of seabird prey species, thereby affecting breeding success and productivity, and adult survival (including changes in foraging effort);
- Sea surface salinity: changes in sea salinity may affect seabird prey species as above; and
- North Atlantic Oscillation and Atlantic Multidecadal Oscillation: These climatic indices describe regional-scale meteorological and oceanographic conditions (e.g., wind events, storm events, precipitation). Variations may affect adult survival, breeding success, chick diet and chick mass.

4.14.5 Analysis by Searle et al. (2022) and a review by Johnston et al. (2021) emphasised the evidence for climate change impacts on seabirds being mostly related to bottom-up effects of climate change on marine food webs, with terrestrial climate change impacts being relatively minor.

EFFECT OF CLIMATE CHANGE AND THE PROJECT ON THE LOCAL ENVIRONMENT

4.14.6 The project is not predicted to contribute to any of the above identified impacts of climate change in the local area to any significant extent.

4.15 INTER-RELATIONSHIPS

4.15.1 The construction, operation and decommissioning phases of the proposed VE project would cause a range of impacts on offshore ornithological interests. The magnitude of these impacts has been assessed individually above in section 4.11 using expert knowledge and judgement, drawing from a wide science base that includes project-specific surveys and previously acquired knowledge of the bird ecology of the North Sea (from published scientific papers and books, and 'grey' literature).

4.15.2 Impacts to offshore ornithological interests may be inter-related with other receptor groups. With respect to the impacts assessed for offshore ornithology (Section 4.11), this is considered to be the case for indirect impacts through effects on habitats and prey species only. For direct disturbance/displacement and collision risk there is considered to be no potential for interaction with other receptor groups.

4.15.3 Inter-relationships are summarised in Table 4.67, which indicates where assessments carried out in other ES chapters have been used to inform the offshore ornithology assessment.

Table 4.67: Ornithology Inter-relationships.

Impact	Related Chapter	Where addressed in this Chapter	Rationale
Indirect impacts through effects on habitats and prey during construction	Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology	Impact 2	Potential impacts on benthic ecology and fish and shellfish during construction could affect the prey resource for birds.
Indirect impacts through effects on habitats and prey during operation	Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology	Impact 5	Potential impacts on benthic ecology and fish and shellfish during operation could affect the prey resource for birds.
Indirect impacts through effects on habitats and prey during decommissioning	Volume 6, Part 2, Chapter 5: Benthic and Intertidal Ecology Volume 6, Part 2, Chapter 6: Fish and Shellfish Ecology	Impact 7	Potential impacts on benthic ecology and fish and shellfish during decommissioning could affect the prey resource for birds.

4.16 TRANSBOUNDARY EFFECTS

4.16.1 With regard to the potential for transboundary cumulative impacts, there is clearly potential for collisions and displacement at windfarms outside UK territorial waters. However, the spatial scale and hence seabird reference population sizes for a transboundary assessment would be much larger. Therefore, the inclusion of non-UK windfarms is considered very unlikely to alter the conclusions of the existing cumulative assessment, and highly likely to reduce the cumulative impact assessed on the larger population present over a larger spatial scale.

4.17 SUMMARY OF EFFECTS

4.17.1 This chapter provides an assessment of the potential impacts on offshore ornithology that may arise from the construction, operation and decommissioning of the offshore components (array areas and offshore ECC).

4.17.2 The impacts that could potentially arise for offshore ornithology during the construction, operation and decommissioning of the proposed VE project have been subject to discussions with consultees as part of the Evidence Plan process. The potential impacts that required detailed assessment were:

- In the construction phase:
  - Impact 1: Direct disturbance and displacement.
  - Impact 2: Indirect impacts through effects on habitats and prey species.
- In the operational phase:
  - Impact 3: Direct disturbance and displacement (from offshore infrastructure and due to increased vessel and helicopter activity);
  - Impact 4: Collision risk;
  - Impact 5: Indirect impacts through effects on habitats and prey species; and
  - Impact 6: Combined operational collision risk and displacement.
- In the decommissioning phase:
  - Impact 7: Disturbance/displacement; and
  - Impact 8: Indirect impacts through effects on habitats and prey species.

4.17.3 During the construction phase of the proposed project no effects have been assessed to be greater than **minor adverse** for any IOF (Table 4.68), which is **not significant** in EIA terms.

4.17.4 During operation, displacement impacts on red-throated divers, gannets, razorbills and guillemots would not create effects of more than **minor adverse** (**not significant** in EIA terms) during any biological season. The risk to birds from collisions with wind turbines from the proposed VE project alone is assessed as no greater than **minor adverse** (**not significant** in EIA terms) for gannet, kittiwake, lesser black-backed gull and great black-backed gull when considered for all biological seasons against the most appropriate population scale.

4.17.5 Three potential impacts of the proposed VE project were screened in for cumulative assessment: construction disturbance, operational displacement and collision risk. Other potential impacts would be temporary, small scale and localised and given the distances to other activities in the region (e.g. other offshore windfarms and aggregate extraction) it was concluded that there is no pathway for cumulative interaction.

4.17.6 A screening process was also carried out for potential plans and projects that might affect ornithological features cumulatively with the proposed project. In the offshore environment only other UK windfarms that were operational, under construction, consented but not constructed, subject to current applications or subject to consultation were screened in. This list of windfarms with their status is provided in Table 4.53.

4.17.7 The effect on IOFs from cumulative construction disturbance, operational displacement and collisions is assessed as no greater than **minor adverse** for all species, which is **not significant** in EIA terms. Table 4.69 presents a summary of the predicted magnitude of change and significance of cumulative effects, showing both the worst-case, considering Natural England advice (NE), and the more evidence-based, but still precautionary judgement (VE). The potential for collisions and displacement from windfarms outside UK territorial waters (transboundary) to contribute to cumulative impacts was considered, but the inclusion of non-UK windfarms is considered very unlikely to alter the cumulative effect assessed on the larger populations present over a larger spatial scale.

Table 4.68: Predicted effects on IOFs.

Potential Impact	IOF	Sensitivity	Magnitude	Significance	Mitigation	Residual Significance
Construction						
Impact 1: Direct disturbance and displacement during offshore ECC construction	Red-throated diver	High	Negligible	Minor adverse (Not significant)	N/A (best practice protocol included in mitigation)	Minor adverse (Not significant)
	Common scoter	High	Negligible	Minor adverse (Not significant)	N/A	Minor adverse (Not significant)
Impact 1: Direct disturbance and displacement from construction activity within array areas	Razorbill	Medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)
	Guillemot	Medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)
Impact 2: Indirect impacts through effects on habitats and prey species	All IOFs	Low to high	Negligible	Negligible (Not significant)	N/A	Negligible or Minor adverse (Not significant)
Operation						

Potential Impact	IOF	Sensitivity	Magnitude	Significance	Mitigation	Residual Significance
Impact 3: Direct disturbance and displacement	Red-throated diver	High	Negligible	Minor adverse (Not significant)	N/A	Minor adverse (Not significant)
	Gannet	Low to medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)
	Razorbill	Medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)
	Guillemot	Medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)
Impact 4: In Indirect impacts through effects on habitats and prey species	All IOFs	Low to high	Negligible	Negligible (Not significant)	N/A	Negligible or Minor adverse (Not significant)
Impact 5: Collision risk	Gannet	Low to medium	Negligible	Negligible (Not significant)	N/A	Negligible or Minor adverse (Not significant)
	Kittiwake	Low to medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)
	Lesser black-backed gull	Low to medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)

Potential Impact	IOF	Sensitivity	Magnitude	Significance	Mitigation	Residual Significance
	Herring gull	Low to medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)
	Great black-backed gull	Low to medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)
Impact 6: Combined collision and displacement	Gannet	Low to medium	Negligible	Negligible (Not significant)	N/A	Minor adverse (Not significant)
Decommissioning						
Impact 7: Direct disturbance and displacement	All IOFs	Low to high	Negligible	Negligible to minor adverse (Not significant)	N/A	Minor adverse (Not significant)
Impact 8: Indirect impacts through effects on habitats and prey species	All IOFs	Low to high	Negligible	Negligible to minor adverse (Not significant)	N/A	Negligible or minor adverse (Not significant)

Table 4.69: Predicted cumulative effects on IOFs.

This Table presents a summary of the predicted magnitude of change and significance of cumulative effects, showing both the worst-case based on Natural England (NE) advice (through consultation and SNCB guidance notes) and the more evidence-based, but still precautionary judgement (VE), as described in Section 4.13. for each impact.

Potential Impact	IOF	Sensitivity	NE Magnitude	VE Magnitude	Mitigation	NE Residual Significance	VE Residual Significance
Construction							
Disturbance and displacement	Red-throated diver	High	Low	Negligible	N/A	Minor adverse (Not significant)	Minor adverse (Not significant)
Operation							
Disturbance and displacement	Red-throated diver	High	Medium	Low	N/A	Moderate or major adverse (Significant)	Minor adverse (Not significant)
	Gannet	Low to medium	Negligible	Negligible	N/A	Minor adverse (Not significant)	Minor adverse (Not significant)
	Razorbill	Low to medium	Medium	Low	N/A	Moderate adverse (Significant)	Minor adverse (Not significant)
	Guillemot	Low to medium	Medium	Low	N/A	Moderate adverse (Significant)	Minor adverse (Not significant)
Collision risk	Gannet	Low to medium	Low	Low	N/A	Minor adverse (Not significant)	Minor adverse (Not significant
	Kittiwake	Low to medium	Low-Medium	Low	N/A	Minor to moderate adverse (Not significant)	Minor adverse (Not significant

Potential Impact	IOF	Sensitivity	NE Magnitude	VE Magnitude	Mitigation	NE Residual Significance	VE Residual Significance
	Lesser black-backed gull	Low to medium	Low	Low	N/A	Minor adverse (Not significant)	Minor adverse (Not significant
	Herring gull	Low to medium	Low	Negligible	N/A	Minor adverse (Not significant)	Minor adverse (Not significant
	Great black-backed gull	Low to medium	Low to Medium	Low	N/A	Minor to Moderate adverse (Significant)	Minor adverse (Not significant
Combined collision risk and displacement	Gannet	Low to medium	Low	Low	N/A	Minor adverse (Not significant)	Minor adverse (Not significant

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