FIVE ESTUARIES OFFSHORE WIND FARM

PRELIMINARY ENVIRONMENTAL INFORMATION REPORT

VOLUME 2, CHAPTER 4: OFFSHORE ORNITHOLOGY

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TABLES

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
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
NPS	National Policy Statement

Term	Definition
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
PEI or 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 (note, pSPA indicates a proposed site not yet designated)
SSSI	Site of Special Scientific Interest
UK	United Kingdom
WWT	Wildfowl and Wetlands Trust

GLOSSARY OF TERMS

Term	Definition
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.
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.
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.
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.

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).

4.1.2 The chapter 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 2, Chapter 1: Offshore Project Description;
- Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes;
- Volume 2, Chapter 5: Benthic and Intertidal Ecology;
- Volume 2, Chapter 6: Fish and Shellfish Ecology which provide further information regarding potential impacts on prey species; and
- VE Habitat Regulations Assessment: 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 4 annexes:

- Annex 4.1: Offshore Ornithology Technical Report;
- Annex 4.2: Seabird Abundance 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: Digital video aerial surveys of seabirds and marine mammals at Five Estuaries: Annual report for March 2019 to February 2020; and
- Annex 4.11: Digital video aerial surveys of seabirds and marine mammals at Five Estuaries: Two-year report March 2019 to February 2021.

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 taken into account 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 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 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.	This chapter presents an assessment of the potential effects on birds, including those species protected under the Habitats Regulations (Birds Directive) in sections 4.10 to 4.15. 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 VE RIAA.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
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 birds, including those species protected under the Habitats Regulations (Birds Directive) in sections 4.10 to 4.15. 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 VE RIAA.
The Conservation of Habitats and Species Regulations 2017	The Conservation of Habitats and Species Regulations 2017 (hereafter called the 'Habitats Regulations'), 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.	This chapter presents an assessment of the potential effects on birds, including those species protected under the Habitats Regulations (Birds Directive) in sections 4.10 to 4.15.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	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).	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 VE RIAA.
Policy		
National Planning Policy Framework	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 170 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 1, Chapter 4: Site Selection and Alternatives) and subsequent refinements to the array areas and offshore export cable corridor have been made which has helped to reduce the total area over which there is potential for impacts.
UK Marine Policy Statement (MPS)	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 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	The identification of the species most sensitive to the VE project has been undertaken through a process of consultation with statutory and non-statutory organisations (see Section 4.3). An assessment of the potential impacts of the proposed VE project-alone

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	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.	(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, embedded mitigation measures (see section 4.9) will be implemented to reduce potential impacts as far as possible.
Draft Overarching National Policy Statement (NPS) for Energy (EN-1) September 2021	Paragraph 5.4.5 – states that the IPC *"should take account of the context of the challenge of climate change: failure to address this challenge will result in significant adverse impacts to biodiversity." It also notes that "the benefits of nationally significant low carbon energy infrastructure development may include benefits for biodiversity and geological conservation interests and these benefits may outweigh harm to these interests. The IPC [the Secretary of State] may take account of any such net benefit in cases where it can be demonstrated."*	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 (Volume 2, Chapter 1: Offshore Project Description), to the UK Government's target of producing 40GW of renewable energy from offshore wind by 2030 and achieving net zero by 2050 (BEIS 2020).
Draft Overarching National Policy Statement (NPS) for Energy (EN-1) September 2021	Paragraph 5.4.6 - states that *"development should aim to avoid significant harm to biodiversity and geological conservation interests, including through mitigation and consideration of reasonable*	VE has been designed to avoid significant harm to biodiversity interests through the site selection process. Further details are provided in Volume 1,

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	alternatives… where significant harm cannot be avoided, then appropriate compensation measures should be sought.”	Chapter 4: Site Selection and Alternatives.
Draft Overarching National Policy Statement (NPS) for Energy (EN-1) September 2021	Paragraph 5.4.7 intimates that *“the IPC [the Secretary of State] should ensure that appropriate weight is attached to designated sites of international, national and local importance; protected species; habitats and other species of principal importance for the conservation of biodiversity; and to biodiversity and geological interests within the wider environment.”*	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 VE RIAA.
Draft Overarching National Policy Statement (NPS) for Energy (EN-1) September 2021	Paragraph 5.4.8 – states that *“the most important sites for biodiversity are those identified through international conventions and European Directives. The Habitats Regulations provide statutory protection for these sites but do not provide statutory protection for potential Special Protection Areas (pSPAs) before they have been classified as a Special Protection Area. For the purposes of considering development proposals affecting them, as a matter of policy the Government wishes pSPAs to be considered in the same way as if they had already been classified. Listed Ramsar sites should, also as a matter of policy, receive the same protection.”*	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 VE RIAA.
Draft Overarching National Policy Statement (NPS) for Energy (EN-1) September 2021	Paragraph 5.3.15 states – *“Development proposals provide many opportunities for building-in beneficial biodiversity or geological features as part of good design. When considering proposals, the [the Secretary of State] should maximise such opportunities in and around developments, using*	Five Estuaries Offshore Wind Farm Limited (VE OWFL) has explored, developed and created suitable opportunities for building-in beneficial biodiversity and geological features as part of good design for VE, as detailed

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	requirements or planning obligations where appropriate."	in the commitments listed in Volume 2, Chapter 1: Offshore Project Description.
Draft Overarching National Policy Statement (NPS) for Energy (EN-1) September 2021	Paragraph 5.4.15– reminds that *"many individual wildlife species receive statutory protection under a range of legislative provisions."*	Statutory protection afforded to bird species has been considered in determining the conservation value of receptors as part of this assessment, outlined in Section 4.5: Sensitivity.
Draft Overarching National Policy Statement (NPS) for Energy (EN-1) September 2021	Paragraph 5.4.16 – explains that *"other species and habitats have been identified as being of principal importance for the conservation of biodiversity in England and Wales and thereby requiring conservation action. The IPC [the Secretary of State] should ensure that these species and habitats are protected from the adverse effects of development by using requirements or planning obligations. The IPC [the Secretary of State] should refuse consent where harm to the habitats or species and their habitats would result, unless the benefits (including need) of the development outweigh that harm. In this context the IPC [the Secretary of State] should give substantial weight to any such harm to the detriment of biodiversity features of national or regional importance which it considers may result from a proposed development."*	Species of principal importance in England are considered in determining the conservation value of features as part of this assessment, outlined in Section 4.5: Sensitivity. VE is committed to minimising potential impacts on biodiversity, and embedded mitigation measures are described in Section 4.9. VE OWFL 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. VE OWFL 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 2, Chapter 1:

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
		Offshore Project Description. Climate change is a significant threat to bird biodiversity interests (Pearce-Higgins 2021). VE will contribute a significant amount of renewable energy (Volume 2, Chapter 1: Offshore Project Description), to the UK Government's target of producing 40GW of renewable energy from offshore wind by 2030 and achieving net zero by 2050 (BEIS 2020).
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.24.5 - states that the *"assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed offshore wind farm."*	Assessment of potential effects on offshore ornithology across all stages of VE's lifespan have been described and considered within Sections 4.10 to 4.15.
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.24.6 – states that *"Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate."*	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).
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.24.18 – states that *"the IPC [the Secretary of State] should consider the effects of a proposal on marine ecology and biodiversity [and the physical environment] taking into account all relevant information made available to it."*	The offshore ornithology aspects of marine ecology and biodiversity have been described and considered within this PEIR chapter for VE.
Draft NPS for Renewable Energy	Paragraph 2.24.19 – *"However, where adverse effects on site integrity/ conservation objectives are predicted,*	VE has been designed to avoid and/ or mitigate potential adverse effects

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
Infrastructure (EN-3) September 2021	*in coming to a decision, the Secretary of State should consider the extent to which the effects are temporary or reversible and the timescales for recovery."*	on the national site network, as described in the VE RIAA.
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.29.1– explains that *"offshore wind farms* *have the potential to impact on birds through:* > *collisions with rotating blades;* > *direct habitat loss;* > *disturbance from construction activities such as the movement of construction/ decommissioning vessels and piling;* > *displacement during the operational phase, resulting in loss of foraging/roosting area;* > *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 protected sites (e.g. SPAs)."*	Assessment of potential effects on offshore ornithology across all stages of VE's lifespan have been described and considered within Sections 4.10 to 4.15.
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.29.3 - states that *"the scope, effort and methods required for ornithological surveys should have been discussed 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).
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.29.4 – states that *"collision risk modelling, as well as displacement and population viability assessments must be undertaken for certain bird species."*	Collision risk modelling and displacement analysis has been undertaken using parameters that have been agreed with SNCBs

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
		through the Evidence Plan process. Potential effects from displacement and collision risk are presented and assessed in Section 4.11.
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.29.5 – requires that *"aviation and navigation lighting be minimised [and/ or on demand] 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.
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.29.6 – notes that, *"subject to other constraints, wind turbines should be laid out within a site, in a way that minimises collision risk, where the collision risk assessment shows there is a significant risk of collision."*	The collision risk assessment in Section 4.11 has shown non-significant unmitigated effects of collisions on all species under the worst-case scenario.
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.29.7 – requires that *"construction vessels associated with offshore wind farms should, where practicable and compatible with operational requirements and navigational safety, avoid rafting seabirds during sensitive periods."*	Construction vessels associated with VE will, where practicable and compatible with operational requirements and navigational safety, avoid rafting seabirds and particularly red-throated diver aggregations during sensitive periods. See Section 4.9: Embedded Mitigation.
Draft NPS for Renewable Energy Infrastructure (EN-3) September 2021	Paragraph 2.29.8 – explains that *"the exact timing of peak migration events is inherently uncertain. Therefore, shutting down turbines within migration routes during estimated*	Mitigation measures for offshore ornithology have been considered within the VE assessment process

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	peak migration periods is unlikely to offer suitable mitigation."	where relevant (Section 4.9: Embedded Mitigation). Additional risks with regards to migratory movements of birds associated with SPAs are further considered within the VE RIAA.
Overarching National Policy Statement (NPS) for Energy (NPS EN-1) (July 2011)	Paragraph 5.3.3 states that *"the Applicant should ensure that the ES clearly sets out any impacts on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity."* Paragraph 5.3.4 states that *"the Applicant should also show how the proposed project has taken advantage of opportunities to conserve and enhance biodiversity and geological conservation interests."* Paragraph 5.3.18 states that *"the Applicant should include appropriate mitigation measures as an integral part of the proposed development."*	The potential impacts on the designated sites and species which have been scoped into the assessment are presented in sections 4.10 to 4.12, and cumulatively with other projects in section 4.13. The VE array areas were identified through the Zonal Appraisal and Planning process (Volume 1, Chapter 4: Site Selection and Alternatives) and as far as possible has sought to avoid European Sites.
NPS for Renewable Energy Infrastructure (NPS EN-3) (July 2011)	Paragraph 2.6.64 states that the *"assessment of offshore ecology and biodiversity should be undertaken by the Applicant for all stages of the lifespan of the proposed offshore windfarm."* Paragraph 2.6.102 states that *"the scope, effort and methods required for ornithological surveys should have been discussed with the relevant statutory advisor. Paragraph 2.6.104 states that it may be appropriate for the assessment to include collision risk modelling for certain bird species."*	An assessment of potential impacts during the construction, operation and decommissioning has been provided in sections 4.10 to 4.12) and cumulatively with other projects in section 4.13. The scope of the ornithological surveys was agreed with the relevant Statutory Nature Conservation Bodies (SNCBs) during the Evidence Plan Process (see Table 4.2), with

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
		analysis methods agreed through submission of the Offshore Ornithology Method Statement. Collision risk modelling for the bird species that were scoped into that assessment has been conducted (see Volume 4, Annex 4.8: Collision risk modelling inputs and outputs and an assessment of collision risk provided in section 4.11).
East Offshore Marine Plans	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	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 including on habitats and species that are protected or of conservation concern in the East marine plans and adjacent areas (marine, terrestrial)".*	Due consideration to the baseline characterisation of the site has been given in Volume 4, Annex 4.1: Offshore Ornithology 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	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*	Designated nature conservation sites, with regards to offshore ornithology and within the VE study area have been described in Section 4.7.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	any current agreed advice on an ecologically coherent network".	Potential impacts to features of designated sites have been assessed in Sections 4.10, 4.11, 4.12 and 4.13.
East Inshore Marine Plans	Policy SE-MPA-1: *"Proposals that may have adverse impacts on the objectives of marine protected areas must demonstrate that they will, in order of reference:* *a) avoid* *b) minimise* *c) mitigate adverse impacts, with due regard given to statutory 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	Policy SE-BIO-2: *"Proposals that may cause significant adverse impacts on native species or habitat adaptation or connectivity, or native species migration, must demonstrate that they will, in order of preference:* *a) avoid* *b) minimise* *c) mitigate adverse impacts so they are no longer significant* *d) compensate for significant adverse impacts that cannot be mitigated".*	Potential impacts on offshore ornithology receptors have been assessed in Sections 4.10, 4.11, 4.12 and 4.13, and embedded mitigation detailed in Section 4.9.
East Offshore Marine Plans	Policy SE-DIST-1: *"Proposals that may have significant adverse impacts on highly mobile species through disturbance or displacement must demonstrate that they will, in order of preference:* *a) avoid* *b) minimise* *c) mitigate adverse impacts so they are no longer significant".*	Potential impacts from the disturbance or displacement of offshore ornithology receptors have been assessed in Sections 4.10, 4.11, 4.12 and 4.13.
East Offshore Marine Plans	Policy SE-CE-1: *"Proposals which may have adverse cumulative effects with other existing, authorised, or*	Cumulative effects are considered within Section 4.12.

LEGISLATION/ POLICY	KEY PROVISIONS	SECTION WHERE COMMENT ADDRESSED
	reasonably foreseeable proposals must demonstrate that they will, in order of preference: *a) avoid* *b) minimise* *c) mitigate adverse cumulative and/or in-combination effects so they are no longer significant".*	

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). The EIA methodology described in section 4.5 and applied in this chapter is based on that 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);
- Guidance on ornithological cumulative impact assessment for offshore wind developers (King et al. 2009);
- Advice on assessing displacement of birds from offshore windfarms (SNCB 2017; updated 2022);
- 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);
- Interim advice on updated Collision Risk Modelling parameters (Natural England, July 2022a); and
- Offshore Wind marine Environmental Assessment: Best Practice Advice for Evidence and Data Standards (Natural England 2022b).

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 Vol 1, Chapter 3 EIA Methodology, with various meetings held in October 2020, 2021 and 2022. Furthermore, consultation has been carried out through formal submission of the VE Scoping Report. Feedback received through this process has been considered in preparing the PEIR where appropriate.

4.3.2 The responses received from stakeholders with regards to the Scoping Report, 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.

4.3.3 Further consultation will continue to be undertaken during further ETG meetings prior to the DCO application submission.

Table 4.2: Summary of consultation relating to offshore ornithology.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
12/07/2019 Pre-scoping advice from Natural England (NE) on aerial survey methodology submitted by VE OWFL on 23/02/2019.	<u>Description of the proposed survey and survey design:</u> 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 VE OWFL on 30/08/2019.
	<u>Flight height methodology:</u>	

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	NE advises that where robust and reliable site-specific flight height data can be obtained, these should be used for collision modelling. 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 VE OWFL on 06/11/2019. It was proposed at the time to present CRM results from both Band Option 1 and Band Option 2.
10/02/2020 Pre-scoping ETG meeting	CRM: It was agreed that both Band (2012) model versions 1 and 2 would be used within the PEIR and ES and presented side by side.	Results of the Band (2012) version 2 have been used in this PEIR and are presented in Volume 4, Annex 4.8: Collision Risk Modelling Inputs and Outputs and assessed in section 4.11.
18/09/2021	Survey coverage: a potential disagreement over where 10%	Subsequent agreement has been reached for an aerial

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
Pre-scoping ETG meeting	aerial bird survey coverage is sufficient for the purposes of baseline characterisation.	survey site coverage of 15% (data from three cameras) to be used for calculating density and 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 dDCO and DML 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;	These potential impacts have been scoped in to the assessment (see section 4.4), although it should be noted that barrier effects during operation are considered within Impact 3: Direct Disturbance and Displacement.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	• Cumulative effects with non-OWF developments; and • Cumulative construction and decommissioning effects.	
	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 4, 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).
	VE OWFL is advised to agree assessment methodologies with relevant stakeholders represented on the ornithology Expert Working Group (EWG). If fundamental	Agreement on methodologies has been reached with consultees during the ETG process, as described in this table. Where justification or

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	disagreements remain on the methods for assessing effects from displacement and collision-related mortality the ES should include assessments based on VE OWFL's preferred method and those advocated by Natural England.	rationale has been required, this has been provided in the appropriate section.
	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 VE OWFL 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.
14/12/2021 Post-scoping ETG meeting	It was agreed that the proposed approach for quantifying displacement of seabirds will utilise the SNCB 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 CRM model. Following analysis then the stochastic CRM may be utilised.	The Band (2012) model has been used to estimate collision rates. The methods and results are detailed in Volume 4, 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.	The Option 2 variant of the Band (2012) model 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.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	Migrant collisions will be considered using the BTO tool produced for the SOSS-05 BTO report (Wright *et al*. 2012)	Potential impacts on migrants, in relation to SPA populations, have been assessed in the VE RIAA.
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 4, Annex 4.1: Offshore Ornithology Technical Report).

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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 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.	Noted. Methodology for calculating density and abundance is presented in Volume 4, Annex 4.1: Offshore Ornithology Technical Report. 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 4, 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 4, 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	Option 2 of the Band (2012) model has been used to estimate the collision rates for all species (see Volume 4, Annex 4.3: Offshore Ornithology Collision Risk Modelling for

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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 parameters is captured by undertaking multiple runs.	details). 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 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 collision modelling.
	Species biometric values for seven species are laid out in the Natural England (2022) 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 (2022), including for little gull. See Table 20 of Volume 4, Annex 4.8: Collision risk modelling inputs and outputs for details.
	Natural England recommends to follow the guidance for displacement matrices laid out in the Natural England (2022) Best Practice for Data Analysis document.	The Natural England (2022) 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:	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	Section where comment addressed
	> Definition of study area; > Confirmation of number and appropriateness of aerial survey transects; > 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 recommended avoidance rates in Natural England's interim guidance have been applied to the estimates of collision rates for other offshore windfarm projects in the cumulative assessment (section 4.13.

Date and consultation phase/ type	Consultation and key issues raised	Section where comment addressed
	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 for gannet owing to awaiting the final publication of the associated interim report.	Estimates of gannet collision rates with and without the macro-avoidance factor are considered in this PEIR (section 4.11, Impact 5 and Volume 4, Annex 4.8: Collision risk modelling inputs and outputs).

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).
- 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 In the assessment of potential impacts below they are assessed:

- In the order of construction, operation and decommissioning;
- 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 embedded mitigation that is described in section 4.9.

IMPACTS SCOPED OUT OF ASSESSMENT

4.4.3 On the basis of the baseline environment and the project description outlined in Volume 2, Chapter 1: Offshore Project Description and in accordance with the Scoping Opinion (Planning Inspectorate, 2021), a number of impacts have been scoped out (see Table 4.2), 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 route during operation (subject to the DCO and DML including clear and detailed commitments on the management of vessel movements during the operation and maintenance stage).

STUDY AREA

4.4.4 For the purpose of 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 the RSPB during the Evidence Plan Process (Table 4.2).

4.4.5 This study area, based on SNCB (2017) guidance in relation to maximum displacement buffers, comprises the VE array areas and a 4km buffer placed around them (Volume 4, 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, 2022). In the case of the VE array areas, these are approximately 17km from the Outer Thames Estuary SPA, and so a 4km 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 export cable corridor (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 4, Annex 4.9: Seabird distributions recorded in aerial surveys , Figure 2.4.1). Refer to Volume 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 PEIR makes use of all of the available analysed data.

4.4.9 The study area where surveys were conducted encompassed the array areas and a 4 km buffer (Volume 4, 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%.

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). 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 4km study area defined above), and therefore other data sources, 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.
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.
Essex Wildlife Trust, Landguard Bird Observatory, BTO and any other relevant nature organisations.	Information on breeding records, ringing recoveries etc.	Records may help determine movements of migratory species or foraging birds within 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 &	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.

Source	Summary	Spatial coverage of VE
Verdaat, 2018; Mendel *et al*. 2019.		
Mitchell *et al*. 2004; BirdLife International 2004; Holling *et al*. 2011; Frost *et al*. 2019; Musgrove *et al*. 2013; Furness 2015; Horswill *et al*. 2017.	Scientific literature describing bird population estimates and demographic rates.	Species studied will 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 will 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.
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 Band (2012) model. 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). Details of CRM methods and results are presented in Volume 4 Annex 4.1: Offshore Ornithology Technical Report and Volume 4, 4.8:Collision Risk Modelling Inputs and Outputs respectively.

DENSITY AND ABUNDANCE ESTIMATES METHODOLOGY

4.4.15 Detailed analysis includes density and abundance estimates (with associated confidence intervals and levels of precision).

4.4.16 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 500m 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. 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).

4.4.17 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 auto-correlation 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.

REFERENCE POPULATIONS AND HPAI

4.4.18 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).

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

4.4.20 With seabird species of conservation concern being affected, understanding the currently unknown long-term impacts of HPAI 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.

4.4.21 For the purposes of this assessment, all reference populations used have been estimated from data collected prior to the widespread effects of HPAI on seabirds in 2022, 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 HPAI impacts, with numbers of birds recorded within the study area declining proportionately with population sizes). Consequently, no adjustments to account for impacts of HPAI on populations are considered necessary for the assessment.

4.5 ASSESSMENT CRITERIA AND ASSIGNMENT OF SIGNIFICANCE

4.5.1 The impact assessment methodology will be based on that described in Volume 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 ecological/ornithological receptors (CIEEM 2018; updated 2019).

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) 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.

Sensitivity	Definition
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 species. 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. 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[1].

Table 4.7: Matrix to determine effect significance.

Magnitude		Sensitivity: High	Medium	Low	Negligible
Negative	High	Major	Major	Moderate	Minor
Negative	Medium	Major	Moderate	Minor	Negligible
Negative	Low	Moderate	Minor	Minor	Negligible
Neutral	Negligible	Minor	Minor	Negligible	Negligible
Beneficial	Low	Moderate	Minor	Minor	Negligible
Beneficial	Medium	Major	Moderate	Minor	Negligible
Beneficial	High	Major	Major	Moderate	Minor

Note: shaded cells are defined as significant with regards to the EIA Regulations 2017[1].

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 effect and vice versa. Potential impact significance will not be inflated simply because a feature is 'valued'. Similarly, potentially highly significant impacts 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.

[1] The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

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 2022), and /or biological removal thresholds determined through population modelling), 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 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 the Planning Inspectorate (2019) and from the renewables industry (RenewableUK 2013) and The Crown Estate (2019).

4.6 UNCERTAINTY AND TECHNICAL DIFFICULTIES ENCOUNTERED

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.

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 4, Annexes 4.1: Offshore Ornithology Technical Report and 4.2: Seabird Abundance by Month.

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 4, Annex 4.9: Seabird Distributions in Aerial Surveys.

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

[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
Cormorant	*Phalacrocorax carbo*	BoCC Green listed, Birds Directive Migratory Species ‘High risk’ breeding population vulnerability to climate change	S	S
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
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

Species	Scientific name	Conservation status	Array areas	4km buffer
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. 'Medium benefit' breeding population vulnerability to climate change	N, S	N, S
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

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) and other sources (Table 4.9).

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)
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)	-

Species	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
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 are also considered in the assessment where appropriate. These are provided in Table 4.10.

Table 4.10 Biogeographic population sizes taken from Furness (2015).

Species	Biogeographic population with connectivity to UK waters (adults and immatures)
Red-throated diver	27,000
Fulmar	8,055,000
Gannet	1,180,000
Cormorant	324,000
Arctic skua	229,000
Great skua	73,000
Puffin	11,840,000
Razorbill	1,707,000
Guillemot	4,125,000
Common tern	248,000
Sandwich tern	148,000
Kittiwake	5,100,000
Black-headed gull	Not in Furness (2015)
Common gull	Not in Furness (2015)

Species	Biogeographic population with connectivity to UK waters (adults and immatures)
Great black-backed gull	235,000
Herring gull	1,098,000
Lesser black-backed gull	864,000
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. Taking 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	-	
	DR	0.82	0.885	0.885	0.885		0.885	0.53	0.124

Species	Para-meter	Survival (age class) 0-1	1-2	2-3	3-4	4-5	Adult	Productivity	Average mortality
Lesser black-backed gull	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
	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 have a combined survival rate from 0 – 2 of 0.441, giving an annual rate of 0. 66.
2 – Razorbill have a combined survival rate from 0 – 2 of 0.63, giving an annual rate of 0.79.
3 – Puffin have 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 4, 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 abundances 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 4, 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 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.

	Biological Season									
Species	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)
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)

Biological Season										
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)
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 The survey area was coincidental with the extent of the SPA component parts, and therefore much of the offshore ECC either overlapped or was directly adjacent to the 'southern' SPA area and relatively close to the 'northern (large)' SPA area (see Volume 4, Annex 4.9: Seabird Distributions Recorded in Aerial Surveys, Figure 2.4.1 for a comparison).

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. Gannet 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
Gannet	429	10
Cormorant	1,140	257

Species	Peak population estimate (individuals)	
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 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 offshore ECC overlaps with part of the Outer Thames Estuary SPA (Volume 4, 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 a separate HRA Screening report. 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 HRA screening report 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 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 VE RIAA.

EVOLUTION OF THE BASELINE

4.7.26 Key drivers of seabird population size in western Europe are 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). In 2022 HPAI 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 aforementioned pressures (see section 4.4: Reference Populations).

4.7.27 Trends in seabird numbers in breeding populations are better known, and better understood than trends in numbers at sea within particular areas. Breeding numbers are regularly monitored at many colonies (JNCC 2016), and in the British Isles there have been three comprehensive censuses of breeding seabirds in 1969-70, 1985-88 and 1998-2002 (Mitchell *et al*. 2004) 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.

4.7.28 Breeding numbers of many seabird species in the British Isles are declining, especially in the northern North Sea (Foster and Marrs 2012; Macdonald *et al*. 2015; JNCC 2016). The most striking exception is gannet, which continues to increase (Murray *et al*. 2015), although the rate of increase has been slowing (Murray *et al*. 2015). These trends in British seabird populations seem likely to continue in the short to medium term future, although for gannet, which has notably been susceptible to the effects of HPAI, the long-term impact on the population trend is unclear.

4.7.29 Climate change has been identified as one of three key threats to UK seabirds and a key cause of recent declines, along with invasive alien species and by-catch in fisheries (Burthe *et al*. 2014; Macdonald *et al*. 2015; Capuzzo *et al*. 2018; Dias *et al*. 2019, Mitchell *et al*. 2020. Pearce-Higgins 2021). 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).

4.7.30 Whilst the results of the current seabird census (Seabirds Count) will provide important information, there is 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). It is therefore highly likely that breeding numbers of most of our seabird species will continue to decline under a scenario with continuing climate change due to increasing levels of greenhouse gases.

4.7.31 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. 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.

4.7.32 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. Gannet numbers may continue to increase for some years, but evidence suggests that this increase is already slowing (Murray *et al*. 2015), 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).

4.7.33 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). 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.

4.7.34 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. 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.

4.7.35 For offshore ornithology, the ecological impact assessment is therefore carried out in a context of declining baseline populations of a number of 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.

4.7.36 Climate change has been identified as the strongest influence 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.

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 in to 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 370 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 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 2, Chapter 1: Offshore Project Description, which is assumed to be implemented for the purposes of this assessment.

Table 4.15: Maximum design scenario for the project alone.

Potential effect	Maximum adverse scenario assessed	Justification
Construction		
Impact 1: Direct disturbance and displacement	<u>**Array Areas:**</u> **WTGs and OSPs:** > <u>Small WTGs:</u> > 79 monopile WTGs with foundation of 13m x 15m, RD of 260m, minimum blade tip height of 28m above MHWS and maximum blade tip height of 320m above MHWS. > <u>Large WTGs:</u>	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 adverse scenario assessed	Justification
	> 41 monopile WTGs with foundation of 15m x 15m, RD of 360m, minimum blade tip height of 28m above MHWS and maximum blade tip height of 420m above MHWS. > 2 monopile OSPs 125m x 100m > Total length of array cables = 200km > Minimum spacing of WTGs = 830m > Minimum spacing of OSPs = 450m > Aviation lighting = up to 2000 cd on WTGs **Vessels:** > WTG and OSP foundation installation vessels (includes tugs and feeders) = 38 peak, 1,359 round trips. > WTG installation vessels (includes tugs and feeders) = 15 peak, 71 round trips. > OSP topside installation vessels (includes tugs and feeders) = 4 peak, 8 round trips. > Commissioning (including accommodation vessels) = 5 peak, 130 round trips. > Other vessels = 15 peak, 2,300 round trips. > Up to 530 round trips, by up to two helicopters. **Offshore ECC:** > Number of export cable circuits = 4 > Total length of export cables = 370km. > Maximum trench width = 1m. > Maximum installation tool seabed disturbance width (jetting) = 18m. > Total area of seabed disturbed by cable installation = 6.66 km^2.	

Potential effect	Maximum adverse scenario assessed	Justification
	> Array cable installation vessels (includes support, cable protection and anchor handling vessels) = 12 peak, 166 round trips. > Export cable installation spreads (includes support, cable protection and anchor handling vessels) = 12 peak, 1,076 round trips. **Construction Programme:** > Programme to occur over five-year period > OSP installation and commissioning = 15 months duration > Offshore ECC installation = 6 months > Foundation installation = 12 months > Array cable installation = 12 months > WTG installation = 9 months > Total offshore construction duration to commissioning = 36 months > 24-hour offshore working will be required, with illumination required on construction vessels during night-time and low light conditions	
Impact 2: Indirect impacts through effects on habitats and prey species	**Temporary subtidal habitat disturbance** The total temporary subtidal habitat disturbance for the array areas and the offshore ECC is fully described in Table 6.10, Volume 2, Chapter 6: Fish and Shellfish Ecology.	See justification within Table 6.10, Volume 2, Chapter 6: Fish and Shellfish Ecology.
Operation		
Impact 3: Direct disturbance and displacement	**Array Areas and Offshore ECC specifications as per Impact 1.** Project lifespan = 24 to 40 years Number of WTG major component replacements requiring JUVs over project lifetime = 284	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

Potential effect	Maximum adverse scenario assessed	Justification
	Number of offshore export cable repairs over project lifetime = 16 Indicative peak vessels on-site simultaneously = 27, with 1,776 round trips annually Up to 125 helicopter return trips per year	will require more vessel and helicopter activity for maintenance reasons.
Impact 4: Indirect impacts through effects on habitats and prey species	**Habitat change of 3,611,128 m² (3.6 km²)** > WTG total structure footprint including scour protection, based on Small WTG layout = 1,313,612 m² > OSP total structure footprint including scour protection, based on two GBS monopile foundations = 81,656 m² > Total area of seabed covered by cable protection (export cables and inter-array) required for cable crossings = 502,260 m² > Total area of seabed covered by cable protection (export cables and inter-array) = 1,428,000 m² > 20% replenishment of scour protection during operation and maintenance phase = 285,600 m² **Total direct disturbance to seabed = 1,090,336 m² (1.09 km²)** > Maximum seabed area impacted for all JUV operations = 554,400 m² > Total seabed area disturbed by array cable replacement through life = 276,656 m² > Total seabed area disturbed by export cable replacement through life = 259,280 m² **Inter-array cables** > Up to 200km of inter-array cable, operating up to 132 kV > Inter-array cable depth = 3.5 m	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 WTGs is also likely to increase the possibility of a pollution incident.

Potential effect	Maximum adverse scenario assessed	Justification
	Offshore export cables > Up to 370km of export cable, operating up to 400 Kv	
Impact 5: Collision risk	> Small WTGs: > 79 monopile WTGs with foundation of 13m x 15m, RD of 260m, minimum blade tip height of 28m above MHWS and maximum blade tip height of 320m above MHWS. > Large WTGs: > 41 monopile WTGs with foundation of 15m x 15m, RD of 360m, minimum blade tip height of 28m above MHWS and maximum blade tip height of 420m 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 Band (2012) model, the Small WTGs has been taken forward for assessment, with the higher annual collision rates predicted for all species.
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

Potential effect	Maximum adverse scenario assessed	Justification
		of prey species. A larger number of WTGs is also likely to increase the possibility of a pollution incident.

4.9 EMBEDDED 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 arrays and offshore ECC, are described separately.

Table 4.16: Embedded mitigation relating to offshore ornithology.

Project phase	Mitigation measures embedded into the project design
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 array areas, and avoidance of these, while minimising overlap with the Outer Thames Estuary SPA as far as possible (Volume 4, 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, and is also likely to reduce displacement effects.
Construction	

Project phase	Mitigation measures embedded into the project design
Construction disturbance	Development of, and adherence to, a Project Environmental Management Plan (PEMP) to reduce direct and indirect disturbance-displacement effects in the array areas and around the offshore ECC.
Construction disturbance	Implementation of a best practice protocol for minimising disturbance to the Outer Thames Estuary SPA (or any other potentially affected designated site) qualifying features during construction and operation, which would comprise restrictions of vessel movements to and from the array areas (including determining best practice on vessel movements through the SPA when red-throated divers are present), and any offshore ECC construction activity within the SPA.
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.
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 of potential impacts below the 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 embedded mitigation that is described in Table 4.16.

IMPACT 1: DIRECT DISTURBANCE AND DISPLACEMENT.

4.10.2 The VE project has the potential to affect bird populations in the marine environment through disturbance due to activity 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 moulting. 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.

4.10.3 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.

4.10.4 Piling to be undertaken 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.

4.10.5 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. Causes of potential disturbance would comprise the presence of construction vessels, helicopters and associated human activity, noise and vibration from construction activities and lighting associated with construction sites. 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.

4.10.6 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. Construction related disturbance and displacement is most likely to affect foraging birds. 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).

4.10.7 Bird species differ in their susceptibility to anthropogenic disturbance and in their responses to noise and visual disturbance stimuli. 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.

4.10.8 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). 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.

4.10.9 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).

4.10.10 Considering variation between species recorded on site in response to disturbance, 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.

4.10.11 There are a number of different measures used to assess bird disturbance and displacement from areas of sea in response to activities associated with an offshore 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.

4.10.12 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).

4.10.13 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 or with a low sensitivity to displacement was screened out of further assessment.

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

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)
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)

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Rationale
Razorbill	Medium	IN	Potentially susceptible to disturbance and abundant in the VE array areas
Guillemot	Medium	IN	Potentially susceptible to disturbance and abundant in the VE array areas
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

4.10.15 Red-throated diver is classified as being of **high sensitivity** to human activities in marine areas, including through 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

4.10.16 The assessment takes account of embedded mitigation in the form of a best practice protocol for minimising construction disturbance of red-throated divers (see Table 4.16, section 4.9).

4.10.17 There is potential for 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 (WTGs, offshore platforms and met mast) 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 16km (c. 17% of the total length), towards the array areas (Volume 4, Annex 4.9: Seabird Distributions Recorded in Aerial Surveys, Figure 2.4.1), although the offshore ECC working corridor width is small.

4.10.18 The worst-case scenario for cable-laying operations would utilise up to 12 vessels on-site at any one time for export cable installation spreads (Table 4.15). This includes support, cable protection and anchor handling vessels. 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.

4.10.19 The greatest potential for the displacement of red-throated divers would lie with the vessels directly 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.

4.10.20 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 cable laying related vessels (or three separate, non-overlapping locations along the offshore ECC route where vessels are congregated). 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

4.10.21 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. This is considered to be a precautionary assessment, based on the assumption that most of the offshore ECC, which is outside of the demarcated SPA, would be suboptimal for red-throated divers and therefore host lower densities than within the SPA.

4.10.22 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 2, Chapter 9: Shipping and Navigation show that over a 14-day period in winter, 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 summer, 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 recreational vessels in summer.

4.10.23 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.

4.10.24 These two surveys, less than two weeks apart, took place within the spring migration period. The considerable range of densities indicates rapid changes in numbers of birds on site, presumably due to turnover of individuals passing through on migration.

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

4.10.26 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/vessel aggregations associated with cable laying operations, which is 37.71km^2 (3 x 12.57km^2). This is considered precautionary because it is unlikely that the three vessels/vessel aggregations would be spaced 2km apart, and so there would most likely be some overlap in displacement areas.

4.10.27 If 100% displacement is assumed to occur within this area, then based on densities of 0.62 – 3.77 birds per km^2 within the SPA, 23 to 142 divers would be displaced at any given time. It is however considered reasonable to assume that 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. 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. The numbers displaced are based on density estimates in the spring migration period, which is likely to be a time of relatively high densities, and also the greatest turnover of individuals as birds pass through the site. Thus, using densities during the spring migration period to estimate the number of birds displaced over the course of an entire winter is highly precautionary.

4.10.28 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.

4.10.29 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.

4.10.30 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.

4.10.31 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 <1 to 14 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 14 birds to this would increase the mortality rate by 0.6%.

4.10.32 For the reasons outlined above, this value is considered to be an overestimate of mortality. This is because (i) 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; (ii) cable laying vessels are likely to be relatively close together and so the overall displacement extent is likely to be lower than a 3 x 2km radius area considered here; and (iii) mortality rates are unlikely to be as high as 10%.

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

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

ARRAY AREAS

4.10.35 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 wind farm peak abundance estimate was three individuals in January.

4.10.36 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 wind farm peak abundance was three individuals in February.

4.10.37 There is potential for disturbance and displacement of red-throated divers due to construction activities, including the construction of wind turbines and other infrastructure (offshore electrical platforms, construction operation and maintenance platforms and meteorological mast) and associated vessel traffic. However, construction will not occur across the whole of the proposed wind turbine array area 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 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).

4.10.38 No red-throated divers were recorded in either array area during the autumn migration or breeding seasons.

4.10.39 During the winter period in the north array, a seasonal density of 0.05/km^2 was estimated (no birds were recorded in the south array). With a highly precautionary 2km radius of disturbance around each of three construction areas (WTGs or other infrastructure), two individual birds (0.05 x 12.56 x 3) could be at risk of displacement, of which the mortality would be <1 bird (0-0.2 birds).

4.10.40 During spring migration in the south array, a peak seasonal density abundance of 0.06/km^2 was estimated. This would result in a similarly low magnitude of impact, with two individuals at risk of displacement, and a mortality of <1 bird.

4.10.41 For the array areas, the estimated number of red-throated divers subject to construction disturbance/displacement throughout the year would be four, with a mortality of <1 bird.

4.10.42 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

4.10.43 Throughout the year, the estimated number of red-throated divers subject to construction disturbance/displacement would be up to 272 (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 15 individuals.

4.10.44 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 15 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

4.10.45 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 1000-2000m, somewhat longer distances than reported by Schwemmer *et al*. (2011).

4.10.46 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.

OFFSHORE EXPORT CABLE CORRIDOR

4.10.47 The species 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).

4.10.48 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 recorded at 0.42 birds/km² in Survey 2 equating to 509 birds (± 95% CI 0 – 1466).

4.10.49 The 'worst case' area from which birds could be displaced was defined as a circle with a 2km radius around each cable laying vessel, 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. If 100% displacement is assumed to occur within this area, then based on densities of 0.07 to 0.23 birds per km^2, 3 to 9 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.

4.10.50 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 one bird (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 so this highly precautionary assessment generates a worst-case impact of **negligible** magnitude (Table 4.6).

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

RAZORBILL

SENSITIVITY

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

MDS IMPACT

4.10.53 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/km^2) and in the south array in March (2.64/km^2). Low densities of razorbills were recorded during the 2018 aerial surveys within the Outer Thames Estuary SPA (Irwin *et al*. 2019) (peak of 60 and 21 individuals in the whole southern and northern (large) SPA areas respectively, Table 4.13), and so the assessment concentrates on the array areas only.

4.10.54 There is potential for disturbance and displacement of razorbills due to construction activities, including the construction of WTGs and other infrastructure (offshore electrical platforms, construction operation and maintenance platforms and meteorological mast) and associated vessel traffic. However, construction will not occur across the whole of the proposed wind turbine array area simultaneously or every day but will be phased and assumed to occur at three discrete locations for the purposes of this assessment. Consequently, 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 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).

4.10.55 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 section 4.11 below).

AUTUMN MIGRATION

4.10.56 During the autumn migration season, with a mean peak density of 1.07/km^2 (north array) and 0.28/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. 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.

4.10.57 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 significance of effect is **minor adverse** in EIA terms.

WINTER

4.10.58 During the winter period, at a mean peak density of 4.34/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. 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.

4.10.59 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 significance of effect is **minor adverse** in EIA terms.

SPRING MIGRATION

4.10.60 During the spring migration season, at a mean peak density of 2.97/km^2 (north array) and 2.64/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.

4.10.61 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 significance of effect is **minor adverse** in EIA terms.

BREEDING SEASON

4.10.62 During the breeding season, the maximum mean peak density was 0.21/km^2 (north array) and 0.23/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.

4.10.63 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).

4.10.64 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 may be estimated as 43% of the total wintering BDMPS population (Furness 2015). This gives a breeding season population of 94,007 (BDMPS for the UK North Sea and Channel, 218,622 x 43%).

4.10.65 Based on the average mortality for the species, a total of 16,357 birds would be expected to die each year from the sub-adult component of the winter BDMPS for this species (94,007; Furness 2015). 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%. (Use of the average mortality produces a conservative estimate of % change, as the mortality of birds less than two years old is higher than (survival rates are lower than) that of adult birds, Table 4.11). This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable.

4.10.66 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 significance of effect is **minor adverse** in EIA terms.

YEAR ROUND

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

4.10.68 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** in EIA terms.

GUILLEMOT

SENSITIVITY

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

MDS IMPACT

4.10.70 Guillemots were recorded in the array areas year-round, with abundance estimates peaking at 326 in the north array in March, and 1,413 in the south array in February, and being at their lowest from June to August (e.g. no records from both array areas in August).

4.10.71 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 vessels are operating at any given point and not the entire array areas.

4.10.72 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 section 4.11 below).

NON-BREEDING

4.10.73 During the nonbreeding season, at a mean peak density of 4.67/km^2 (north array) and 23.1/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. 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; UK North Sea and English Channel, Furness 2015). The addition of 8-87 birds to this would increase the mortality rate by up to 0.03%. 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 guillemot is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

BREEDING

4.10.75 During the breeding season, the maximum mean peak density in the array areas was 4.88/km^2 (north array) and 3.14/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 2-22 birds would be expected.

4.10.76 The mean maximum foraging range for breeding guillemot is 73km (Woodward *et al*, 2019) which places the array areas considerably beyond the range of any guillemot breeding colonies. The nearest breeding colony is Flamborough Head, 275km from the array areas (the minimum distance to the Flamborough and Filey Coast SPA, Table 4.14).

4.10.77 On the basis of the above evidence, it can be stated with confidence that there are no major breeding colonies for guillemot within foraging range of the array areas, therefore 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 number of sub-adult birds in the relevant population during the breeding season may be estimated as 43% (the proportion of the wintering BDMPS population that is immature, Furness 2015). This gives a breeding season population of 695,441 (BDMPS for the UK North Sea and English Channel, 1,617,306 x 43%).

4.10.78 Based on the average mortality for the species of 0.14, a total of 97,362 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 22 birds from construction disturbance and displacement would increase the mortality rate by 0.02%. (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). This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable.

4.10.79 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 impact significance is **minor adverse**.

YEAR ROUND

4.10.80 The estimated number of guillemots subject to construction disturbance/ displacement mortality throughout the year is between 10 and 109 individuals.

4.10.81 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 109 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 effect is assessed as **negligible**. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

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

4.10.82 Indirect disturbance and displacement of birds may occur during the construction phase if there are impacts on prey species and the habitats of prey species. These indirect effects include those resulting from the production of underwater noise (e.g. during piling) and the generation of suspended sediments (e.g. during preparation of the sea bed for foundations) that may alter the behaviour or availability of bird prey species. Underwater noise may cause fish and mobile invertebrates to avoid the construction area and also affect their physiology and behaviour. Suspended sediments may cause fish and mobile invertebrates to avoid the construction area and may smother and hide immobile benthic prey. These mechanisms may result in less prey being available within the construction area to foraging seabirds. Such potential effects on benthic invertebrates and fish have been assessed in Volume 2, Chapter 5: Benthic and Intertidal Ecology and Volume 2, Chapter 6: Fish and Shellfish Ecology and the conclusions of those assessments inform this assessment of indirect effects on IOFs.

4.10.83 With regard to noise impacts on fish, Volume 2, Chapter 6: Fish and Shellfish Ecology assesses the potential impacts upon fish relevant to ornithology as prey species of IOFs. 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). The chapter 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. This means that fish in close proximity will move outside the impact range before noise levels reach a level likely to cause irreversible injury.

4.10.84 Underwater noise impacts (death, physical injury or behavioural changes) during construction are considered to be minor adverse at worst for all prey species. It is concluded that the indirect impact significance on seabirds 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.

4.10.85 With regard to changes to the seabed and to suspended sediment levels, Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 2, Chapter 5: Benthic and Intertidal Ecology discusses 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 VE arrays, short-term duration (as it is limited to the duration of construction activities), intermittent and with high reversibility.

4.10.86 Prey species such as herring and sandeel are demersal spawners and may be subject to temporary localised increases in suspended sediment concentration and associated sediment deposition and smothering from foundation and cable installation works and seabed preparation works (including sandwave clearance).

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

4.10.88 Impacts from increased suspended sediment concentration and sediment deposition are considered to be of greater concern for herring eggs. The VE site boundary has 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 effects 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.

4.10.89 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. For all prey species, a minor adverse effect was predicted in Volume 2, Chapter 6 Fish and Shellfish Ecology. With regard to changes to the seabed and to suspended sediment levels, Volume 2, Chapter 2: Marine Geology, Oceanography and Physical Processes and Volume 2, Chapter 5: Benthic and Intertidal Ecology discusses 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 VE arrays, 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 such as gannet and auks.

4.10.90 It is concluded that the indirect impact 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.

4.11 ENVIRONMENTAL ASSESSMENT: OPERATIONAL PHASE

IMPACT 3: DIRECT DISTURBANCE AND DISPLACEMENT

4.11.1 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 is assessed 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 certain species of birds.

4.11.2 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. Displacement is apparently stronger when wind turbines are rotating. 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.

4.11.3 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. A review by Furness (2018) 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.

4.11.4 There is 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).

4.11.5 The assessment below is based on a guidance note on displacement from the UK Statutory Nature Conservation Bodies (SNCB 2022).

4.11.6 Displacement is defined as 'a reduced number of birds occurring within or immediately adjacent to an offshore windfarm' (Furness *et al*. 2013) and involves birds present in the air and on the water (SNCB 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 2022).

4.11.7 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. Birds that are resident in an area 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.

4.11.8 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. Therefore, in this assessment the effects of displacement and barrier effects on the key resident species are considered together.

4.11.9 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, and 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.

4.11.10 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 16 repairs during 40-year lifespan of project, see MDS, Table 4.15) temporary and localised, and likely of lower magnitude than during construction, and are unlikely to result in detectable effects at either the local or regional population level. Therefore, no impact due to cable operation and maintenance is predicted, and this affect is scoped out, as per consultation agreements (Table 4.2).

4.11.11 The focus of this section is therefore 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 MDS outlined in Table 4.15.

4.11.12 The methodology presented in the updated SNCB Advice Note (SNCB 2022) 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. SPA or BDMPS) to determine the magnitude of effect.

4.11.13 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 4.18). The species identified as at risk were then assessed within the biological seasons within 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. Displacement rates (based on observations of macro-avoidance, that is avoidance at the level of the whole windfarm rather than the wind turbine) 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).

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
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

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Season(s)	Rationale
				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
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

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Season(s)	Rationale
				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
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)				

4.11.14 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 4, 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. As per the SNCB (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.

4.11.15 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). The small risk of impact to migrating birds is better considered in terms of barrier effects. However, SNCB (2022) suggests that migration periods should also be assessed using the matrix approach and this has been undertaken where appropriate.

4.11.16 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.

4.11.17 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.

4.11.18 Demographic rates for each species from Horswill and Robinson (2015) were entered into a matrix population model. This was used to calculate the expected proportions in each age class. To obtain robust stable age class distributions for less well studied species (e.g., divers) the rates were modified to obtain a stable population size. Each age class survival rate was multiplied by its proportion and the total for all ages summed to give the average survival rate for all ages. Taking 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 4.20.

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)	-

Species	Area considered for displacement	Breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
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 number of birds recorded in the overlapping period (March 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 (south 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.

		Age class							
Species	Parameter	0-1	1-2	2-3	3-4	4-5	Adult	Productivity	Average mortality
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

Species	Parameter	Age class 0-1	1-2	2-3	3-4	4-5	Adult	Productivity	Average mortality
	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	-	-

4.11.19 Natural England advice is 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

4.11.20 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).

4.11.21 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). 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. 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. 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).

4.11.22 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. 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.

4.11.23 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).

4.11.24 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).

4.11.25 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).

4.11.26 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).

4.11.27 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.

4.11.28 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).

4.11.29 Natural England has advised 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, and a mortality rate of up to 10% for displaced birds.

4.11.30 The assessment below follows this advice. 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.

4.11.31 At VE, the largest numbers of red-throated divers were recorded during the spring migration period, at which time 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 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 effects 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.

4.11.32 The displacement matrices in Table 4.21 through 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 2022). The windfarm site is 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

4.11.33 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 0-10% 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 0 individuals (Table 4.21). This would not increase the background mortality rate of the autumn BDMPS for red-throated diver (13,277; Furness, 2015).

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

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

4.11.35 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 north and south array areas 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).

4.11.36 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 impact significance is **minor adverse**.

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

Midwinter	Mortality rate										
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

4.11.37 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.

4.11.38 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 during the spring migration period (including the breeding season) has been estimated as 0-4 individuals (Table 4.24 and Table 4.25). The BDMPS for red-throated diver in spring is 13,277 (Furness, 2015).

4.11.39 At an average mortality rate of 0.228, the number of individuals expected to die in the spring BDMPS is 3,027 (13,277 x 0.228). The addition of a maximum of four to this 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. 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 significance is **minor adverse**.

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	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	9
	50%	0	0	0	0	1	1	2	4	6	9	12
	60%	0	0	0	1	1	1	3	4	7	11	14

Spring migration		Mortality rate										
	70%	0	0	0	1	1	2	3	5	8	13	17
	80%	0	0	1	1	1	2	4	6	9	15	19
	90%	0	0	1	1	1	2	4	6	11	17	21
	100%	0	0	1	1	1	2	5	7	12	19	24

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	1	1	2	2
	20%	0	0	0	0	0	0	1	1	2	3	4
	30%	0	0	0	0	0	1	1	2	3	5	6
	40%	0	0	0	0	0	1	2	2	4	6	8
	50%	0	0	0	0	1	1	2	3	5	8	10
	60%	0	0	0	0	1	1	2	4	6	10	12
	70%	0	0	0	1	1	1	3	4	7	11	14
	80%	0	0	0	1	1	2	3	5	8	13	16
	90%	0	0	1	1	1	2	4	5	9	15	18
	100%	0	0	1	1	1	2	4	6	10	16	20

YEAR ROUND

4.11.40 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 0-10%, would be 0-6 (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). The biogeographic red-throated diver population with connectivity to UK waters is 27,000 (Furness 2015).

4.11.41 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 0-6 to this increases the mortality rate by 0-0.1%. 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 impact significance is **minor adverse**.

GANNET

SENSITIVITY

4.11.42 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 (medium) sensitivity to displacement from structures such as offshore WTGs (Wade *et al*. 2016) and on this basis SNCB (2022) indicates that a detailed assessment of potential displacement should be carried out as standard.

4.11.43 Cook *et al*. (2018) review a number of studies of displacement of gannets from offshore windfarms. Where quantified, macro-avoidance rates (the % 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).

4.11.44 Displacement effects 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 recommendations within the SNCB (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).

4.11.45 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, 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

4.11.46 Based on displacement rates of 60% to 80% and mortality rates of 0-1%, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from both array areas during the autumn migration period has been estimated as five individuals (cells highlighted in Table 4.26 and Table 4.27).

4.11.47 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 significance is **minor adverse** at worst.

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

4.11.48 Within the range of 60-80% displacement and 0-1% 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).

4.11.49 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 impact significance is negligible.

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

4.11.50 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).

4.11.51 On a precautionary basis, predicted displacement mortality of gannet during the breeding season has been compared to the Flamborough and Filey Coast SPA reference population. The SPA population at designation was 11,061 pairs, with a count of 13,125 pairs in 2022 (Clarkson *et al*. 2022). These equate to total population sizes of approximately 40,222 and 47,272 (designated and 2022 count respectively; calculated as individuals and multiplied up to include subadult birds, based on the adult proportion of 0.55 from Furness 2015). The 2022 estimate of total numbers of individuals (breeding and non-breeding/sub-adult birds) has been used as a reference population, being closer in time to baseline surveys.

4.11.52 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 9,029 (47,272 x 0.191). The addition of a maximum of two 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 spring migration period, the magnitude of impact is assessed as **negligible**. As the species is of low to medium sensitivity to displacement, the effect significance is **minor adverse** at worst.

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

4.11.53 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 0-1%, 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).

4.11.54 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 10 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 significance is **minor adverse** at worst.

AUKS (RAZORBILL AND GUILLEMOT)

SENSITIVITY

4.11.55 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).

4.11.56 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).

4.11.57 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).

4.11.58 Following statutory guidance (SNCB 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.

4.11.59 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.

4.11.60 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).

4.11.61 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.

4.11.62 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.

4.11.63 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 695,441 guillemots (BDMPS for the UK North Sea and Channel, 1,617,306 x 43%), and 94,007 razorbills (BDMPS for the UK North Sea and Channel, 218,622 x 43%). 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.

RAZORBILL

AUTUMN MIGRATION

4.11.64 The estimated number of razorbills subject to mortality during the autumn migration period due to displacement from the VE array areas is between zero and 20 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, Table 4.32 and Table 4.33). The BDMPS for the UK North Sea and Channel is 591,874 (Furness 2015).

4.11.65 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 significance is **minor adverse**.

Table 4.32: 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

Autumn migration		Mortality rate										
	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 4.33: 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

4.11.66 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 4.34 and Table 4.35). The BDMPS for the UK North Sea and Channel is 218,622 (Furness 2015).

4.11.67 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 significance is **minor adverse**.

Table 4.34: North array displacement matrix for razorbill during the winter period.

Winter		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	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 4.35: South array displacement matrix for razorbill during the winter period.

Winter		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	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
	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

4.11.68 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 4.36 and Table 4.37). The BDMPS for the UK North Sea and Channel is 591,874 (Furness 2015).

4.11.69 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 significance is **minor adverse**.

Table 4.36: 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 4.37: South 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%	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

Spring migration	Mortality rate										
100%	3	5	8	10	13	25	51	76	127	203	254

BREEDING SEASON

4.11.70 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 4.38 and Table 4.39). The BDMPS is 94,007 non-breeding individuals (see paragraph 213 above).

4.11.71 At the average baseline mortality rate for razorbill of 0.174, the number of individuals expected to die in the breeding season is 16,357 (94,007 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 significance is **minor adverse**.

Table 4.38: 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
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 4.39: South 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	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

Breeding		Mortality rate										
	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

4.11.72 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 4.32 through Table 4.39).

4.11.73 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 significance is **minor adverse**.

GUILLEMOT

NON-BREEDING

4.11.74 The estimated number of guillemots subject to mortality during the non-breeding period due to displacement from the VE array areas is between 11 and 258 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, Table 4.40 and Table 4.41). The BDMPS for the UK North Sea and Channel is 1,617,306 (Furness 2015).

4.11.75 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 significance is **minor adverse**.

Table 4.40: North array displacement matrix for guillemot during the non-breeding period.

Non-breeding	Mortality rate										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
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 4.41: South array displacement matrix for guillemot during the non-breeding period.

Non-breeding	Mortality rate										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
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

4.11.76 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 4.42 and Table 4.43). The BDMPS is 695,441 non-breeding individuals (see paragraph 213 above).

4.11.77 At the average baseline mortality rate for guillemot of 0.140, the number of individuals expected to die in the breeding season is 97,362 (695,441 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 significance is **minor adverse**.

Table 4.42: 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 4.43: 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
	90%	4	8	11	15	19	38	76	115	191	305	382

Breeding	Mortality rate										
	100%	4	8	13	17	21	42	85	127	212	339	424

YEAR ROUND

4.11.78 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 4.40 through Table 4.43).

4.11.79 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 significance is **minor adverse**.

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

4.11.80 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 the habitats of prey species. These indirect effects include those resulting from the production of underwater noise (e.g. the turning of the WTGs), electro-magnetic fields (EMF) 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 also 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. 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 is presented in Table 4.15.

4.11.81 With regard to noise impacts on fish, Volume 2, Chapter 6: Fish and Shellfish Ecology discusses the potential impacts upon fish relevant to IOFs as prey species. With regard to behavioural changes related to underwater noise impacts on fish during the operation of the proposed VE project, Volume 2, Chapter 6 Fish and Shellfish Ecology concludes that the effects on fish and shellfish species to operational noise is considered to of minor adverse significance. With a non-significant unmitigated effect on fish that are bird prey species, 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 of **negligible or minor adverse** significance, occurring over a very limited extent compared to overall foraging areas.

4.11.82 With regard to changes to the seabed and to suspended sediment levels, Volume 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. With unmitigated negligible effects on benthic habitats and species, it can be concluded that the indirect impact on seabirds occurring in or around the array areas and offshore ECC during the operational phase is similarly a **negligible or minor adverse** effect.

4.11.83 With regard to EMF effects, 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 and offshore ECC during the operational phase is similarly a **negligible or minor adverse** effect.

4.11.84 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 wider scale (**negligible or minor adverse** significance).

IMPACT 5: COLLISION RISK

4.11.85 Birds flying through the wind turbine arrays of offshore windfarms may collide with rotor blades. This would result in fatality or injury to birds which fly through the VE array areas, during migration, whilst foraging for food, or commuting between breeding sites and foraging areas.

4.11.86 Modelling has been undertaken in this assessment to estimate the risk to birds associated with the VE array areas. The Band model (Band 2012) CRM has been used to produce predictions of collision rates for particular species across biological seasons and annually. The approach to CRM is summarised here and further details are provided in Volume 4, Annex 4.8: Collision Risk Modelling Inputs and Outputs.

4.11.87 The assessment is based on collision risk for each key seabird species from the Band CRM Option 2. 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).

4.11.88 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, Volume 4, Annex 4.8: Collision Risk Modelling Inputs and Outputs) and the 41 Large WTG scenario (turbine parameter set 2).

4.11.89 CRM has been run using the deterministic Band model (Band 2012), incorporating uncertainty in flight densities by estimating collisions using the mean values and upper and lower 95% confidence intervals. While other model parameters can also be adjusted across ranges of values to provide further estimates of uncertainty, variation in flight density typically accounts for the largest component of overall variation (by some margin) and thus only this parameter has been varied in the current assessment. Avoidance rates and Nocturnal Activity Factors (NAF) used for CRM were the upper values of those advised by Natural England[3] (Table 4.44); and proportions at collision height (based on the generic dataset in Johnston *et al*. 2014a, 2014b).

4.11.90 The input parameters and complete CRM results are provided in Volume 4, Annex 4.8: Collision Risk Modelling Inputs and Outputs.

Table 4.44: Parameters used in CRM.

<table>
<tr><th>Species</th><th>Avoidance Rate</th><th>Standard Deviation (SD)</th><th>Nocturnal activity factor (1 to 5 / %)</th></tr>
<tr><td>Black-headed gull</td><td>99.5</td><td>0.2%</td><td>3 / 50%</td></tr>
<tr><td>Common gull</td><td>99.5</td><td>0.2%</td><td>3 / 50%</td></tr>
<tr><td>Common tern</td><td>99.0</td><td>0.2%</td><td>5 / 100%</td></tr>
<tr><td>Fulmar</td><td>99.0</td><td>0.2%</td><td>4 / 75%</td></tr>
<tr><td rowspan="2">Gannet*</td><td>99.72</td><td rowspan="2">0.2%</td><td rowspan="2">1.32 / 8%</td></tr>
<tr><td>99.88</td></tr>
<tr><td rowspan="2">Great black-backed gull</td><td rowspan="2">99.4</td><td rowspan="2">0.1%</td><td>3 / 50%</td></tr>
<tr><td>2 / 25%</td></tr>
<tr><td>Great skua</td><td>99.0</td><td>0.2%</td><td>1 / 0%</td></tr>
<tr><td rowspan="2">Herring gull</td><td rowspan="2">99.4</td><td rowspan="2">0.1%</td><td>3 / 50%</td></tr>
<tr><td>2 / 25%</td></tr>
<tr><td rowspan="2">Kittiwake</td><td rowspan="2">99.2</td><td rowspan="2">0.2%</td><td>3 / 50%</td></tr>
<tr><td>2 / 25%</td></tr>
<tr><td rowspan="2">Lesser black-backed gull</td><td rowspan="2">99.4</td><td rowspan="2">0.1%</td><td>3 / 50%</td></tr>
<tr><td>2 / 25%</td></tr>
<tr><td>Little gull</td><td>99.5</td><td>0.2%</td><td>2 / 50%</td></tr>
<tr><td>Sandwich tern</td><td>99.0</td><td>0.2%</td><td>5 / 100%</td></tr>
</table>

[3] Interim advice on updated Collision Risk Modelling parameters (July 2022), which updates the SNCB (JNCC *et al*. 2014) guidance on CRM

*Following Natural England (2022a) interim advice on CRM, macro-avoidance has been accounted for by a 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, in the interim NE advise the use of a range of macro avoidance rates between 65% - 85% or a single rate of 70%.

4.11.91 The nocturnal activity parameter (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.

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

4.11.93 Seasonal mortality predictions have been compared to the relevant BDMPS populations and the predicted increase in background mortality which could result has been estimated.

4.11.94 The full CRM results for the proposed project are presented in Volume 4, Annex 4.8: Collision Risk Modelling Inputs and Outputs. The following sections provide a summary of the outputs for assessment, using the seasons defined in Table 4.9. An overview of annual collision risk estimates for all species (using the deterministic Band model Option 2) are presented in Table 4.45 for the Small and Large WTG scenarios. This table includes a range of estimates for species where CRM was run for variations in nocturnal activity, and for gannet, macro-avoidance rate.

Table 4.45: 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)

Species (sensitivity to collision)	Model run type (NAF = Nocturnal Avoidance Factor)	79 Small WTG Scenario	41 Large WTG Scenario
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)

4.11.95 The annual collision risk estimates presented in Table 4.45 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 Small WTG scenario.

4.11.96 Each species was assigned a sensitivity rating for collision risk, based on available data on the % 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).

4.11.97 Most species had very low predicted annual collision risks within the combined VE array areas (i.e. worst case mean prediction was below approximately five birds per year; Table 4.45). As the magnitudes of predicted impact were so small, even for the worst case, no further assessment is considered necessary for these species (although additional outputs for these species are provided in Volume 4, Annex 4.8: Collision Risk Modelling Inputs and Outputs) and **negligible or minor adverse** significance of effects are predicted.

4.11.98 The species scoped in to 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 risks 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 at the request of Natural England (see section 4.13).

4.11.99 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. Herring gull was scoped in, based on the request of Natural England for other southern North Sea offshore windfarms, to ensure that this species was carried through to the cumulative assessment for collision risk. This was also the case for great-black backed gull.

4.11.100 The seasonal collision estimates for species scoped in to the collision risk assessment are presented in Table 4.46. The collision risk assessment uses the outputs for the worst-case, Small WTG scenario, calculated using CRM option 2. The mean results (and 95% confidence intervals) have been used in the assessment. For all species these encompass all or most of the variation in different CRM run scenarios varying nocturnal activity (and in the case of gannet, macro-avoidance rate).

4.11.101 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 reference populations calculated as described in the assessment for a given species.

Table 4.46: Seasonal Collision Risk Estimates. Values are the Mean Number of predicted collisions.

Species	Array	Breeding season	Autumn migration	Non-breeding/ Winter	Spring migration	Annual
Gannet	North	0.77 (0-1.76)	1.30 (0-2.81)	-	0.04 (0-0.13)	2.12 (0.1-4.71)
	South	1.63 (0.11-3.71)	1.37 (0.25-2.68)	-	0.24 (0-0.64)	3.24 (0.36-7.04)
Great black-backed gull	North	0.68 (0-2.05)	-	1.17 (0-3.53)	0.59 (0-1.78)	1.86 (0-5.57)
	South	0.57 (0-1.70)	-	0.88 (0-2.65)	0.45 (0-1.35)	1.45 (0-4.35)
Herring gull	North	0.69 (0-1.39)	-	0.52 (0-1.57)	-	1.21 (0-2.96)
	South	-	1.00 (0-3.01)	-	-	1.00 (0-3.01)
Kittiwake	North	4.93 (0.53-10.33)	2.68 (0.22-6.74)	-	2.28 (0-5.18)	9.88 (0.74-22.26)

Species	Array	Breeding season	Autumn migration	Non-breeding/ Winter	Spring migration	Annual
	South	9.83 (0.83-22.24)	7.62 (1.83-14.15)	-	4.89 (1.05-9.08)	22.34 (3.71-45.46)
Lesser black-backed gull	North	24.51 (0-63.31)	0.49 (0-1.46)	0.44 (0-1.33)	-	25.44 (0-66.10)
	South	11.25 (0-30.91)	1.73 (0-5.20)	2.22 (0-6.66)	0.83 (0-2.48)	16.03 (0-45.24)

BREEDING SEASON REFERENCE POPULATIONS FOR COLLISION ASSESSMENT

GANNET

4.11.102 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 315km (Woodward *et al*. 2019). However, tracking studies of gannets from Bempton Cliffs during 2010-2012 suggest very little, if any, use of the VE array areas during the breeding season (Langston *et al*. 2013).

4.11.103 Nonetheless, on a precautionary basis, additional mortality of gannet during the breeding season has been assessed in relation to the Flamborough and Filey Coast SPA reference population. The SPA population at designation was 11,061 pairs, increasing to 13,392 pairs by 2017 (Aitken *et al*. 2017). These equate to total population sizes of approximately 40,222 and 48,698 (designated and 2017 count respectively; calculated as individuals and multiplied up to include subadult birds, based on the adult proportion of 0.55 from Furness 2015). The 2017 estimate of total numbers of individuals (breeding and non-breeding/sub-adult birds) has been used as a reference population, being closer in time to baseline surveys.

KITTIWAKE

4.11.104 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.

4.11.105 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, based on 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.

4.11.106 Consequently, the breeding season impact on kittiwake has been assessed against a reference population estimated using the same approach as that for 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 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. This can be calculated as 47.3% of the spring migration BDMPS population (Furness 2015). This yields a breeding season reference population of 296,956 (Spring BDMPS for the UK North Sea and Channel, 627,816 x 47.3%).

LESSER BLACK-BACKED GULL

4.11.107 Lesser black-backed gulls breed at the Alde-Ore Estuary SPA on the Suffolk coast, which is within the 127km mean 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.

4.11.108 The Alde-Ore SPA lesser black-backed gull breeding population has been 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 count in 2020 of 1,775 pairs (Green *et al*. 2021)).

4.11.109 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.

4.11.110 An estimated breeding season reference population of 9,694 individuals of all age classes has been identified for this species in relation to VE project (VE RIAA). 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.

4.11.111 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 colour-ring and tracking studies which indicate that breeding lesser black-backed gulls from the Netherlands normally remain on the continental side of the North Sea.

HERRING GULL

4.11.112 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 and December only (Volume 4, Annex 4.8), suggesting that herring gulls pass through the VE array areas only occasionally, and outside of the main breeding season.

4.11.113 The most recent colony count available within the Alde-Ore Estuary SPA was 549 herring gull pairs in 2020 (Green *et al*. 2021) which suggests that the total population (all age classes) associated with the SPA is around 2,287 individuals (assuming adults comprise 48% of the population, Furness 2015). This is taken as a precautionary reference population, assuming birds present are from the SPA.

GREAT BLACK-BACKED GULL

4.11.114 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 the Impact 3 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 can be calculated as 57.8% of the nonbreeding BDMPS populations of great black-backed gull (Furness 2015). This yields a breeding season population of nonbreeding great black-backed gull of 52,829 (nonbreeding BDMPS for the UK North Sea and Channel, 91,399 x 57.8%). This value has also been used as the reference population for the spring migration period.

NONBREEDING SEASON REFERENCE POPULATIONS FOR COLLISION ASSESSMENT

4.11.115 As advised by Natural England, the non-breeding season reference populations were taken from Furness (2015).

COLLISION IMPACTS

4.11.116 The impacts of 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.

4.11.117 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 rates were entered into a matrix population model to calculate the expected proportions in each age class. For each age class, the survival rate was multiplied by its proportion and the total for all ages summed to give the average survival rate for all ages. Taking this value away 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 4.47.

Table 4.47: 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		

4.11.118 The percentage increases in background mortality rates of seasonal and annual populations due to predicted collisions with the VE WTGs are shown in Table 4.48 for all species using avoidance rates recommended by Natural England (Table 4.44).

4.11.119 The mean and upper 95% confidence interval collision predictions for all species in all seasons and also summed across the year resulted in increases in background mortality of up to 0.42% (for lesser black-backed gull) or less, when comparing against relevant annual BDMPS and biogeographic populations. For lesser black-backed gull, an increase in breeding season background mortality of 2.9% is predicted, which is considered within the context of the Alde-Ore Estuary SPA population in the VE RIAA.

4.11.120 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 effect significances of **minor adverse**.

Table 4.48: 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 deterministic 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	48,698			296,956			9,694			2,287			52,829		
	Seasonal mortality	2.4	0.11	5.48	14.76	1.36	32.56	35.76	0	94.22	0.69	0	1.39	1.25	0	3.75
	Increase in background mortality (%)	0.026	0.001	0.059	0.032	0.003	0.070	2.928	0	7.714	0.175	0	0.353	0.013	0	0.038
Autumn	Reference population	456,298			829,937			209,007			466,511			N/A		
	Seasonal mortality	2.68	0.35	5.49	10.31	2.05	20.88	2.22	0	6.65	1	0	3.01	0	0	0
	Increase in background mortality (%)	0.003	0.000	0.006	0.008	0.002	0.016	0.008	0	0.025	0.001	0	0.004	0	0	0
	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	0	0	0	0	0	0	2.66	0	7.99	1.52	0	4.58	2.06	0	6.17
	Increase in background mortality (%)	0	0	0	0	0	0	0.054	0	0.161	0.002	0	0.006	0.012	0	0.036
Spring	Reference population	248,835			627,816			197,483			N/A			52,829		
	Seasonal mortality	0.28	0	0.77	7.16	1.05	14.26	0.83	0	2.48	0	0	0	1.04	0	3.12
	Increase in background mortality (%)	0.001	0	0.002	0.007	0.001	0.015	0.003	0	0.010	0	0	0	0.011	0	0.032
Annual largest BDMPS	Reference population	456,298			829,937			209,007			466,511			91,399		
	Seasonal mortality	5.36	0.46	11.75	32.22	4.45	67.72	41.47	0	111.35	2.21	0	5.97	3.31	0	9.92
	Increase in background mortality (%)	0.006	0.001	0.013	0.025	0.003	0.052	0.157	0	0.423	0.003	0	0.007	0.020	0	0.059
Annual biogeo-graphic	Reference population	1,180,000			5,100,000			854,000			1,098,000			235,000		
	Seasonal mortality	5.36	0.46	11.75	32.22	4.45	67.72	41.47	0	111.35	2.21	0	5.97	3.31	0	9.92
	Increase in background mortality (%)	0.002	<0.001	0.005	0.004	0.001	0.009	0.039	0	0.103	0.001	0	0.003	0.008	0	0.023

IMPACT 6: COMBINED OPERATIONAL COLLISION RISK AND DISPLACEMENT

GANNET

4.11.121 Being the only species that has been scoped in for 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 collision risk monitoring, 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.

4.11.122 As noted above (Table 4.47), the estimated annual gannet collision mortality associated with VE is 5.36 (0.46-11.75). 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).

4.11.123 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.

4.11.124 Thus, the combined impact of displacement and collision risk on gannet would be of negligible magnitude and the significance of effect for a feature of medium sensitivity would be **minor adverse**.

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 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 relevant bird species in the construction section above and have been found to be of negligible to minor negative 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 species of low to high sensitivity to disturbance is of **negligible or minor adverse** significance.

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 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 species of low to high sensitivity to disturbance is of **negligible or minor adverse** significance.

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 1, Annex 3.1: Cumulative Effects Assessment Methodology.

4.13.2 The methodology will also be aligned with 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 recent consent decisions. It also follows the approach set out in guidance from the Planning Inspectorate (2019) and from the renewables industry (RenewableUK 2013) and The Crown Estate (2019).

4.13.3 Wherever possible the cumulative assessment is quantitative (i.e. where data in an appropriate format have been obtained). However, the level of data available and the ease with which impacts can be combined across the windfarms is quite variable, reflecting the availability of relevant data for older projects and the approach to assessment taken. Where this has not been possible (e.g. for older projects), a qualitative assessment has been undertaken.

SCREENING FOR CUMULATIVE EFFECTS

4.13.4 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 4.49 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 4.49: Screening for Potential Cumulative Effects.

Impact	Potential for cumulative impact	Data confidence[1]	Rationale
Construction			
Impact 1: Direct disturbance and displacement:	Yes	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	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 5: Collision risk	Yes	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.

Impact	Potential for cumulative impact	Data confidence[1]	Rationale
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

4.13.5 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 North Sea, the cumulative effect assessment technical note submitted through the EIA Evidence Plan (Volume 1, Annex 3.1: Cumulative Effects Assessment Methodology of this PEIR) screened in a number of projects and plans as presented in Table 4.51.

4.13.6 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.

4.13.7 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. 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. 2km radius around cable laying vessels.

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

4.13.9 The identification of offshore windfarms to include in the cumulative assessment of offshore ornithological receptors has been based on:

- Approved plans;
- Constructed projects;
- Approved but as yet unconstructed projects; and
- Projects for which an application has been made, are currently under consideration, have reached PEIR stage and may be consented before the VE project.

4.13.10 For other ‘foreseeable’ projects, i.e., those for which an application has not been made but have been the subject of consultation by the developer, or those are listed in plans that have clear delivery mechanisms, the absence of robust or relevant data could preclude a quantitative cumulative assessment being carried out.

4.13.11 The windfarms listed in Table 4.51 have been assigned to three Tiers (see Table 4.50 below and Volume 1, Annex 3.1: Cumulative Effects Assessment Methodology).

4.13.12 The level of data available and the ease with which impacts can be combined across the windfarms is quite variable, reflecting the availability of relevant data for older projects and the approach to assessment taken. Wherever possible the cumulative assessment is quantitative (i.e. where data in an appropriate format have been obtained). Where this has not been possible (e.g. for older projects) a qualitative assessment has been undertaken.

4.13.13 Projects that would be Tier 2 by having reached scoping stage but not yet PEIR stage (at the time of writing, Dogger Bank South and Outer Dowsing offshore windfarms) have been excluded due to a lack of sufficient available data. Berwick Bank, now at Tier 1 application stage, has also been excluded due to time constraints. It is proposed that these three projects will be included in the EIA’s cumulative assessment.

4.13.14 The windfarms listed in Table 4.51 have been assigned to four Tiers see Table 4.50 below and Volume 1, Annex 3.1: Cumulative Effects Assessment Methodology.

Table 4.50: Description of Tiers of other developments considered for CEA.

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

Table 4.51: Projects considered within the offshore ornithology cumulative effect assessment.

Tier	Project	Distance to Array Area (km)	Distance to Offshore ECC (km)
1	Beatrice	759	752
1	Beatrice Demonstrator	c.750	c.750
1	Blyth Demonstration Project	416	404
1	Dudgeon	143	146
1	East Anglia ONE	20	27
1	European Offshore Wind Deployment Centre (Aberdeen Bay)	638	631
1	Galloper	0	0
1	Greater Gabbard	3	1
1	Gunfleet Sands	52	6

Tier	Project	Distance to Array Area (km)	Distance to Offshore ECC (km)
1	Hornsea Project One	23	209
1	Humber Gateway	218	206
1	Hywind	649	645
1	Kentish Flats	71	37
1	Kentish Flats Extension	71	39
1	Kincardine	611	604
1	Lincs	167	152
1	London Array	35	14
1	Lynn and Inner Dowsing	168	152
1	Methil	574	559
1	Moray Firth (EDA)	746	740
1	Race Bank	160	152
1	Rampion	195	157
1	Scroby Sands	74	80
1	Sheringham Shoal	137	134
1	Teesside	363	349
1	Thanet	43	36
1	Westermost Rough	138	226
1	Dogger Bank Creyke Beck Projects A and B	296	302
1	Firth of Forth Alpha and Bravo	557	550
1	Hornsea Project Two	207	214
1	Neart na Gaoithe	546	535
1	Triton Knoll	174	170
1	Dogger Bank Teesside Projects A and B	330	337

Tier	Project	Distance to Array Area (km)	Distance to Offshore ECC (km)
1	East Anglia ONE North	36	41
1	East Anglia THREE	69	75
1	East Anglia TWO	5	12
1	Hornsea Project Three - revised	193	198
1	Inch Cape	565	555
1	Moray West	748	741
1	Norfolk Boreas	105	110
1	Norfolk Vanguard	91	97
1	Hornsea 4	209	215
1	Dudgeon Offshore Extension Project	136	139
1	Sheringham Shoal Extension Project	135	132
2	Rampion 2	206	166

4.13.15 The level of data available and the ease with which impacts can be combined across the windfarms is quite variable, reflecting the availability of relevant data for older projects and the approach to assessment taken. Wherever possible the cumulative assessment is quantitative (i.e. where data in an appropriate format have been obtained). Where this has not been possible (e.g. for older projects) a qualitative assessment has been undertaken.

CUMULATIVE ASSESSMENT OF CONSTRUCTION: DIRECT DISTURBANCE AND DISPLACEMENT

4.13.16 Cumulative construction disturbance and displacement impacts may occur when the construction phase of VE overlaps with that of one or more other Tier 1 consented, or more likely, Tier 1 application stage or Tier 2 projects. Within the array areas, 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 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 (see Cumulative Assessment of Operational Displacement section below).

4.13.17 Cumulative operational displacement could therefore effectively be seen as a worst-case WTG construction disturbance scenario, when considering Tier 1 application stage and Tier 2 projects only, albeit the duration of impact is extended, starting in the construction phase. 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 1 application stage and Tier 2 projects.

4.13.18 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.

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

4.13.20 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.

4.13.21 Based on the screening exercise undertaken in Table 4.17, red-throated diver is therefore the only species requiring a cumulative assessment, 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 further offshore Tier 1 applications and Tier 2 project footprints is likely to be associated with export cable corridors.

RED-THROATED DIVER

4.13.22 Predicted mortality numbers due to construction-related disturbance in Table 4.52 have been compiled from assessments in ESs of Tier 1 application stage and Tier 2 projects, 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 assumed to be on site at any particular time – this is either one or two for other projects, with the assumption for VE being three vessels directly associated with cable laying, based on the offshore ECC MDS (a total of up to 12 vessels at any one time, likely including non-cable laying vessels) which is outlined in Volume 2, Chapter 1: Offshore Project Description and Table 4.15.

Table 4.52: 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
1	East Anglia THREE	0 - 2	1-10% mortality
1	Norfolk Vanguard	0 - 9	2 - 4 at 5% mortality, converted to 1-10% mortality
1	Norfolk Boreas	0 – 9	1-10% mortality
1	East Anglia ONE North	0 - 10	1-10% mortality
1	East Anglia TWO	0 - 10	1-10% mortality
1	Hornsea Project 4	0 - 0	No losses even with 100% displacement
1	Dudgeon Offshore Extension Project	0 - 0	1-10% mortality
1	Sheringham Shoal Extension Project	0 - 3	1-10% mortality
2	Rampion 2	0 – 0	Species not assessed
	Total (other projects)	**0 - 43**	
	VE	1 - 15	1-10% mortality (3 vessels)
	Total (all projects)	**1 - 58**	

4.13.23 In total, up to 43 red-throated divers are predicted to be lost as a result of other Tier 1 application and Tier 2 projects, which rises to 58 when including the more precautionary VE, where three vessels were assumed. 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 58 individuals to this increases the mortality rate by 1.9%.

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

- 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. 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;
- Much 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 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 - 70), would represent up to 1.7%.

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 displacement 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 impact significance would be **minor adverse**.

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 BDMPS regions for each species indicated that for gannet, guillemot, and razorbill, all the windfarms identified for inclusion in the cumulative assessment in Table 4.51 have the potential to contribute a cumulative effect. For red-throated diver, the BDMPS is the southwest North Sea. 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) were also excluded.

RED-THROATED DIVER

4.13.28 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 (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).

4.13.29 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 projects (where quantitative information is available) is shown in Table 4.53.

Table 4.53: Red-throated diver cumulative displacement mortality for the South West 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.

Tier	Project	Autumn	Midwinter	Spring	Annual
1	Wider region (Norfolk Vanguard Ltd 2019a)	N/A	N/A	N/A	6 – 56
1	East Anglia ONE	0.4 - 5	1 - 10	1.4 - 15	2.8 - 30
1	East Anglia THREE	0.4 - 5	0.2 – 2	2 - 20	2.6 - 27
1	Norfolk Vanguard East	0.4 - 5	0.2 - 3	1 - 12	1.6 - 20
1	Norfolk Vanguard West	0 – 3	3 - 36	2 – 20	5 – 59
1	Norfolk Boreas	0 - 1	1 - 15	5 - 62	6 – 78
1	East Anglia ONE North	0 - 1	1 - 3	3 - 17	4 - 21
1	East Anglia TWO	0	0 - 2	2 - 25	3 - 28
1	Hornsea Project 4	0	0	0	0
1	Dudgeon Offshore Extension Project	1 – 6	0 - 1	1 – 5	1 – 13

Tier	Project	Autumn	Midwinter	Spring	Annual
1	Sheringham Shoal Extension Project	1 – 8	0 - 1	2 – 18	3 - 26
2	Rampion 2	Not assessed			
	Total (other projects)	**3.2 – 34**	**6.4 - 73**	**19.4 – 194**	**35 - 358**
	VE	0	0 - 2	0-4	0 - 6
	Total (all projects)	**3.2 – 34**	**6.4 – 75**	**19.4 – 198**	**35 – 364**

4.13.30 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.

4.13.31 Natural England has previously advised (for East Anglia TWO), that to establish a baseline to inform the cumulative assessment for this species, an estimate of the abundance of red-throated diver in all windfarms in this area using the SeaMaST spatial dataset (Bradbury *et al*. 2014) should be carried out. This dataset provides estimated seabird non-breeding season densities (sitting and flying birds summed) from a density surface model (DSM) of Wildfowl and Wetlands Trust (WWT) visual aerial survey data collected between 2001 - 2011, and JNCC European Seabirds At Sea (ESAS) boat-based survey data collected between 1979 - 2011. The non-breeding season as defined for the SeaMAST data set covers the months September until February; it is not subdivided into spring and autumn migration and winter periods, as has been done for individual species by Furness (2015).

4.13.32 Based on the SeaMAST data, the estimated number of red-throated divers within areas occupied by other offshore wind farms (excluding VE) in the Southwest North Sea, and within wind farms and 4km buffers, is respectively 3.2% and 16.2% of the total reference population of red-throated divers in this area in the non-breeding season.

4.13.33 The predicted cumulative displacement mortality for red-throated divers from offshore windfarms in the southern North Sea, assuming a range of 90-100% displacement from the windfarms and a 4km buffer, and 1-10% mortality of displaced birds, is between 35 and 364 birds per year.

4.13.34 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 35-364 to this would increase the mortality rate by 1.1-12.0%. 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 35-364 to this would increase the mortality rate by 0.6-5.9%.

4.13.35 Looking at the winter period alone, the BDMPS 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 6.4-75 birds to this would increase the mortality rate by 0.3-3.2%.

4.13.36 The cumulative red-throated diver displacement mortality total combines several sources of precaution, some of which were noted previously in paragraph 4.13.24:

- 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. 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 Southwest North Sea BDMPS for spring and autumn migration (13,277) is an underestimate, based on the Outer Thames SPA population estimate which has 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 (35-364), would represent 0.8% - 8.8%.

4.13.37 A further potential source of precaution is that the assessment methodology makes no allowance for the fact that WTG densities (and hence the negative stimulus to which the birds respond) within the 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 and currently being constructed with 102. Thus, the final windfarm will have less than one third the original number of proposed (and assessed) wind turbines. Similar reductions are likely for other consented windfarms which have not yet been built. This may 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 medium.

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 lower than the worst-case totals presented here, resulting in increases in background mortality below 1%, and thus the magnitude of cumulative displacement is assessed as **negligible**. Therefore, as the species is of high sensitivity to disturbance, the cumulative impact significance would be **minor adverse**.

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 (Woodward *et al*. 2019) mean maximum foraging range of gannets from breeding colonies in the North Sea, evidence from tagging data in Langston *et al*. (2013) has shown that there is very, if any, overlap with the range of breeding birds. Therefore, displacement risk is primarily of concern outside 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 as very few birds migrate through the southern North Sea in spring (Furness 2015). Thus, 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 windfarms 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 is considered to be negligible.

4.13.44 Table 4.54 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 49,145. When the estimated numbers at risk due to VE are included this would increase to 50,085 birds.

Table 4.54: Cumulative Numbers of Gannets at Risk of Displacement from Offshore Windfarms in the North Sea.

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual
1	Beatrice Demonstrator	-	-	-	-
1	Greater Gabbard	252	69	105	426
1	Gunfleet Sands	0	12	9	21
1	Kentish Flats	-	-	-	-
1	Kentish Flats Extension	0	13	0	13
1	Lincs	-	-	-	-
1	London Array	-	-	-	-
1	Scroby Sands	-	-	-	-
1	Sheringham Shoal	47	31	2	80
1	Teesside	1	0	0	1
1	Thanet	-	-	-	-
1	Humber Gateway	-	-	-	-
1	Westermost Rough	-	-	-	-
1	Hywind	10	0	4	14
1	Kincardine	120	0	0	120
1	Beatrice	151	0	0	151
1	Dudgeon	53	25	11	89
1	Galloper	360	907	276	1543
1	Race Bank	92	32	29	153
1	Rampion	0	590	0	590
1	Hornsea Project One	671	694	250	1615
1	Blyth Demonstration Project	-	-	-	-
1	East Anglia ONE	161	3638	76	3875
1	European Offshore Wind Deployment Centre	35	5	0	40
1	Methil	23	0	0	23
1	Moray Firth (EDA)	564	292	27	883
1	Dogger Bank Creyke Beck Projects A and B	1155	2048	394	3597
1	Firth of Forth Alpha and Bravo	2956	664	332	3952

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual
1	Inch Cape	2398	703	212	3313
1	Neart na Gaoithe	1987	552	281	2820
1	Dogger Bank Teesside Projects A and B	2250	887	464	3601
1	Triton Knoll	211	15	24	250
1	Hornsea Project Two	457	1140	124	1721
1	East Anglia THREE	412	1269	524	2205
1	Hornsea Project Three - revised	1333	984	524	2841
1	Norfolk Vanguard	271	2453	437	3161
1	Moray West	2827	439	144	3410
1	Norfolk Boreas	1229	1723	526	3478
1	East Anglia TWO	192	891	192	1275
1	East Anglia ONE North	149	468	44	661
1	Hornsea 4	976	790	401	2167
1	Dudgeon Offshore Extension Project	417	343	47	807
1	Sheringham Shoal Extension Project	23	295	11	28
2	Rampion 2	98	78	45	221
	Total (other projects)	**21881**	**22050**	**5515**	**49145**
	VE	233	640	67	940
	Total	**22114**	**22690**	**5582**	**50085**

4.13.45 At displacement rates of 60-80%, and 0-1% mortality of displaced birds, between 0 and 401 gannets would be predicted to be lost due to cumulative displacement (including the seven associated with VE) (Table 4.55). 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 401 individuals would represent a 0.5% 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 412 individuals would represent an 0.2% increase in mortality.

Table 4.55: Cumulative Annual Displacement Matrix for Gannet.

Annual cumulative	Mortality rate										
Displacement	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	50	100	150	200	250	501	1002	1503	2504	4007	5009
20%	100	200	301	401	501	1002	2003	3005	5009	8014	10017
30%	150	301	451	601	751	1503	3005	4508	7513	12020	15026
40%	200	401	601	801	1002	2003	4007	6010	10017	16027	20034
50%	250	501	751	1002	1252	2504	5009	7513	12521	20034	25043
60%	301	601	902	1202	1503	3005	6010	9015	15026	24041	30051
70%	351	701	1052	1402	1753	3506	7012	10518	17530	28048	35060
80%	401	801	1202	1603	2003	4007	8014	12020	20034	32054	40068
90%	451	902	1352	1803	2254	4508	9015	13523	22538	36061	45077
100%	501	1002	1503	2003	2504	5009	10017	15026	25043	40068	50085

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 0.5% 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 impact significance of cumulative displacement on a receptor of low to medium sensitivity is **minor adverse**.

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 4.56).

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 139,396 individuals, which rises to 141,572 individuals when including VE (Table 4.56). 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 425 and 9,910 (Table 4.57).

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

Tier	Windfarm	Breeding season	Autumn migration	Nonbreeding season	Spring migration	Annual
1	Beatrice Demonstrator	No estimate available				
1	Greater Gabbard	0	0	387	84	471
1	Gunfleet Sands	0	0	30	0	30
1	Kentish Flats	No estimate available				
1	Kentish Flats Extension	No estimate available				
1	Lincs & LID	45	34	22	34	134
1	London Array	14	20	14	20	68
1	Scroby Sands	No estimate available				
1	Sheringham Shoal	106	1343	211	30	1690
1	Teesside	16	61	2	20	99
1	Thanet	3	0	14	21	37
1	Humber Gateway	27	20	13	20	80
1	Westermost Rough	91	121	152	91	455
1	Hywind	30	719	10		759
1	Kincardine	22				22
1	Beatrice	873	833	555	833	3094
1	Dudgeon	256	346	745	346	1693
1	Galloper	44	43	106	394	587
1	Race Bank	28	42	28	42	140
1	Rampion	630	66	1244	3327	5267
1	Hornsea Project One	1109	4812	1518	1803	9242

Tier	Windfarm	Breeding season	Autumn migration	Nonbreeding season	Spring migration	Annual
1	Blyth Demonstration Project	121	91	61	91	364
1	East Anglia ONE	16	26	155	336	533
1	Dogger Bank Creyke Beck A	1250	1576	1728	4149	8703
1	Dogger Bank Creyke Beck B	1538	2097	2143	5119	10897
1	European Offshore Wind Deployment Centre	161	64	7	26	258
1	Firth of Forth Alpha	5876		1103		6979
1	Firth of Forth Bravo	3698		1272		4970
1	Inch Cape	1436	2870	651		4957
1	Methil	4	0	0	0	4
1	Moray Firth (EDA)	2423	1103	30	168	3724
1	Neart na Gaoithe	331	5492	508		6331
1	Dogger Bank Teesside A	834	310	959	1919	4022
1	Dogger Bank Teesside B	1153	592	1426	2953	6125
1	Triton Knoll	40	254	855	117	1265
1	Hornsea Project Two	2511	4221	720	1668	9119
1	East Anglia THREE	1807	1122	1499	1524	5952
1	Hornsea Project Three - Revised	630	2020	3649	2105	8404
1	Norfolk Vanguard	879	866	839	924	3508
1	Moray West	2808	3544	184	3585	10121
1	Norfolk Boreas	630	263	1065	345	2303
1	East Anglia TWO	281	44.1	136.4	230	692
1	East Anglia ONE North	403	85	54	207	749

Tier	Windfarm	Breeding season	Autumn migration	Nonbreeding season	Spring migration	Annual
1	Hornsea 4	386	4311	455	449	5600
1	Dudgeon Offshore Extension Project	3741	923	320	848	5829
1	Sheringham Shoal Extension Project	759	316	144	686	1905
2	Rampion 2	44	18	22	2130	2214
	Total (other projects)	**37054**	**40668.1**	**25036.4**	**36644**	**139396**
	VE	90	284	1046	756	2176
	Total	**37144**	**40952.1**	**26082.4**	**37400**	**141572**

Table 4.57: Cumulative Annual Displacement Matrix for Razorbill.

Annual cumulative		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	142	283	425	566	708	1416	2831	4247	7079	11326	14157
	20%	283	566	849	1133	1416	2831	5663	8494	14157	22652	28314
	30%	425	849	1274	1699	2124	4247	8494	12741	21236	33977	42472
	40%	566	1133	1699	2265	2831	5663	11326	16989	28314	45303	56629
	50%	708	1416	2124	2831	3539	7079	14157	21236	35393	56629	70786
	60%	849	1699	2548	3398	4247	8494	16989	25483	42472	67955	84943
	70%	991	1982	2973	3964	4955	9910	19820	29730	49550	79280	99100
	80%	1133	2265	3398	4530	5663	11326	22652	33977	56629	90606	113258
	90%	1274	2548	3822	5097	6371	12741	25483	38224	63707	101932	127415
	100%	1416	2831	4247	5663	7079	14157	28314	42472	70786	113258	141572

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 425 to 9,910 individuals to this increases the background mortality rate by respectively 0.4% and 9.6%.

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 likely to be undetectable 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 (Norfolk Vanguard Ltd 2019b, Dierschke *et al*. 2016).

4.13.56 A detailed review of the potential effects of displacement from offshore windfarms on auks (Norfolk Vanguard Ltd 2019b) acknowledged that that the impact of displacement of razorbills and guillemots by offshore windfarms is uncertain. The existing information indicates that annual mortality of adults (including impacts of existing human activities) is very low (10% and 6% per annum respectively), and that displacement of razorbills and guillemots 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. 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%.

4.13.57 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.

4.13.58 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 708 deaths annually from displacement (Table 4.57) and an 0.7% increase in mortality. 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 below 1%. The magnitude of cumulative displacement is assessed as **negligible**. Therefore, as the species is of medium sensitivity to disturbance, the cumulative effect significance would be **minor adverse**.

GUILLEMOT

4.13.59 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. Large numbers are found throughout the North Sea in the nonbreeding season (defined as August to February, Furness 2015).

4.13.60 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).

4.13.61 The estimates of the total numbers of guillemots at risk of displacement from other offshore windfarms in the North Sea are included in Table 4.58. 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.

4.13.62 The estimated annual cumulative total of guillemots at risk of displacement from windfarms in the North Sea is 405,314 individuals, which rises to 410,213 individuals when including VE (Table 4.58). 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 1,231 and 28,715 (Table 4.59).

4.13.63 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 1,231 and 28,715 individuals to this increases the background mortality rate by between 0.5 and 12.7%.

4.13.64 This is a large range, so the assessment considers the most realistic value within this range. Recommendations of an evidence-based review (Vattenfall 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%.

4.13.65 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 assessed as of medium magnitude.

4.13.66 However, on the basis of the evidence review (Vattenfall 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 2,051 deaths annually from displacement (Table 4.59) and 0.9% increase in mortality. 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**. Therefore, as the species is of medium sensitivity to disturbance, the cumulative effect significance would be **minor adverse**.

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

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
1	Beatrice Demonstrator	No estimate available		
1	Gunfleet Sands	0	363	363
1	Kentish Flats	0	3	3
1	Kentish Flats Extension	0	4	4
1	Greater Gabbard	345	548	893
1	Lincs & LID	582	814	1396
1	London Array	192	377	569
1	Scroby Sands	No estimate available		
1	Sheringham Shoal	390	715	1105
1	Teesside	267	901	1168
1	Thanet	18	124	142
1	Humber Gateway	99	138	237
1	Westermost Rough	347	486	833
1	Hywind	249	2136	2385
1	Kincardine	632	0	632
1	Beatrice	13610	2755	16365
1	Dudgeon	334	542	876
1	Galloper	305	593	898
1	Race Bank	361	708	1069
1	Rampion	10887	15536	26423
1	Hornsea Project One	9836	8097	17933
1	Blyth Demonstration Project	1220	1321	2541
1	East Anglia ONE	274	640	914
1	European Offshore Wind Deployment Centre	547	225	772
1	Dogger Bank Creyke Beck A	5407	6142	11549
1	Dogger Bank Creyke Beck B	9479	10621	20100
1	Firth of Forth Alpha	13606	4688	18294
1	Firth of Forth Bravo	11118	4112	15230

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
1	Inch Cape	4371	3177	7548
1	Methil	25	0	25
1	Moray Firth (EDA)	9820	547	10367
1	Neart na Gaoithe	1755	3761	5516
1	Dogger Bank Teesside A	3283	2268	5551
1	Dogger Bank Teesside B	5211	3701	8912
1	Triton Knoll	425	746	1171
1	Hornsea Project Two	7735	13164	20899
1	East Anglia THREE	1744	2859	4603
1	Hornsea Project Three - Revised	13374	17772	31146
1	Norfolk Vanguard	4320	4776	9096
1	Moray West	24426	38174	62600
1	Norfolk Boreas	7767	13777	21544
1	East Anglia TWO	2077	1675	3752
1	East Anglia ONE North	4183	1888	6071
1	Hornsea 4	9382	20326	29708
1	Dudgeon Offshore Extension Project	3839	14887	18726
1	Sheringham Shoal Extension Project	1085	1095	2180
2	Rampion 2	185	13020	13205
	Total (other projects)	**185112**	**220202**	**405314**
	VE	1201	3698	4899
	Total	**186313**	**223900**	**410213**

Table 4.59: 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%	410	820	1231	1641	2051	4102	8204	12306	20511	32817	41021
	20%	820	1641	2461	3282	4102	8204	16409	24613	41021	65634	82043
	30%	1231	2461	3692	4923	6153	12306	24613	36919	61532	98451	123064
	40%	1641	3282	4923	6563	8204	16409	32817	49226	82043	131268	164085
	50%	2051	4102	6153	8204	10255	20511	41021	61532	102553	164085	205107
	60%	2461	4923	7384	9845	12306	24613	49226	73838	123064	196902	246128
	70%	2871	5743	8614	11486	14357	28715	57430	86145	143575	229719	287149
	80%	3282	6563	9845	13127	16409	32817	65634	98451	164085	262536	328170
	90%	3692	7384	11076	14768	18460	36919	73838	110758	184596	295353	369192
	100%	4102	8204	12306	16409	20511	41021	82043	123064	205107	328170	410213

CUMULATIVE ASSESSMENT OF OPERATIONAL COLLISION RISK

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

4.13.68 It is considered that all of the windfarms identified for inclusion in the cumulative assessment in Table 4.45 have the potential to contribute to a cumulative effect.

GANNET

4.13.69 The cumulative gannet collision risk prediction is set out in Table 4.60. This collates collision predictions from other windfarms which may contribute to the cumulative total.

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

Table 4.60: Cumulative Collision Risk Assessment for Gannet.

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual
1	Beatrice Demonstrator	0.6	0.9	0.7	2.2
1	Greater Gabbard	14	8.8	4.8	27.5
1	Gunfleet Sands	-	-	-	-
1	Kentish Flats	1.4	0.8	1.1	3.3
1	Kentish Flats Extension	-	-	-	-
1	Lincs	2.1	1.3	1.7	5
1	London Array	2.3	1.4	1.8	5.5
1	Lynn and Inner Dowsing	0.2	0.1	0.2	0.5
1	Scroby Sands	-	-	-	-
1	Sheringham Shoal	14.1	3.5	0	17.6
1	Teesside	4.9	1.7	0	6.7
1	Thanet	1.1	0	0	1.1
1	Humber Gateway	1.9	1.1	1.5	4.5
1	Westermost Rough	0.2	0.1	0.2	0.5
1	Hywind	5.6	0.8	0.8	7.2
1	Kincardine	3	0	0	3
1	Beatrice	37.4	48.8	9.5	95.7
1	Dudgeon	22.3	38.9	19.1	80.3
1	Galloper	18.1	30.9	12.6	61.6
1	Race Bank	33.7	11.7	4.1	49.5
1	Rampion	36.2	63.5	2.1	101.8
1	Hornsea Project One	11.5	32	22.5	66
1	Blyth Demonstration Project	3.5	2.1	2.8	8.4
1	East Anglia ONE	3.4	131	6.3	141
1	European Offshore Wind Deployment Centre	4.2	5.1	0.1	9.3
1	Methil	6	0	0	6
1	Moray Firth (EDA)	80.6	35.4	8.9	124.9
1	Dogger Bank Creyke Beck Projects A and B	81.1	83.5	54.4	219
1	Firth of Forth Alpha and Bravo	800.8	49.3	65.8	915.9

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual
1	Inch Cape	336.9	29.2	5.2	371.3
1	Neart na Gaoithe	143	47	23	213
1	Dogger Bank Teesside Projects A and B	14.8	10.1	10.8	35.7
1	Triton Knoll	26.8	64.1	30.1	121
1	Hornsea Project Two	7	14	6	27
1	East Anglia THREE	6.1	33.3	9.6	49
1	Hornsea Project Three - revised	10	5	4	19
1	Norfolk Vanguard	8.2	18.6	5.3	32.1
1	Moray West	10	2	1	13
1	Norfolk Boreas	14.1	12.7	3.9	30.7
1	East Anglia TWO	12.5	23.1	4	39.6
1	East Anglia ONE North	12.4	11	1.1	24.5
1	Dudgeon Offshore Extension Project	1.8	2.8	0.2	4.9
1	Sheringham Shoal Extension Project	0.2	0.7	0	0.9
1	Hornsea 4	11	4.4	1.8	17.3
2	Rampion 2	9.7	4	1.4	15.1
	Total (other projects)	**1814.7**	**834.7**	**328.4**	**2978.1**
	VE	2.4	2.68	0.28	5.36
	Total	**1817.1**	**837.4**	**328.7**	**2983.5**

4.13.71 The annual cumulative total for estimated collision mortality is 2,978 of which VE contributes five 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 2,983 individuals would represent a 3.4% 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 2,983 individuals would represent 1.3% increase in mortality.

4.13.72 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.

4.13.73 Note, however that many of the collision estimates for other windfarms were calculated for 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. 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% (Appendix 12.3 of East Anglia TWO EIA submission). Therefore, due to the reduced collision risks for projects which undergo design revisions post-consent, the values presented in Table 4.60 can be reduced to around 2,774 collisions.

4.13.74 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 overestimates. 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 4.60 to 2,169 at 99.2% avoidance.

4.13.75 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. 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 2,983 cumulative value, the amended collision rate can be reduced by 0.15 (85% macro-avoidance rate) to 0.35 (65% macro-avoidance rate).

4.13.76 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.

4.13.77 In conclusion, based on the above information and realistic reductions in predicted collision rates due to (i) post-consent windfarm design revisions; (ii) increase in avoidance rate; (iii) inclusion of macro-avoidance in modelling; and (iv) reduction in nocturnal activity factor, the cumulative impact on the gannet population due to collisions both year round and within individual seasons is considered to be 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 significance is therefore **minor adverse**.

KITTIWAKE

4.13.78 The cumulative collision risk predictions for kittiwake are set out in Table 4.61. This collates collision predictions from other windfarms which may contribute to the cumulative total.

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

Table 4.61: Cumulative Collision Risk Assessment for Kittiwake.

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual
1	Beatrice Demonstrator	0	2.1	1.7	3.8
1	Greater Gabbard	1.1	15	11.4	27.5
1	Gunfleet Sands	-	-	-	-
1	Kentish Flats	0	0.9	0.7	1.6
1	Kentish Flats Extension	0	0	2.7	2.7
1	Lincs	0.7	1.2	0.7	2.6
1	London Array	1.4	2.3	1.8	5.5
1	Lynn and Inner Dowsing	-	-	-	-
1	Scroby Sands	-	-	-	-
1	Sheringham Shoal	-	-	-	-
1	Teesside	38.4	24	2.5	64.9
1	Thanet	0.2	0.5	0.4	1.1
1	Humber Gateway	1.9	3.2	1.9	7
1	Westermost Rough	0.1	0.2	0.1	0.5
1	Hywind	16.6	0.9	0.9	18.3
1	Kincardine	22	9	1	32
1	Beatrice	94.7	10.7	39.8	145.2
1	Dudgeon	-	-	-	-
1	Galloper	6.3	27.8	31.8	65.9

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual
1	Race Bank	1.9	23.9	5.6	31.4
1	Rampion	54.4	37.4	29.7	121.5
1	Hornsea Project One	44	55.9	20.9	120.8
1	Blyth Demonstration Project	1.7	2.3	1.4	5.4
1	Dogger Bank Creyke Beck Projects A and B	288.6	135	295.4	719
1	East Anglia ONE	1.8	160.4	46.8	209
1	European Offshore Wind Deployment Centre	11.8	5.8	1.1	18.7
1	Firth of Forth Alpha and Bravo	153.1	313.1	247.6	713.8
1	Inch Cape	13.1	224.8	63.5	301.4
1	Methil	0.4	0	0	0.4
1	Moray Firth (EDA)	43.6	2	19.3	64.9
1	Neart na Gaoithe	32.9	56.1	4.4	93.4
1	Dogger Bank Teesside Projects A and B	136.9	90.7	216.9	444.5
1	Triton Knoll	24.6	139	45.4	209
1	Hornsea Project Two	16	9	3	28
1	East Anglia THREE	6.1	69	37.6	112.7
1	Hornsea Project Three - revised	77	38	8	123
1	Norfolk Vanguard	21.8	16.4	19.3	57.5
1	Moray West	79	24	7	110
1	Norfolk Boreas	13.3	32.2	11.9	57.5
1	East Anglia TWO	29.5	5.4	7.4	42.3
1	East Anglia ONE North	40.4	8.1	3.5	52
1	Hornsea 4	35.4	31.7	13.5	80.6
1	Dudgeon Offshore Extension Project	9.1	4.6	1.3	15
1	Sheringham Shoal Extension Project	0.8	1.2	0	2
2	Rampion 2	-	-	-	-

Tier	Wind farm	Breeding season	Autumn migration	Spring migration	Annual
	Total (other projects)	**1320.6**	**1583.8**	**1207.9**	**4112.4**
	VE	14.76	10.31	7.16	32.22
	Total (all projects)	**1335.4**	**1594.1**	**1215.1**	**4144.6**

4.13.80 The estimated annual cumulative total is 4,145 birds of which VE contributes 32 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 4,145 individuals would represent a 3.2% 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 4,145 individuals would represent an 0.5% increase in mortality.

4.13.81 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. Comparison of cumulative collision mortality for kittiwakes 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.

4.13.82 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% (Appendix 12.3 of East Anglia TWO EIA submission). Therefore, the values presented in Table 4.61, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 12% due to the reduced collision risks for projects which undergo design revisions post consent.

4.13.83 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 overestimates. Use of this higher rate would reduce the cumulative total by 27.2% (i.e. the cumulative total at this rate would be 3,014).

4.13.84 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 have 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 4.45). Applying the same approach to other windfarms in Table 4.61 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.

4.13.85 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 populations (EATL 2015). Both density independent and density dependent models were developed. For annual mortality of 4,000, the density dependent model predicted the population after 25 years would be 3.6% to 4.4% smaller than that predicted in the absence of additional mortality from collisions with offshore wind farms, while the more precautionary density independent model predicted equivalent declines of 10.3% to 10.9%.

4.13.86 There is evidence that kittiwake populations are limited by food supply, and therefore 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), and therefore the density-dependent model is more appropriate for this species. To place these predicted magnitudes of change in context, over three approximately 15-year periods (between censuses) the British kittiwake population changed by +24% (1969 to 1985), -25% (1985 to 1998) and -50% (2000 to 2018) (JNCC, 2020). Changes of between 3% and 10% across a longer (25 year) period against a background of changes 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.

4.13.87 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 its inclusion in the kittiwake population model (EATL 2015) balanced this evidence with reasonable precaution. Consequently, the density dependent kittiwake model results are considered to be the more robust ones on which to base this assessment.

4.13.88 Kittiwake is considered to be of low to medium sensitivity and the magnitude of worst-case cumulative collision mortality is considered to be **low**, resulting in impacts of **minor adverse** significance. However, when the various sources of precaution are taken into account (precautionary avoidance rate estimates, reduction in construction versus consented windfarm sizes, over-estimated nocturnal activity) the cumulative collision risk effect magnitude is almost certainly smaller still.

LESSER BLACK-BACKED GULL

4.13.89 The cumulative collision risk prediction for lesser black-backed gull is set out in Table 4.62. This collates collision predictions from other windfarms which may contribute to the cumulative total.

4.13.90 The collision values presented in Table 4.62 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 4.62 have been multiplied by 0.8 to estimate the nonbreeding component and 0.2 to estimate the breeding component.

Table 4.62: Cumulative Collision Risk Assessment for Lesser black-backed Gull.

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
1	Beatrice Demonstrator	-	-	-
1	Greater Gabbard	12.4	49.6	62
1	Gunfleet Sands	1	0	1
1	Kentish Flats	-	-	-
1	Kentish Flats Extension	0.3	1.3	1.6
1	Lincs	1.7	6.8	8.5
1	London Array	-	-	-
1	Lynn and Inner Dowsing	-	-	-
1	Scroby Sands	-	-	-
1	Sheringham Shoal	1.7	6.6	8.3
1	Teesside	0	0	0
1	Thanet	3.2	12.8	16
1	Humber Gateway	0.3	1.1	1.4
1	Westermost Rough	0.1	0.3	0.4
1	Hywind	0	0	0
1	Kincardine	0	0	0

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
1	Beatrice	0	0	0
1	Dudgeon	7.7	30.6	38.3
1	Galloper	27.8	111	138.8
1	Race Bank	43.2	10.8	54
1	Rampion	1.6	6.3	7.9
1	Hornsea Project One	4.4	17.4	21.8
1	Blyth Demonstration Project	0	0	0
1	Dogger Bank Creyke Beck Projects A and B	2.6	10.4	13
1	East Anglia ONE	5.9	33.8	39.7
1	European Offshore Wind Deployment Centre	0	0	0
1	Firth of Forth Alpha and Bravo	2.1	8.4	10.5
1	Inch Cape	0	0	0
1	Methil	0.5	0	0.5
1	Moray Firth (EDA)	0	0	0
1	Neart na Gaoithe	0.3	1.2	1.5
1	Dogger Bank Teesside Projects A and B	2.4	9.6	12
1	Triton Knoll	7.4	29.6	37
1	Hornsea Project Two	2	2	4
1	East Anglia THREE	1.8	8.2	10
1	Hornsea Project Three (revised)	8	1	9
1	Norfolk Vanguard	8.4	3.6	12
1	Moray West	0	0	0
1	Norfolk Boreas	6.2	8.1	14.3
1	East Anglia TWO	4.2	0.5	4.7
1	East Anglia ONE North	0.9	0.6	1.5
1	Hornsea 4	0.3	0.1	0.4
1	Dudgeon Offshore Extension Project	1	0.3	1.3
1	Sheringham Shoal Extension Project	0.5	0	0.5
2	Rampion 2	-	-	-

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
	Total (other projects)	**159.9**	**372.0**	**531.9**
	VE	35.76	5.71	41.47
	Total (all projects)	**195.66**	**377.7**	**573.37**

4.13.91 The cumulative predicted annual total is 573 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 573 individuals would represent a 2.2% 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 573 individuals would represent an 0.5% increase in mortality.

4.13.92 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.

4.13.93 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% (Appendix 12.3 of East Anglia TWO EIA application). Therefore, the values presented in Table 4.62, 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.

4.13.94 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 4.62 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.

4.13.95 A review of nocturnal activity in seabirds (EATL 2015) has indicated that the value currently used for this parameter (50%) to estimate collision risk at night 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 4.45). 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 suggest that any increase in collision rates due to lower avoidance may be balanced by a lower nocturnal activity factor.

4.13.96 In conclusion, the current cumulative total is considerably lower than previously consented cumulative totals (as much as 3 times lower), and yet this total still includes some of precaution (e.g. 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 significance is **minor adverse**.

HERRING GULL

4.13.97 The cumulative herring gull collision risk prediction is set out in Table 4.63. Assessments at other windfarms have been conducted using a range of avoidance rates and alternative collision model Options.

Table 4.63: Cumulative Collision Risk Assessment for Herring Gull.

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
1	Beatrice Demonstrator	0		0
1	Greater Gabbard	0		0
1	Gunfleet Sands	-	-	-
1	Kentish Flats	0	0	0
1	Kentish Flats Extension	0.5	1.7	2.2
1	Lincs	0		0
1	London Array	-	-	-
1	Lynn and Inner Dowsing	0		0
1	Scroby Sands	-	-	-
1	Sheringham Shoal	0		0
1	Teesside	8.7	34.5	43.2
1	Thanet	4.9	19.6	24.5
1	Humber Gateway	0.4	1.1	1.5

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
1	Westermost Rough	0.1	0	0.1
1	Hywind	0.6	7.8	8.4
1	Kincardine	1	0	1
1	Beatrice	49.4	197.4	246.8
1	Dudgeon	-	-	-
1	Galloper	27.2		27.2
1	Race Bank	0		0
1	Rampion	155		155
1	Hornsea Project One	2.9	11.6	14.5
1	Blyth Demonstration Project	0.5	2.2	2.7
1	Dogger Bank Creyke Beck Projects A and B	0		0
1	East Anglia ONE	0	28	28
1	European Offshore Wind Deployment Centre	4.8		4.8
1	Firth of Forth Alpha and Bravo	10	21	31
1	Inch Cape	0	13.5	13.5
1	Methil	5.8	3.7	9.5
1	Moray Firth (EDA)	52		52
1	Neart na Gaoithe	5	12.5	17.5
1	Dogger Bank Teesside Projects A and B	0		0
1	Triton Knoll	0		0
1	Hornsea Project Two	23.8		23.8
1	East Anglia THREE	0	23	23
1	Hornsea Project Three (revised)	1	4	5
1	Norfolk Vanguard	0.4	7.1	7.5
1	Moray West	12	1	13
1	Norfolk Boreas	1.5	5.4	6.9
1	East Anglia TWO	0	0.5	0.5
1	East Anglia ONE North	0	0	0
1	Hornsea 4	0.5	0.3	0.8

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
1	Dudgeon Offshore Extension Project	0.25	0	0.25
1	Sheringham Shoal Extension Project	0	0	0
2	Rampion 2	-	-	-
	Total (other projects)	**368.3**	**395.9**	**764.2**
	VE	0.69	1.52	2.21
	Total (all projects)	**368.9**	**397.4**	**766.4**

4.13.98 The annual cumulative total for estimated herring gull collision mortality is 766 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 766 individuals would represent a 0.96% 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 768 individuals would represent a 0.4% increase in mortality.

4.13.99 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 1% when considering the reference populations (Furness 2015).

4.13.100 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 have 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** 4.45). Applying the same approach to other wind farms 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 wind farm latitude due to the variation in day and night length). This emphasises the precautionary nature of the current assessment.

4.13.101 In conclusion, the cumulative impact on herring gull due to collisions both year-round and within individual seasons includes precaution and is considered to be of **negligible** magnitude; and the relative contribution of the proposed VE project to this cumulative total is very small. Herring gulls are considered to be of low to medium sensitivity to collision mortality and the effect significance is therefore **minor adverse**.

GREAT BLACK-BACKED GULL

4.13.102 The cumulative predicted collision risk for great black-backed gull is set out in Table 4.64. Assessments for other windfarms have been conducted using a range of avoidance rates and alternative collision model Options.

4.13.103 The collision values presented in Table 4.64 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 4.64 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 Great Black-backed Gull.

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
1	Beatrice Demonstrator	0	0	0
1	Greater Gabbard	15	60	75
1	Gunfleet Sands	-	-	-
1	Kentish Flats	-	-	-
1	Kentish Flats Extension	0.1	0.2	0.3
1	Lincs	0	0	0
1	London Array	-	-	-
1	Lynn and Inner Dowsing	0	0	0
1	Scroby Sands	-	-	-
1	Sheringham Shoal	0	0	0
1	Teesside	8.7	34.8	43.6
1	Thanet	0.1	0.4	0.5
1	Humber Gateway	1.3	5.1	6.3
1	Westermost Rough	0	0	0.1
1	Hywind	0.3	4.5	4.8
1	Kincardine	0	0	0
1	Beatrice	30.2	120.8	151
1	Dudgeon	0	0	0
1	Galloper	4.5	18	22.5

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
1	Race Bank	0	0	0
1	Rampion	5.2	20.8	26
1	Hornsea Project One	17.2	68.6	85.8
1	Blyth Demonstration Project	1.3	5.1	6.3
1	Dogger Bank Creyke Beck Projects A and B	5.8	23.3	29.1
1	East Anglia ONE	0	46	46
1	European Offshore Wind Deployment Centre	0.6	2.4	3
1	Firth of Forth Alpha and Bravo	13.4	53.4	66.8
1	Inch Cape	0	36.8	36.8
1	Methil	0.8	0.8	1.6
1	Moray Firth (EDA)	9.5	25.5	35
1	Neart na Gaoithe	0.9	3.6	4.5
1	Dogger Bank Teesside Projects A and B	6.4	25.5	31.9
1	Triton Knoll	24.4	97.6	122
1	Hornsea Project Two	3	20	23
1	East Anglia THREE	4.6	34.4	39
1	Hornsea Project Three (revised)	8	28	36
1	Norfolk Vanguard	4.5	21.5	26
1	Moray West	4	5	9
1	Norfolk Boreas	6.9	28.7	35.6
1	East Anglia TWO	3.5	3.4	6.9
1	East Anglia ONE North	3.7	1.2	5
1	Hornsea 4	0.4	4	4.4
1	Dudgeon Offshore Extension Project	1.1	0.2	1.3
1	Sheringham Shoal Extension Project	3.7	0.0	3.7
2	Rampion 2	0.9	3.1	4.0

Tier	Windfarm	Breeding season	Nonbreeding season	Annual
	Total (other projects)	**190.0**	**802.7**	**992.8**
	VE	1.25	2.06	3.31
	Total (all projects)	**191.3**	**804.8**	**996.1**

4.13.104 The annual cumulative total of predicted collisions is 996 of which VE contributes 3 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 996 individuals would represent a 5.9% 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 2.3% increase in mortality.

4.13.105 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.

4.13.106 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% (Appendix 12.3 of East Anglia TWO EIA submission). Therefore, the values presented in Table 4.64, 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.

4.13.107 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 4.45). 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.

4.13.108 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.

4.13.109 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 996 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.

4.13.110 In conclusion, the cumulative impact on the great black-backed gull population due to predicted collisions both year-round and within individual seasons is considered to be of **low** magnitude and great black-backed gull is considered to be of low to medium sensitivity, therefore the effect significance is **minor adverse**.

CUMULATIVE ASSESSMENT OF OPERATIONAL COLLISION RISK AND DISPLACEMENT

GANNET

4.13.111 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.

4.13.112 As noted above, the estimated cumulative annual total for gannet collision mortality is 2,983. The estimated cumulative total for gannet displacement is 0-401 birds.

4.13.113 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 2,983-3,384 individuals would represent a 3.4–3.9% 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 2,983-3,384 individuals would represent 1.3-1.5% increase in mortality.

4.13.114 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.

4.13.115 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 significance would be **minor adverse**.

4.14 INTER-RELATIONSHIPS

4.14.1 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).

4.14.2 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.

4.14.3 Inter-relationships are summarised in Table 4.65, which indicates where assessments carried out in other ES chapters have been used to inform the offshore ornithology assessment.

Table 4.65: Ornithology Inter-relationships.

Impact	Related Chapter	Where addressed in this Chapter	Rationale
Indirect impacts through effects on habitats and prey during construction	Volume 2, Chapter 5: Benthic and Intertidal Ecology Volume 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 2, Chapter 5: Benthic and Intertidal Ecology Volume 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 2, Chapter 5: Benthic and Intertidal Ecology Volume 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.

4.15 TRANSBOUNDARY EFFECTS

4.15.1 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.

4.16 SUMMARY OF EFFECTS

4.16.1 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).

4.16.2 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 Natural England and the RSPB 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.

4.16.3 During the construction phase of the proposed project no effects have been assessed to be greater than of **minor adverse** significance for any IOF.

4.16.4 During operation, displacement impacts on red-throated divers, gannets, razorbills and guillemots would not create effects of more than **minor adverse** significance 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 significance for gannet, kittiwake, lesser black-backed gull and great black-backed gull when considered for all biological seasons against the most appropriate population scale.

4.16.5 Two potential impacts of the proposed VE project were screened in for cumulative assessment: 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.

4.16.6 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 4.51.

4.16.7 The effect on IOFs from cumulative displacement and collisions is assessed as no greater than **minor adverse** significance for all species.

4.16.8 The potential for collisions and displacement from windfarms outside UK territorial waters (transboundary) to contribute to cumulative impacts was considered. However, the operational offshore windfarms which might contribute to cumulative effects are comparatively small (in combination these projects are of a similar size to no more than one to two of the more recent UK windfarms, such as VE). Since the spatial scale and hence seabird 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 effect assessed on the larger population present over a larger spatial scale.

4.16.9 The identified effects for the project alone are summarised in Table 4.66 and cumulative effects in Table 4.67.

4.17 NEXT STEPS

4.17.1 The following steps will be undertaken in order to progress the offshore ornithology impact assessment from PEIR stage to DCO Application stage.

- Further ETG consultation to reach agreement on assessment methodology, scope and potential level of effects;
- Any new relevant information to aid the impact assessment will be gathered, for example data from other offshore projects which may contribute to cumulative effects, any monitoring and scientific studies, or updates in guidance.

Table 4.66: Predicted effects on IOFs.

Potential Impact	IOF	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Impact 1: Direct disturbance and displacement during offshore ECC construction	Red-throated diver	High	Negligible	Minor adverse	N/A	Minor adverse
	Common scoter	High	Negligible	Minor adverse	N/A	Minor adverse
Impact 1: Direct disturbance and displacement from construction activity within array areas	Razorbill	Medium	Negligible	Negligible	N/A	Minor adverse
	Guillemot	Medium	Negligible	Negligible	N/A	Minor adverse
Impact 2: Indirect impacts through effects on habitats and prey species	All IOFs	Low to high	Negligible	Negligible	N/A	Negligible or Minor adverse
Operation						
Impact 3:	Red-throated diver	High	Negligible	Minor adverse	N/A	Minor adverse

Potential Impact	IOF	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Direct disturbance and displacement	Gannet	Low to medium	Negligible	Negligible	N/A	Minor adverse
	Razorbill	Medium	Negligible	Negligible	N/A	Minor adverse
	Guillemot	Medium	Negligible	Negligible	N/A	Minor adverse
Impact 4: In Indirect impacts through effects on habitats and prey species	All IOFs	Low to high	Negligible	Negligible	N/A	Negligible or Minor adverse
Impact 5: Collision risk	Gannet	Low to medium	Negligible	Negligible	N/A	Minor adverse
	Kittiwake	Low to medium	Negligible	Negligible	N/A	Minor adverse
	Lesser black-backed gull	Low to medium	Negligible	Negligible	N/A	Minor adverse
	Herring gull	Low to medium	Negligible	Negligible	N/A	Minor adverse
	Great black-backed gull	Low to medium	Negligible	Negligible	N/A	Minor adverse
Impact 6:	Gannet	Low to medium	Negligible	Negligible	N/A	Minor adverse

Potential Impact	IOF	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Combined collision and displacement						
Decommissioning						
Impact 7: Direct disturbance and displacement	All IOFs	Low to high	Negligible	Negligible to minor adverse	N/A	Minor adverse
Impact 8: Indirect impacts through effects on habitats and prey species	All IOFs	Low to high	Negligible	Negligible to minor adverse	N/A	Negligible or minor adverse

Table 4.67: Predicted cumulative effects on IOFs.

Potential Impact	IOF	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Disturbance and displacement	Red-throated diver	High	Negligible	Minor adverse	N/A	Minor adverse
Operation						
Disturbance and displacement	Red-throated diver	High	Negligible	Minor adverse	N/A	Minor adverse
	Gannet	Low to medium	Negligible	Negligible	N/A	Minor adverse
	Razorbill	Low to medium	Negligible	Negligible	N/A	Minor adverse
	Guillemot	Low to medium	Low	Minor	N/A	Minor adverse
Collision risk	Gannet	Low to medium	Low	Minor adverse	N/A	Minor adverse
	Kittiwake	Low to medium	Low	Minor adverse	N/A	Minor adverse
	Lesser black-backed gull	Low to medium	Low	Minor adverse	N/A	Minor adverse
	Herring gull	Low to medium	Negligible	Negligible	N/A	Minor adverse

Potential Impact	IOF	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	Great black-backed gull	Low to medium	Low	Minor adverse	N/A	Minor adverse
Combined collision risk and displacement	Gannet	Low to medium	Low	Minor adverse	N/A	Minor adverse

4.18 REFERENCES

Aitken, D., Babcock, M., Barratt, A., Clarkson, C., Prettyman, S. (2017). RSPB report to Natural England. publications.naturalengland.org.uk/file/5574008674451456, accessed January 2023.

APEM. (2014) Assessing northern gannet avoidance of offshore wind farms. Report for East Anglia Offshore Wind Ltd.

APEM (2016). Assessment of Displacement Impacts of Offshore Windfarms and Other Human Activities on Red-throated Divers and Alcids. Natural England Commissioned Reports, Number 227.

Austin, G.E. and Rehfisch, M.M. (2005) Shifting nonbreeding distributions of migratory fauna in relation to climate change. Global Change Biology, 11, 31-38.

Balmer, D., Gillings, S., Caffrey, B., Swann, B., Downie, I. and Fuller, R. (2013) Bird Atlas 2007-11: The Breeding and Wintering Birds of Britain and Ireland. BTO Books, Thetford.

Band, W. (2012) Using a collision risk model to assess bird collision risks for offshore wind farms. The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-02. SOSS Website. Original published Sept 2011, extended to deal with flight height distribution data March 2012.

BEIS (2020). New plans to make UK world leader in green energy [webpage]. Available at https://www.gov.uk/government/news/new-plans-to-make-uk-world-leader-in-green-energy. Accessed January 2023.

Bellebaum, J., Diederichs, A., Kube, J., Schulz, A. and Nehls, G. (2006) Flucht- und Meidedistanzen überwinternder Seetaucher und Meeresenten gegenüber Schiffen auf See. Ornithologischer Rundbrief Mecklenburg-Vorpommern, 45, 86–90.

Bicknell, A.W.J., Oro, D., Camphuysen, C.J. and Votier, S.C. (2013) Potential consequences of discard reform for seabird communities. Journal of Applied Ecology, 50, 649-658.

BirdLife International. (2004) Birds in Europe: population estimates, trends and conservation status. (Birdlife Conservation Series No. 12). BirdLife, Cambridge.

Braasch, A., Michalik, A. and Todeskino, E. (2015) Assessing impacts of offshore wind farms on two highly pelagic seabird species. Poster presented at Conference on Wind farms and Wildlife in Berlin.

Bradbury G., Trinder M., Furness B., Banks A.N., Caldow R.W.G., *et al*. (2014) Mapping Seabird Sensitivity to Offshore Wind farms. PLoS ONE, 9(9), e106366. doi:10.1371/journal.pone. 0106366

Brooke, M.D., Bonnaud, E., Dilley, B.J., Flint, E.N., Holmes, N.D., Jones, H.P., Provost, P., Rocamora, G., Ryan, P.G., Surman, C. and Buxton, R.T. (2018) Seabird population changes following mammal eradications on islands. Animal Conservation, 21, 3-12.

Brown, A. and Grice, P. (2005) Birds in England. T and AD Poyser, London.

Burthe, S.J., Wanless, S., Newell, M.A., Butler, A. and Daunt, F. (2014) Assessing the vulnerability of the marine bird community in the western North Sea to climate change and other anthropogenic impacts. Marine Ecology Progress Series, 507, 277-295.

Buckingham L, Bogdanova MI, Green JA, Dunn RE and others (2022) Interspecific variation in non-breeding aggregation: a multi-colony tracking study of two sympatric seabirds. Mar Ecol Prog Ser 684:181-197. https://doi.org/10.3354/meps13960

Camphuysen, C.J. (1995) Herring Gull (Larus argentatus) and Lesser Black-backed Gull (L. fuscus) feeding at fishing vessels in the breeding season: competitive scavenging versus efficient flying. Ardea, 83, 365-380.

Capuzzo, E., Lynam, C.P., Barry, J., Stephens, D., Forster, R.M., Greenwood, N., McQuatters-Gollop, A., Silva, T., Van Leeuwen, S.M. and Engelhard, G.H. (2018) A decline in primary production in the North Sea over 25 years, associated with reductions in zooplankton abundance and fish stock recruitment. Global Change Biology, 24, E352-E364.

Carroll, M.J., Butler, A., Owen, E., Ewing, S.R., Cole, T., Green, J.A., Soanes, L.M., Arnould, J.P.Y., Newton, S.F., Baer, J., Daunt, F., Wanless, S., Newell, M.A., Robertson, G.S., Mavor, R.A. and Bolton, M. (2015) Effects of sea temperature and stratification changes on seabird breeding success. Climate Research, 66, 75-89.

Carroll, M.J., Bolton, M., Owen, E., Anderson, G.Q.A., Mackley, E.K., Dunn, E.K. and Furness, R.W. (2017) Kittiwake breeding success in the southern North Sea correlates with prior sandeel fishing mortality. Aquatic Conservation – Marine and Freshwater Ecosystems, 27, 1164-1175.

CIEEM. (2018) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine. Chartered Institute of Ecology and Environmental Management, Winchester. https://www.cieem.net/data/files/ECIA%20Guidelines.pdf

Cook, A.S.C.P., Wright, L.J., and Burton, N.H.K. (2012) A review of flight heights and avoidance rates of birds in relation to offshore wind farms. The Crown Estate Strategic Ornithological Support Services (SOSS). SOSS Website.

Cook, A.S.C.P., Humphries, E.M., Masden, E.A., and Burton, N.H.K. (2014) The avoidance rates of collision between birds and offshore turbines. BTO research Report No 656 to Marine Scotland Science. BTO, Thetford.

Cook, A,S.C.P, Humphreys, E.M., Bennet, F., Masden, E.A., and Burton, N.H.K. (2018). Quantifying avian avoidance of offshore wind turbines: Current evidence and key knowledge gaps. Marine Environmental Research, 140: 278-288.

Cramp S. and Simmons K.E.L. (Eds.) (1977 - 1994). The Birds of the Western Palearctic. Oxford University Press, Oxford.

Cury, P., Boyd, I.L., Bonhommeau, S., Anker-Nilssen, T., Crawford, R.J.M., Furness, R.W., Mills, J.A., Murphy, E.J., Österblom, H., Paleczny, M., Piatt, J.F., Roux, J-P., Shannon, L. and Sydeman, W.J. (2011) Global seabird response to forage fish depletion – one-third for the birds. Science, 334, 1703-1706.

Daunt, F., Benvenuti, S., Harris, M.P., Dall'Antonia, L., Elston, D.A. and Wanless, S. (2002) Foraging strategies of the black-legged kittiwake Rissa tridactyla at a North Sea colony: evidence for a maximum foraging range. Marine Ecology Progress Series, 245, 239-247.

Department of Energy and Climate Change (DECC) (2009) Future leasing for offshore wind farms and licensing for offshore oil and gas and gas storage. Environmental Report January 2009. Appendix 3d. Water Environment

DECC (2014) Environmental Assessment Report Comprising: Habitats Regulations Assessment, Transboundary Considerations and Consideration of Greater Back-blacked Gulls Available online at: http://infrastructure.planningportal.gov.uk/wp-content/ipc/uploads/projects/EN010032/3.%20Post%20Decision%20Information/Decision/Rampion%20Environmental%20Assessment%20Report.pdf

Del Hoyo, J., Elliott, A. and Sargatal, J. (Eds.) (1992 – 2011) Handbook of the Birds of the World. Lynx Editions, Madrid.

Dierschke, V., Furness, R.W. and Garthe, S. (2016) Seabirds and offshore wind farms in European waters: avoidance and attraction. Biological Conservation, 202, 59-68.

Dierschke, V., Furness, R.W., Gray, C.E., Petersen, I.K., Schmutz, J., Zydelis, R. and Daunt, F. (2017) Possible behavioural, energetic and demographic effects of displacement of red-throated divers. JNCC Report No. 605. JNCC, Peterborough.

Dooling, R.J. and Therrien, S.C. (2012) Hearing in birds: What changes from air to water. Advances in Experimental Medicine and Biology, 730, 77-82.

Drewitt, A.L. and Langston, R.H.W. (2006) Assessing the impacts of wind farms on birds. Ibis, 148 (Suppl. 1), 4-7.

Dulvy, N.K., Rogers, S.I., Jennings, S., Stelzenmüller, V., Dye, S.R. and Skjoldal, H.R. (2008), Climate change and deepening of the North Sea fish assemblage: a biotic indicator of warming seas. Journal of Applied Ecology, 45: 1029-1039. https://doi.org/10.1111/j.1365-2664.2008.01488.x

East Anglia ONE North Ltd (2019). East Anglia ONE North Offshore Wind Farm Chapter 12 Offshore Ornithology. Preliminary Environmental Report Volume 1.

EATL (2015) East Anglia THREE Chapter 13 Offshore Ornithology. Vol 1 Ref 6.1.13. Available online at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-000418-6.1.13%20Volume%201%20Chapter%2013%20Offshore%20Ornithology.pdf

EATL (2016) Revised CRM. Submitted for Deadline 5: Available online at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-001644-EA3%20-%20Revised%20CRM.pdf

Eaton, M.A., Aebischer, N.J., Brown, A.F., Hearn, R.D., Lock, L., Musgrove, A.J., Noble, D.G., Stroud, D.A. and Gregory, R.D. (2015) Birds of Conservation Concern 4: the population status of birds in the United Kingdom, Channel Islands and Isle of Man. British Birds, 108, 708–746.

EATL (2016a). Applicants Comments on Written Representations. Deadline 3. appendix 1 Great black-backed gull PVA. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010056/EN010056-001424-East%20Anglia%20THREE%20Limited%202

Exo, K-M., Hüppop, O. and Garthe, S. (2003) Offshore wind farms and bird protection. Seevögel, 23, 83-95.

Foster, S. and Marrs, S. (2012) Seabirds In Scotland. Scottish Natural Heritage Trend Note No. 21.

Foster, S., Swann, R.L. and Furness, R.W. (2017) Can changes in fishery landings explain long-term population trends in gulls? Bird Study, 64, 90-97.

Fox, A.D. and 19 Others. (2016) Seeking explanations for recent changes in abundance of wintering Eurasian wigeon (Anas penelope) in Northwest Europe. Ornis Fennica, 93, 12-25.

Frederiksen, M., Wanless, S., Harris, M.P., Rothery, P. and Wilson, L.J. (2004) The role of industrial fisheries and oceanographic change in the decline of North Sea black-legged kittiwakes. Journal of Applied Ecology, 41, 1129-1139.

Frederiksen, M., Furness, R.W. and Wanless, S. (2007) Regional variation in the role of bottom-up and top-down processes in controlling sandeel abundance in the North Sea. Marine Ecology Progress Series, 337, 279-286.

Frederiksen, M., Daunt, F., Harris, M.P. and Wanless, S. (2008) The demographic impact of extreme events: Stochastic weather drives survival and population dynamics in a long-lived seabird. Journal of Animal Ecology, 77, 1020-1029.

Frederiksen, M., Anker-Nilssen, T., Beaugrand, G. and Wanless, S. (2013) Climate, copepods and seabirds in the Boreal Northeast Atlantic – Current state and future outlook. Global Change Biology, 19, 364-372.

Furness, R.W. (2015) Non-breeding season populations of seabirds in UK waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Report Number 164.

Furness, R.W. (2016) Impacts and effects of ocean warming on seabirds. In: Laffoley, D. and Baxter, J.M. (Editors). Explaining Ocean Warming: Causes, Scale, Effects And Consequences. Full Report. Gland, Switzerland: IUCN. Pp. 271-288.

Furness, R.W. (2018). Consequences for birds of obstruction lighting on offshore wind turbines.

Furness, R.W. and Tasker, M.L. (2000) Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance and identification of key areas for sensitive seabirds in the North Sea. Marine Ecology Progress Series, 202, 253-264.

Furness, R.W., Wade, H.M. and Masden, E.A. (2013) Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management, 119, 56-66.

Furness, R.W., Hallgrimsson, G.T., Montevecchi, W.A., Fifield, D., Kubetzki, U., Mendel, B. and Garthe, S. (2018a) Adult gannet migrations frequently loop clockwise around Britain and Ireland. Ringing and Migration, doi: 10.1080/03078698.2018.1472971.

Furness, R.W., Garthe, S., Trinder, M., Matthiopoulos, J., Wanless, S. and Jeglinski, J. (2018b) Nocturnal flight activity of northern gannets Morus bassanus and implications for modelling collision risk at offshore wind farms. Environmental Impact Assessment Review, 73, 1-6. https://www.sciencedirect.com/science/article/abs/pii/S019592551830091X

Furness *et al*. (in prep). Nocturnal flight activity of black-legged kittiwakes, Rissa tridactyla and implications for modelling collision risk at offshore wind farms.

Garthe, S and Hüppop, O. (2004) Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology, 41, 724-734.

Garthe, S., Grémillet, D. and Furness, R.W. (1999) At-sea-activity and foraging efficiency in chick-rearing northern gannets Sula bassana: a case study in Shetland. Marine Ecology Progress Series, 185, 93-99.

Garthe, S., Ludynia, K., Hüppop, O., Kubetzki, U., Meraz, J.F. and Furness, R.W. (2012) Energy budgets reveal equal benefits of varied migration strategies in northern gannets. Marine Biology, 159, 1907-1915.

GGOWL. (2011) Quarterly Ornithological Monitoring Report (Q3): December 2010-February 2011 for the Greater Gabbard Offshore Wind farm. Produced by ESS and Royal Haskoning on behalf of Greater Gabbard Offshore Wind Limited (GGOWL). April 2011.

Green, R.E., Langston, R.H.W., McCluskie, A., Sutherland, R. and Wilson, J.D. (2016) Lack of sound science in assessing wind farm impacts on seabirds. Journal of Applied Ecology, 53, 1635-1641.

Green, R.M., Thaxter, C.B., Johnston, D.T., Boersch-Supan, P.H., Bouten, W., and Burton, N.H.K. (2021). Assessing Movements of Lesser Black-backed Gulls using GPS Tracking Devices in Relation to the Galloper Wind Farm. The British Trust for Ornithology, The Nunnery, Thetford, Norfolk.

Hamer, K.C., Monaghan, P., Uttley, J.D., Walton, P. and Burns, M.D. (1993) The influence of food supply on the breeding ecology of kittiwakes Rissa tridactyla in Shetland. Ibis, 135, 255-263.

Harris, M. and Wanless, S. (1989) The breeding biology of razorbills Alca torda on the Isle of May. Bird Study, 36, 105-114.

Hiddink, J.G., Burrows, M.T. and García Molinos, J. (2015), Temperature tracking by North Sea benthic invertebrates in response to climate change. Glob Change Biol, 21: 117-129. https://doi.org/10.1111/gcb.12726.

Holling, M. and the Rare Breeding Birds Panel. (2011) Rare breeding birds in the United Kingdom in 2009. British Birds, 104, 476–537.

Holt, C.A., Austin, G.E., Calbrade, N.A., Mellan, H.J., Hearn, R.D., Stroud, D.A., Wotton, S.R. and Musgrove, A.J. (2012) Waterbirds in the UK 2010/11: The Wetland Bird Survey. BTO/RSPB/JNCC, Thetford.

Horswill, C. and Robinson R. A. (2015) Review of seabird demographic rates and density dependence. JNCC Report No. 552. Joint Nature Conservation Committee, Peterborough

Hüppop, O. and Wurm, S. (2000) Effect of winter fishery activities on resting numbers, food and body condition of large gulls Larus argentatus and L. marinus in the south-eastern North Sea. Marine Ecology Progress Series, 194, 241-247.

Institute of Environmental Management and Assessment (2017). Delivering Proportionate Environmental Impact Assessment (‘EIA’): A Collaborative Strategy for Enhancing UK Environmental Impact Assessment Practice. Available at: https://www.iema.net/resources/reading-room/2017/07/18/delivering-proportionate-eia

Irwin, C., Scott, M., Webb, A., Scott, M. and Caldow, R., (2019) Digital video aerial surveys of Red-throated Diver in the Outer Thames Estuary SPA.

Jarrett, D., Cook, A. S. C. P., Woodward, I., Ross, K., Horswill,C., Dadam, D. & Humphreys, E.M. (2018). Short-Term Behavioural Responses of Wintering Waterbirds to Marine Activity (CR/2015/17). Scottish Marine and Freshwater Science Vol 9, No 7.

JNCC. (2013) The mean surface density map data was from NE's aerial visual surveys undertaken during winter (October – March) between 2001/01 and 2009/10 (GIS data files supplied by JNCC attached to e-mail dated 7th May 2013)

JNCC. (2015) Seabird Displacement Impacts from Offshore Wind Farms: report of the MROG Workshop, 6-7th May 2015. JNCC Report No 568. JNCC Peterborough.

JNCC. (2016) Seabird Population Trends And Causes Of Change: 1986-2015 Report Http://Jncc.Defra.Gov.Uk/Page-3201 Joint Nature Conservation Committee, Peterborough.

JNCC, (2020), Seabird Population Trends and Causes of Change: 1986-2018 Report (https://jncc.gov.uk/our-work/smp-report-1986-2018) Joint Nature Conservation Committee. Updated 10 March 2020.

JNCC, NE, NIEA, NRW and SNH (2014) Joint Response from the Statutory Nature Conservation Bodies to the Marine Scotland Science Avoidance Rate Review.

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. and Burton, E.H.K. (2014a) Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology, 51, 31-41.

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. and Burton, N.H.K. (2014b) corrigendum. Journal of Applied Ecology, 51, doi: 10.1111/1365-2664.12260.

King, S., Maclean, I.M.D., Norman, T., and Prior, A. (2009) Developing Guidance on Ornithological Cumulative Impact Assessment for Offshore Wind Farm Developers. COWRIE.

Kober, K., Webb, A., Win, I., Lewis, M., O'Brien, S., Wilson, L.J. and Reid, J.B. (2010) An analysis of the numbers and distribution of seabirds within the British Fishery Limit aimed at identifying areas that qualify as possible marine SPAs. JNCC Report, No. 431. JNCC, Peterborough.

Kotzerka, J., Garthe, S. and Hatch, S.A. (2010) GPS tracking devices reveal foraging strategies of black-legged kittiwakes. Journal of Ornithology, 151, 495-467.

Krijgsveld, K. L., Fijn, R. C., Japink, M., van Horssen, P. W., Heunks, C., Collier, M. P., Poot, M. J. M., Beuker, D. and Dirksen, S. (2011) Effect Studies Offshore Wind farm Egmond aan Zee. Final report on fluxes, flight altitudes and behaviour of flying birds. Bureau Waardenburg report 10-219, NZW-Report Bureau Waardenburg, Culmeborg, Netherlands.

Kubetzki, U., Garthe, S., Fifield, D., Mendel, B. and Furness, R.W. (2009) Individual migratory schedules and wintering areas of northern gannets. Marine Ecology Progress Series, 391, 257-265.

Langston, R.H.W. (2010) Offshore wind farms and birds: Round 3 zones, extensions to Round 1 and Round 2 sites and Scottish Territorial Waters. RSPB Research Report No. 39. RSPB, Sandy.

Langston, R.H.W., Teuten, E. and Butler, A. (2013) Foraging ranges of northern gannets Morus bassanus in relation to proposed offshore wind farms in the UK: 2010-2012. Report to DECC. Reference DECC URN:13D/306.

Leopold, M.F. and Camphuysen, C.J. (2007) Did the pile driving during the construction of the Offshore Wind farm Egmond aan Zee, the Netherlands, impact local seabirds? Report CO62/07. Wageningen IMARES Institute for Marine Resources and Ecosystem Studies.

Leopold, M.F., Dijkman, E.M. and Teal, L. (2011) Local birds in and around the Offshore Wind farm Egmond aan Zee (OWEZ) (T-0 and T-1, 2002-2010). NoordzeeWind report OWEZ_R_221_T1_20110915_localbirds_final. Imares / NoordzeeWind, Wageningen /IJmuiden.

Lindgren, M., van Duers, M., Mackenzie, B.R., Clausen, L.W., Christensen, A. and Rindorf, A. (2018) Productivity and recovery of forage fish under climate change and fishing: North Sea sandeel as a case study. Fisheries Oceanography, 27, 212-221.

MacArthur Green (2017) Estimates of Ornithological Headroom in Offshore Wind Farm Collision Mortality. Report to The Crown Estate.

MacArthur Green (2019a). Operational Auk and Gannet Displacement: update and clarification. Norfolk Vanguard Offshore wind Farm. The Applicant Responses to First written Questions. Appendix 3.3.

MacArthur Green (2019b). Beatrice Offshore Wind Farm: Year 1 Post-construction Ornithological Monitoring Report 2019. Available at: https://marine.gov.scot/sites/default/files/bowl_2019_post-con_monitoring_report_v2.2_30042021.pdf

Macdonald, A., Heath, M.R., Edwards, M., Furness, R.W., Pinnegar, J.K., Wanless, S., Speirs, D.C. and Greenstreet, S.P.R. (2015) Climate driven trophic cascades affecting seabirds around the British Isles. Oceanography and Marine Biology, 53, 55-80.

Maclean, I.M.D., Wright, L.J., Showler, D.A. and Rehfisch, M.M. (2009) A Review of Assessment Methodologies for Offshore Wind Farms. BTO report commissioned by COWRIE Ltd.

Marques, A.T., Batalha, H., and Bernardino, J. (2021). Bird Displacement by Wind Turbines: Assessing Current Knowledge and Recommendations for Future Studies. *Birds*, 2, 460-475. https://doi.org/10.3390/birds2040034

Masden, E.A., Haydon, D.T., Fox, A.D. and Furness, R.W. (2010) Barriers to movement: Modelling energetic costs of avoiding marine wind farms amongst breeding seabirds. Marine Pollution Bulletin, 60, 1085-1091.

Masden E.A., Reeve, R., Desholm, M., Fox, A.D., Furness, R.W. and Haydon, D.T. (2012) Assessing the impact of marine wind farms on birds through movement modelling. Journal of the Royal Society Interface, 9, 2120-2130.

Mendel, B., Sonntag, N., Wahl, J., Schwemmer, P., Dries, H., Guse, N., Müller, S. and Garthe, S. (2008) Profiles of seabirds and waterbirds of the German North and Baltic Seas: Distribution, ecology and sensitivities to human activities within the marine environment. Bundesamt Für Naturschutz, Bonn – Bad Godesberg.

Mendel, B., Kotzerka, J., Sommerfeld, J., Schwemmer, H., Sonntag, N., and Garthe, S. (2014) Effects of the alpha ventus offshore test site on distribution patterns, behaviour and flight heights of seabirds. In Ecological Research at the Offshore Wind farm alpha ventus pp. 95-110. Springer Fachmedien, Wiesbaden.

Mendel, B, Schwemmer, P., Peschko, V., Müller, S., Schwemmer, H., Mercker, M. & Garther, S. (2019) Operational offshore wind farms and associated ship traffic cause profound changes in distribution patterns of Loons (Gavia spp.). Journal of Environmental Management 231:429-438. https://doi.org/10.1016/j.jenvman.2018.10.053

Mitchell, P.I., Newton, S.F., Ratcliffe, N. and Dunn, T.E. (2004) Seabird Populations of Britain and Ireland. T. and A.D. Poyser, London.

Mitschke, A., Garthe, S. and Hüppop, O. (2001) Erfassung der Verbreitung, Häufigkeiten und Wanderungen von See- und Wasservögeln in der deutschen Nordsee und Entwicklung eines Konzeptes zur Umsetzung internationaler Naturschutzziele. BfN-Skripten 34, Bonn–Bad Godesberg.

MMO (2018) Displacement and habituation of seabirds in response to marine activities. A report produced for the Marine Management Organisation. MMO Project No: 1139, May 2018.

Murray, S., Harris, M.P. and Wanless, S. (2015) The status of the gannet in Scotland in 2013-14. Scottish Birds, 35, 3-18.

Musgrove, A.J., Aebischer, N.J., Eaton, M.A., Hearn, R.D., Newson, S.E., Noble, D.G., Parsons, M., Risely, K. and Stroud, D.A. (2013) Population estimates on birds in Great Britain and the United Kingdom. British Birds, 106, 64–100.

Natural England (2022a). Interim Advice on Updated Collision Risk Modelling Parameters (July 2022).

Natural England (2022b). Offshore Wind marine Environmental Assessment: Best Practice Advice for Evidence and Data Standards.

Natural England (2022c). Natural England's response to avian influenza in wild birds – August 2022. Available at: https://naturalengland.blog.gov.uk/2022/08/04/natural-englands-response-to-avian-influenza-in-wild-birds-august-2022

Norfolk Boreas Ltd (2018). Norfolk Boreas Offshore Wind Farm Chapter 13 Offshore Ornithology. Preliminary Environmental Report Volume 1. Document Reference PB5640-005-13.

Norfolk Boreas Ltd (2019). Norfolk Boreas Offshore Wind Farm Chapter 13 Offshore Ornithology. Environmental Statement

Norfolk Vanguard Ltd (2018). Norfolk Vanguard Offshore Wind Farm Chapter 13 Offshore Ornithology. Environmental Statement Volume 1. Document Reference 6.1.13.

Norfolk Vanguard Ltd (2019a) The Applicant Responses to First Written Questions Appendix 3.1 - Red-throated diver displacement https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-002249-Womble%20Bond%20Dickinson%20on%20Behalf%20of%20Norfolk%20Vanguard%20-%20Appendices%20to%20written%20Questions-%20Email%204.pdf

Norfolk Vanguard Ltd (2019b) The Applicant Responses to First Written Questions Appendix 3.3 Operational Auk and Gannet Displacement: update and clarification https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-002249-Womble%20Bond%20Dickinson%20on%20Behalf%20of%20Norfolk%20Vanguard%20-%20Appendices%20to%20written%20Questions-%20Email%204.pdf

Norfolk Vanguard Ltd (2019c) Offshore Ornithology Assessment Update for Deadline 6 https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-002764-ExA;%20AS;%2010.D6.17_Norfolk%20Vanguard%20Offshore%20Wind%20Farm%20Offshore%20Ornithology%20Assessment%20Update%20for%20Deadline%206.pdf

Norfolk Vanguard Ltd (2019d) Offshore Ornithology Cumulative and In-combination Collision Risk Assessment Update for Deadline 7 https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-002882-ExA;%20AS;%2010.D7.21_Offshore%20Ornithology%20Cumulative%20and%20In-combination%20Collision%20Risk%20Assessment.pdf

O'Brien, S.H., Wilson, L.J., Webb, A., & Cranswick, P.A. (2008). Revised estimate of numbers of wintering Red-throated Divers Gavia stellata in Great Britain, Bird Study, 55:2, 152-160, DOI: 10.1080/00063650809461517

Ost, M., Lehikoinen, A., Poysa, H. and Linden, A. (2016) European ducks in a changing world: Human impacts, population processes and species interactions. Ornis Fennica, 93, 1-2.

Pearce-Higgins, J.W. and Holt, C.A. (2013) Impacts of climate change on waterbirds. Marine Climate Change Impacts Partnership Science Review, 2013, 149-154.

Pearce-Higgins, J.W. (2021). Climate Change and the UK's Birds. British Trust for Ornithology Report, Thetford, Norfolk.

Pennycuick, C.J. (1987) Flight of auks (Alcidae) and other northern seabirds compared with southern Procellariiformes: ornithodolite observations. Journal of Experimental Biology, 128, 335-347.

Percival, S. (2010) Kentish Flats Offshore Wind farm: Diver Surveys 2009-10. Report to Vattenfall. Ecology Consulting, Durham.

Percival, S. (2013) Thanet Offshore Wind Farm. Ornithological Monitoring 2012-2013 Final Report. (http://ecologyconsult.co.uk/index_htm_files/Ornithological%20monitoring%202012-13%20v3.pdf)

Percival, S.M. (2014) Kentish Flats Offshore Wind farm: Diver Surveys 2011-12 and 2012-13. Ecology Consulting report to Vattenfall.

Petersen, I.K., Christensen, T.K., Kahlert, J., Desholm, M. and Fox, A.D. (2006) Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark. NERI report commissioned by DONG energy and Vattenfall A/S 2006.

Piotrowski (2012).Lesser black-backed gull and herring gull breeding colonies in Suffolk. Suffolk Birds, 62, 23-30. https://issuu.com/suffolknaturalistssociety/docs/sb62a, accessed February 2023.

Planning Inspectorate (2014) Rampion Offshore Wind Farm and connection works Examining Authority's Report of Findings and Conclusions and Recommendation to the Secretary of State for Energy and Climate Change. Available online at: http://infrastructure.planningportal.gov.uk/wp-content/ipc/uploads/projects/EN010032/3.%20Post%20Decision%20Information/Decision/Rampion%20Recommendation%20Report.pdf

Planning inspectorate (2015) Advice note seventeen: Cumulative Effects Assessment relevant to nationally significant infrastructure projects. https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-17/ Accessed February 2023.

Planning Inspectorate (2018) Advice note nine: Using the Rochdale Envelope, Version 3. Planning Inspectorate, Bristol. https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2013/05/Advice-note-9.-Rochdale-envelope-web.pdf https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-nine-rochdale-envelope/, accessed February 2023.

Planning Inspectorate (2019). Advice Note Seventeen: Cumulative Effects Assessment. Available at: https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-17/. Accessed January 2023.

Planning Inspectorate (2022). Advice Note Ten: Habitats Regulations Assessment relevant to nationally significant infrastructure projects (Version 9). Available at: https://infrastructure.planninginspectorate.gov.uk/legislation-and-advice/advice-notes/advice-note-ten/. Accessed January 2023.

R Core Team (2016) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. www.R-project.org

Ratcliffe, N. (2004) Causes of seabird population change. Pp 407-437 In Mitchell, P.I., Newton, S.F., Ratcliffe, N. And Dunn, T.E. (Eds.) Seabird Populations of Britain and Ireland. T.and A.D. Poyser, London.

Ratcliffe, N., Mitchell, I., Varnham, K., Verboven, N. and Higson, P. (2009) How to prioritize rat management for the benefit of petrels: a case study of the UK, Channel Islands and Isle of Man. Ibis, 151, 699-708.

RenewableUK. (2013) Cumulative Impact Assessment Guidelines – Guiding Principles for Cumulative Impacts Assessment in Offshore Wind farms. RenewableUK, London.

Robinson, R.A. (2005) Bird Facts: profiles of birds occurring in Britain and Ireland. BTO Research Report 407, BTO, Thetford.

Rock, P. and Vaughan, I.P. (2013) Long-term estimates of adult survival rates of urban herring gulls Larus argentatus and lesser black-backed gulls Larus fuscus. Ringing and Migration, 28, 21-29.

Sandvik, H., Erikstad, K.E. and Saether, B.-E. (2012) Climate affects seabird population dynamics both via reproduction and adult survival. Marine Ecology Progress Series, 454, 273-284.

Schwemmer, P. Mendel, B., Sonntag, N., Dierschke, V. and Garthe, S. (2011) Effects of ship traffic on seabirds in offshore waters: implications for marine conservation and spatial planning. Ecological Applications, 21, 1851-1860.

Scottish Power Renewables (2017). East Anglia TWO Offshore Windfarm Scoping report.

Searle, K., Mobbs, D., Butler, A., Bogdanova, M., Freeman, S., Wanless, S. and Daunt, F. (2014) Population consequences of displacement from proposed offshore wind energy developments for seabirds breeding at Scottish SPAs (CR/2012/03). Report to Marine Scotland Science. Centre for Ecology and Hydrology, Penicuik.

Searle, K.R., Mobbs, D.C., Butler, A., Furness, R.W., Trinder, M.N. and Daunt, F. (2017) Fate of displaced birds. Report to Marine Scotland Science. Centre for Ecology and Hydrology, Penicuik.

Skov, H., Heinänen, S., Norman, T., Ward, R.M., Méndez-Roldán, S. and Ellis, I. (2018) ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust, United Kingdom.

SNCB (2017; updated January 2022) Joint SNCB Interim Displacement Advice Note. Natural Resources Wales (NRW), Department of Agriculture, Environment and Rural Affairs / Northern Ireland Environment Agency (DAERA/NIEA), Natural England (NE), Scottish Natural Heritage (SNH) and Joint Nature Conservation Committee (JNCC).

Speakman, J., Gray, H. and Furness, L. (2009) University of Aberdeen report on effects of offshore wind farms on the energy demands of seabirds. Report to the Department of Energy and Climate Change.

Stienen, E.W., Waeyenberge, V., Kuijken, E. and Seys, J. (2007) Trapped within the corridor of the southern North Sea: the potential impact of offshore wind farms on seabirds. In Birds and Wind farms. de Lucas, M., Janss, G.F.E. and Ferrer, M. (Eds). Quercus, Madrid.

Stone, C.J. Webb, A., Barton, C., Ratcliffe, N., Reed, T.C. Tasker, M.L. Camphuysen, C.J. and Pienkowski, M.W. (1995) An atlas of seabird distribution in north-west European waters. JNCC, Peterborough.

Sydeman, W.J., Thompson, S.A., Anker-Nilssen, T., Arimitsu, M., Bennison, A., Bertrand, S., Boersch-Supan, P., Boyd, C., Bransome, N., Crawford, R.J.M., Daunt, F., Furness, R.W., Gianuca, D., Gladics, A., Koehn, L., Lang, J., Logerwell, E., Morris, T.L., Phillips, E.M., Provencher, J., Punt, A.E., Saraux, C., Shannon, L., Sherley, R.B., Simeone, A., Wanless, R.M., Wanless, S. and Zador, S. (2017) Best practices for assessing forage fish fisheries – seabird resource competition. Fisheries Research, 194, 209-221.

Tasker, M.L., Camphuysen, C.J., Cooper, J., Garthe, S., Montevecchi, W.A. and Blaber, S.J.M. (2000) The impacts of fishing on marine birds. ICES Journal of Marine Science, 57, 531-547.

Thaxter, C.B., Lascelles, B., Sugar, K., Cook, A.S.C.P., Roos, S., Bolton, M., Langston, R.H.W. and Burton, N.H.K. (2012) Seabird foraging ranges as a preliminary tool for identifying Marine Protected Areas. Biological Conservation, 156, 53-61.

Thaxter, C.B., Ross-Smith, V.H., Bouten, W., Masden, E.A., Clark, N.A., Conway, G.J., Barber, L., Clewley, G.D. and Burton, N.H.K. (2018) Dodging the blades: new insights into three-dimensional space use of offshore wind farms by lesser black-backed gulls Larus fuscus. Marine Ecology Progress series, 587, 247-253.

Thaxter, C.B,. Ross- Smith, V.H., Bouten, W., Clark, N.A., Conway, G.J., Rehfisch, M.M., Burton, N.H.K. 2015. Seabird–wind farm interactions during the breeding season vary within and between years: A case study of lesser black-backed gull Larus fuscus in the UK. Biological conservation 186:347-358

Topping, C. and Peterson, I.K. (2011) Report on a red-throated diver agent-based model to assess the cumulative impact from offshore wind farms. Report commissioned by the Environment Group. Aarhus University. Danish Centre for Environment and Energy.

Trinder, M. (2014) Flamborough and Filey Coast pSPA Seabird PVA Final Report, submitted for Hornsea Wind Farm Project ONE, Appendix N, Deadline V, 14 May 2014.

Uttley, J.D., Walton, P., Monaghan, P. and Austin, G. (1994) The effects of food abundance on breeding performance and adult time budgets of guillemots Uria aalge. Ibis, 136, 205–213.

Vallejo, G.C., Grellier, K., Nelson, E.J., McGregor, R.M., Canning, S.J., Caryl, F.M. and McLean, N. (2017) Responses of two marine top predators to an offshore wind farm. Ecology and Evolution, 7, 8698-8708.

Vanermen, N., Stienen, E.W.M., Onkelinx, T., Courtens, W., Van De Walle, M., Verschelde, P. and Verstraete, H. (2012) Seabirds and Offshore Wind Farms Monitoring Results 2011. Research Institute for Nature and Forest: Study commissioned by the Royal Belgian Institute for Natural Sciences, Management Unit of the North Sea Mathematical Models.

Vanermen, N., Stienen, E.W.M., Courtens, W., Onkelinx, T., Van de walle, M. and Verstraete, H. (2013) Bird monitoring at offshore wind farms in the Belgian part of the North Sea - Assessing seabird displacement effects. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2013 (INBO.R.2013.755887). Instituut voor Natuur- en Bosonderzoek, Brussel.

Vanermen, N, Onkelinx, T, Courtens, W., Van de walle, M., Hilbran Verstraete, and Stienen E.W.M. (2014) Seabird avoidance and attraction at an offshore wind farm in the Belgian part of the North Sea. Hydrobiologia. DOI 10.1007/s10750-014-2088-x

Votier, S.C., Furness, R.W., Bearhop, S., Crane, J.E., Caldow, R.W.G., Catry, P., Ensor, K., Hamer, K.C., Hudson, A.V., Kalmbach, E., Klomp, N.I., Pfeiffer, S., Phillips, R.A., Prieto, I., and Thompson, D.R. (2004) Changes in fisheries discard rates and seabird communities. Nature, 427, 727-730.

Votier, S.C., Hatchwell, B.J., Beckerman, A., Mccleery, R.H., Hunter, F.M., Pellatt, J., Trinder, M. and Birkhead, T.R. (2005) Oil pollution and climate have wide-scale impacts on seabird demographics. Ecology Letters, 8, 1157-1164.

Votier, S.C., Birkhead, T.R., Oro, D., Trinder, M., Grantham, M.J., Clark, J.A., Mccleery, R.H. and Hatchwell, B.J. (2008) Recruitment and survival of immature seabirds in relation to oil spills and climate variability. Journal of Animal Ecology, 77, 974-983.

Votier, S.C., Bicknell, A., Cox, S.L., Scales, K.L. and Patrick, S.C. (2013) A bird's eye view of discard reforms: Bird-borne cameras reveal seabird/fishery interactions. Plos One, 8(3), E57376.

Wade, H.M., Masden E.M., Jackson, A.C. and Furness, R.W. (2016) Incorporating data uncertainty when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments. Marine Policy, 70, 108-113.

Walls, R., Canning, S., Lye, G., Givens, L., Garrett, C. and Lancaster, J. (2013) Analysis of Marine Environmental Monitoring Plan Data from the Robin Rigg Offshore Wind farm, Scotland (Operational Year 1). Natural Power report for E.ON Climate and Renewables UK.

Wernham, C.V., Toms, M.P., Marchant, J.H., Clark, J.A., Siriwardena, G.M. and Baillie, S.R. (eds). (2002) The Migration Atlas: Movements of the birds of Britain and Ireland. T. and A.D. Poyser, London.

Wischnewski, S., Fox, D.S., McCluskie, A. & Wright, L.J. (2017). Seabird tracking at the Flamborough & Filey Coast: Assessing the impacts of offshore wind turbines. Pilot study 2017 Fieldwork report & recommendations. Report to Orsted.

Woodward, I., Thaxter, C.B., Owen, E.,Cook, A.S.C.P. (2019). Desk-based revision of seabird foraging ranges used for HRA screening. Report of work carried out by the British Trust for Ornithology on behalf of NIRAS and The Crown Estate BTO Research Report No. 724

Wright, L.J., Ross-Smith, V.H., Massimino, D., Dadam, D., Cook, A.S.C.P. and Burton, N.H.K. (2012) Assessing the risk of offshore windfarm development to migratory birds designated as features of UK Special Protection Areas (and other Annex I species). Strategic Ornithological Support Services. Project SOSS-05. BTO Research Report No. 592.

WWT (2012) SOSS-04 Gannet PVA – Demographic data, population model and outputs. Available from www.bto.org/science/wetland-and-marine/soss/projects

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