East Anglia ONE North Offshore Windfarm

Chapter 12

Ornithology

Preliminary Environmental Information
Volume 1
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Appendix number	Title
12.1	Baseline Offshore Ornithology Technical Report

Glossary of Acronyms

APEM	APEM is an environmental consultancy with specialist expertise in digital aerial survey
AR	Avoidance Rates
BDMPS	Biologically Defined Minimum Population Scale/size
BEIS	Business Environment and Industrial Strategy
BoCC	Birds of Conservation Concern
BTO	British Trust for Ornithology
CAA	Civil Aviation Authority
CIA	Cumulative Impact Assessment
CRM	Collision Risk Modelling
EA1N	East Anglia ONE North
EA3	East Anglia THREE
EATL	East Anglia THREE Limited
EC	European Commission
EIA	Environmental Impact Assessment
EMF	Electro-magnetic Field
EPP	Evidence Plan Process
ES	Environmental Statement
ESAS	European Seabirds at Sea database
ETG	Expert Topic Group
EU	European Union
FAME	Future of the Atlantic Marine Environment
GGOWL	Greater Gabbard Offshore Wind Farm Limited
GPS	Global Positioning System
HRA	Habitats Regulations Assessment
ICES	International Council for the Exploration of the Sea
IEEM	Institute of Ecology and Environmental Management
JNCC	Joint Nature Conservation Committee
KDE	Kernel Density Estimate
MAGIC	Multi-Agency Geographic Information for the Countryside
MCA	Maritime and Coastguard Agency
MLWS	Mean Low Water Springs
MMO	Marine Management Organisation
MRSea	A spatial modelling software package
MS	Method Statement
MW	Megawatt
NAF	Nocturnal Activity Factor
NE	Natural England
NGO	Non-Governmental Organisation
NPPF	National Planning Policy Framework
NPS	National Policy Statement
ORJIP	Offshore Renewables Joint Industry Programme
OWEZ	Offshore Wind Farm Egmond aan Zee, Netherlands
OWF	Offshore Windfarm
PAWP	Princess Amalia Wind Park, Netherlands
PBR	Potential Biological Removal
PCH	Potential Collision Height
PEI or PEIR	Preliminary Environmental Information Report
PVA	Population Viability Analysis
RSPB	Royal Society for the Protection of Birds

SAC	Special Area of Conservation
SAR	Search and Rescue
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
ZAP	Zonal Appraisal and Planning
ZEA	Zonal Environmental Appraisal

Glossary of Terminology

Applicant	East Anglia ONE North Limited
As built	A term used for offshore windfarm developments that are operational and where the turbine array 'as built' is different to the worst case scenario in the Environmental Impact Assessment for the development (for example where a windfarm is built out with fewer turbines than the consented design envelope).
Construction, operation and maintenance platform	A fixed offshore structure required for construction, operation, and maintenance personnel and activities.
East Anglia ONE North project	The proposed project consisting of up to 67 wind turbines, up to four offshore electrical platforms, up to one construction operation and maintenance platform, inter-array cables, platform link cables, up to one operational meteorological mast, up to two offshore export cables, fibre optic cables, landfall infrastructure, onshore cables and ducts, onshore substation, and National Grid infrastructure.
East Anglia ONE North windfarm site	The red line boundary in which all wind turbines and ancillary infrastructure will be located.
East Anglia Zone	The broader area defined for Round 3 applications within which the East Anglia ONE North windfarm site is located together with East Anglia One, East Anglia THREE, East Anglia TWO, Norfolk Boreas and Norfolk Vanguard.
European site	Sites designated for nature conservation under the Habitats Directive and Birds Directive, as defined in regulation 8 of the Conservation of Habitats and Species Regulations 2017 and regulation 18 of the Conservation of Offshore Marine Habitats and Species Regulations 2017. These include candidate Special Areas of Conservation, Sites of Community Importance, Special Areas of Conservation and Special Protection Areas.
Evidence Plan Process	A voluntary consultation process with specialist stakeholders to agree the approach to the EIA and information to support HRA.
Inter-array cables	Offshore cables which link the wind turbines to each other and the offshore electrical platforms, these cables will include fibre optic cables.
Inter-array cables	Offshore cables which link the wind turbines to each other and the offshore electrical platforms, these cables will include fibre optic cables.
Landfall	Where the offshore cables come ashore, between Sizewell and Leiston.
Meteorological mast	An offshore structure which contains metrological instruments used for wind data acquisition.
Meteorological mast	An offshore structure which contains metrological instruments used for wind data acquisition.
Migration free breeding season	The breeding season for migratory seabird species is defined as a wider breeding season and a narrower window known as the migration free breeding season. In a given species, the timing of breeding will vary depending on the location of the breeding area; with the start of breeding usually later in more northerly locations. Thus, while birds at some colonies are beginning to nest, others may still be migrating to breeding sites. A core or migration free breeding season is defined as the period when all or the majority of breeding adults of a given species are present at breeding colonies.
Natura 2000 site	A site forming part of the network of sites made up of Special Areas of Conservation and Special Protection Areas designated respectively under the Habitats Directive and Birds Directive.
Offshore cable corridor	The corridor of sea bed from the East Anglia ONE North windfarm site to the landfall site within which the offshore export cables will be located.
Offshore development area	Both the East Anglia ONE North windfarm site and the East Anglia ONE North offshore cable corridor combined.

Offshore electrical platform	A fixed structure located within the windfarm area, containing electrical equipment to aggregate the power from the wind turbines and convert it into a more suitable form for export to shore.
Offshore export cables	The cables which would bring electricity from the offshore electrical platforms to the landfall, these cables will include fibre optic cables.
Platform link cables	An electrical cable which links one or more offshore platforms, this will include fibre optic cables.
Safety zones	A marine area declared for the purposes of safety around a renewable energy installation or works / construction area under the Energy Act 2004.
Scour protection	Protective materials to avoid sediment being eroded away from the base of the foundations as a result of the flow of water.

12 Ornithology

12.1 Introduction

1. This chapter is an assessment of the potential impacts that may arise from the construction, operation and decommissioning of the offshore components of the proposed East Anglia ONE North project. It has been prepared by Royal HaskoningDHV from baseline survey work and data processing undertaken by APEM Ltd and data analyses by MacArthur Green.

2. The chapter describes the offshore components of the proposed project in relation to ornithology; 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 potential impacts on birds.

3. An ornithological assessment of the export cable landfall and onshore components of the project is included in ***Chapter 23 Onshore Ornithology***.

4. Full details of the baseline data for the offshore ornithology assessment, acquired through the surveys specifically carried out within the East Anglia ONE North windfarm site and a 4km buffer can be found in ***Appendix 12.1 Baseline Offshore Ornithology Technical Report***.

12.2 Consultation

5. Consultation is a key driver of the Development Consent Order (DCO) application process. To date, consultation regarding offshore ornithology has been conducted through formal submission of the Scoping Report submitted in November 2017 (SPR 2017) and through Expert Topic Group (ETG) Meetings in April 2017 and March 2018 involving Natural England and the Royal Society for the Protection of Birds (RSPB) as detailed in ***section 5.3.3*** of ***Chapter 5 EIA Methodology***. Feedback received through this process has been considered in preparing incorporated into the PEIR where appropriate and this chapter will be updated following the next stage of consultation for the final assessment submitted with the Development Consent Order (DCO) application.

6. Responses from stakeholders have been captured in ***Table 12.1*** below and a reference included to where responses are addressed within this Preliminary Environmental Information Report (PEIR).

7. Correspondence received in relation to transboundary consultations is summarised in ***section 12.8*** below.

8. Further consultation will continue to be undertaken once the PEIR is made available and during further ETG meetings conducted between PEIR submission and the DCO application submission.

Table 12.1 Consultation Responses

Consultee	Date / Document	Comment	Response / where addressed in the PEI
Natural England	08/12/2017 Scoping Response	NE maintains that a seasonal restriction is put in place from Nov – Feb for cable installation in order to mitigate against impacts to red-throated diver. This species has been particularly affected and displaced from large areas within the Outer Thames Estuary due to OWF construction. To reduce impacts further it would be a sensible option to cease works/activities that interact with the designated sites during this period.	A seasonal restriction has been considered further as part of the assessment, but is not considered to be necessary given the small predicted impact of disturbance on red-throated diver (see ***section 12.6.1.1.1***). A best practice protocol for minimising disturbance to red-throated divers will be adopted as for East Anglia THREE.
Natural England	08/12/2017 Scoping Response	It appears that the Birds of Conservation Concern (BoCC) listing from BoCC 3 (Eaton et al. 2009) has been used. This listing has since been updated by BoCC 4, we advise the Applicant to see Eaton et al. (2015), available online at: http://britishbirds.co.uk/wp-content/uploads/2014/07/BoCC4.pdf	Updated to BoCC 4 for this assessment, see ***Table 12.9***.
Natural England	08/12/2017 Scoping Response	We note the comments on the need for mitigation will be to some extent dependent on the results of site specific survey and the impact assessment. However, Natural England's advice at the EA3 hearing was that adverse effect on site integrity cannot be excluded in-combination with other plans or projects in respect of predicted mortality from collision on kittiwake from Flamborough Head and Bempton Cliff SPA and Flamborough and Filey Coast pSPA. Therefore Natural England would welcome any mitigation measures, such as raising the minimum hub height to be	East Anglia ONE North will review impact magnitudes as they become apparent and consider options for mitigation as they arise. Further work has been undertaken to refine realistic cumulative turbine numbers. This includes adjustments to reflect new information on nocturnal activity levels, and reference to revised collision risk figures for developments that are operational and where the turbine array 'as built' has a lower collision risk than the worst case scenario in the Environmental Impact Assessment (see assessment of

Consultee	Date / Document	Comment	Response / where addressed in the PEI
		considered at the earliest opportunity.	cumulative impacts of collision in ***section 12.7.4***).
Natural England	08/12/2017 Scoping Response	We agree with the use of Furness (2015) for use of definitions of biological seasons. However, further consideration will need to be given to lesser black-backed gull as the breeding season for individuals breeding at Alde Ore Estuary SPA will be wider than the May- July period stated as the breeding season only period, given that the project is within the foraging range of Alde-Ore Estuary SPA We suggest that this is discussed and agreed during Evidence Plan Process.	The breeding season collision risk estimate for lesser black-backed gull is based on the full breeding season (April to August; Furness, 2015) as opposed to the migration-free (core) breeding period. Although the project is within foraging range of lesser black-backed gulls breeding at the Alde Ore Estuary, tracking data from the SPA colony indicate that the proposed project is outwith the core foraging areas for this species during the breeding season (***section 12.6.2.3***). It is therefore considered unlikely that breeding birds from the SPA make regular use of the project.
Natural England	08/12/2017 Scoping Response	We note that surveys are planned between May to August 2018 to ensure there are 24 months of site-specific data available for assessment. We welcome the commitment to collect 24 months of site specific data at the East Anglia ONE North windfarm site. We also acknowledge that additional contextual information will come from surveys undertaken for the former East Anglia Zone and the former East Anglia TWO windfarm site.	Noted.
Natural England	08/12/2017 Scoping Response	In addition to the RSPB tagging studies from Flamborough, there is tracking data of lesser black-backed gulls from Alde-Ore Estuary SPA from the Department for Business Environment and Industrial Strategy (BEIS) funded BTO study, and there is further tracking planned as part of Galloper's post construction	Reference has been made to tracking data from the Alde-Ore Estuary SPA in the assessment (see ***section 12.6.2.3.1.3***). Where available we will attempt to obtain any additional relevant data for the assessment.

Consultee	Date / Document	Comment	Response / where addressed in the PEI
		monitoring which may be available during the examination.	
Natural England	08/12/2017 Scoping Response	We would like to clarify if it is planned to use MRSea on all the survey data, or whether reliable model based estimates require a minimum number of observations, and therefore may only be used for the more numerous species.	MRSea has not been used as there are limited data for many species. Design based outputs are however provided for all species irrespective.
Natural England	08/12/2017 Scoping Response	We agree that the species assessed will depend on the results of the surveys but will include: fulmar, gannet, kittiwake, lesser black-backed gull, great black-backed gull, herring gull, red-throated diver, guillemot, razorbill and puffin. We assume that other species assessed may include those that may pass through on migration but are only recorded in small numbers by snap shot aerial surveys, for example little gull. It is not clear in the Scoping Report (SPR 2017) if non-seabird migrants are also being considered.	An evidence plan supporting document on non-seabird migrants has been agreed based on nearby windfarm assessments, to justify scoping out non-seabird migrants, as these will have extremely low predicted impacts.
Natural England	08/12/2017 Scoping Response	We agree with the likely key issues listed in the Scoping Report (SPR 2017), although we would include lesser black-backed gull collision risk during the breeding season, in addition to the non-breeding season.	Noted and agreed, collision risk during the breeding season has been assessed for the project alone (***section 12.6.2.3***) and cumulatively (***section 12.7.4.2***).
Natural England	08/12/2017 Scoping Response	We agree with the list of expected features of the HRA however we recommend that impacts on other qualifying features of Flamborough and Filey Coast pSPA and other qualifying features from the Outer Thames Estuary SPA are also likely be included in the HRA.	We will screen for other impacts in the HRA as suggested. See the HRA Screening Report
Natural England	08/12/2017 Scoping Response	We are content with the proposals for measuring flight height, and would expect there to be enough samples within the site specific	BTO generic flight height data have been used for the assessment of collision risk (***section 12.6.2.3***) the aerial

Consultee	Date / Document	Comment	Response / where addressed in the PEI
		surveys to get an adequate sample particularly if the historic digital aerial survey data can be used. We would expect flight heights to be provided with confidence intervals to enable them to be used with a stochastic collision risk model should that be available by the time the application is submitted.	survey contractors advised ScottishPower Renewables that the flight height estimates from specific baseline survey data were not reliable. Thus, these data have not been used in the assessment.
RSPB	20/12/2017 Scoping Response	Given the recent concerns around potential collision risk to breeding kittiwake and gannet from other windfarms in the former East Anglia Zone, we strongly recommend that the potential for impacts on these species during the breeding season from the proposed East Anglia ONE North project is recognised in the table and the subsequent assessment.	Collision risk during the breeding season has been assessed for the project alone (***section 12.6.2.3***) and cumulatively (***section 12.7.4.2***).
RSPB	20/12/2017 Scoping Response	If figures for the migration-free breeding season were to be used in the PEI as in the Scoping Report, we consider that it would be necessary to attribute birds in the crossover months to breeding and dispersal in order to ensure collision risk to breeding birds is not underestimated.	With the exception of lesser black-backed gull, the turbine array of the proposed project is considered to be outwith the foraging range of the seabird species considered in the assessment of collision risk. Tracking data from the Alde Ore SPA colony of lesser black-backed gulls also indicate that the proposed project is outwith the core foraging areas for this species during the breeding season (***section 12.6.2.3***).
RSPB	20/12/2017 Scoping Response	We recommend the following paper as a recent critique of the methods used to assess impacts of offshore windfarms on seabird populations: Green, R. E., Langston, R. H., McCluskie, A., Sutherland, R., and Wilson, J. D. (2016). Lack of sound science in assessing windfarm impacts on seabirds. *Journal of Applied Ecology.*	Full use of available literature and evidence has been made in assessing the project's potential impacts for the PEIR.

Consultee	Date / Document	Comment	Response / where addressed in the PEI
The Planning Inspectorate	02/12/2017 Scoping Response	The Inspectorate does not agree that the impact of disturbance due to lighting during operation and decommissioning can be scoped out as no information to support this approach and no evidence demonstrating clear agreement with relevant statutory bodies has been provided. The PEI should include an assessment of this matter.	A review of the effects of operational lighting has been prepared (Furness, 2018). At the request of NE, construction and operational lighting is considered in the assessment (***sections 12.6.1.1*** and ***12.6.2.1***).
The Planning Inspectorate	02/12/2017 Scoping Response	The Inspectorate does not agree that the impact of transboundary impacts can be scoped out as no information to support this approach and no evidence demonstrating clear agreement with relevant statutory bodies has been provided.	Evidence is provided that Transboundary impacts can be screened out of the assessment (see ***section 12.8*** and the HRA screening report).
The Planning Inspectorate	02/12/2017 Scoping Response	It is noted that in the Scoping Report no ornithology surveys are proposed to be undertaken along the (cable corridor) AoS, based on conclusions drawn from existing survey information which was used to assess the potential impacts of East Anglia ONE and East Anglia THREE on red- throated diver, and that impacts are expected to be temporary and localised. No other bird species are referenced. The source of the data relied upon to support the conclusions in relation to the proposed East Anglia ONE North project should be identified in the PEI and its relevance to bird species other than red- throated diver should be explained. The evidence demonstrating clear agreement with relevant statutory bodies that no surveys are required must be provided.	The methods and evidence (including source of data) for assessing potential impacts along the cable corridor during construction are set out in ***section 12.6.1.1***. As for East Anglia ONE and East Anglia THREE the assessment for the export cable corridor considers red-throated diver based on survey data collected for the Outer Thames Estuary SPA.
The Planning Inspectorate	02/12/2017 Scoping Response	Only 2 of 4 European sites are identified in the Method Statement in relation to HRA and are referenced under designated sites in the Scoping Report; Flamborough	The HRA screening and assessment provides a comprehensive review of potential connectivity of designated sites. This is

Consultee	Date / Document	Comment	Response / where addressed in the PEI
		and Filey Coast pSPA and Alde-Ore Estuary SPA are omitted. In addition, although the little gull is identified in MS paragraph 46 as a feature of the Greater Wash SPA, it is not included in the list of receptors likely to be affected by the Proposed Development provided in paragraph 44 of the MS. While the information in the ES should not duplicate that in the HRA Report, the Inspectorate expects it to be consistent between the two documents.	reflected in the PEIR (***section 12.5.2***). Little gulls were recorded within the East Anglia ONE North windfarm site although in small numbers (***Table 12.11***) and were not screened in for assessment for any potential impacts.
The Planning Inspectorate	02/12/2017 Scoping Response	It should be clearly explained in the PEI how the value of a feature will be taken into account in judging its sensitivity and the overall assessment of significance.	This is explained in the impact assessment methodology (***section 12.4.3***)
Natural England	18/05/2018 Comments on Expert Topic Group (ETG) meeting agreement points	Agree that BTO flight height data and presentation of Option1 and Option 2 outputs is acceptable given the uncertainty around site specific flight height data.	BTO flight height data and Option 2 outputs used in the assessment of collision risk. Option 1 outputs are provided in the Technical Appendix. See ***section 12.6.2.3*** and ***Appendix 12.1 Technical Report***.
Natural England	18/05/2018 Comments on ETG meeting agreement points	NE have advised SPR that the consequences of lighting for birds during all phases of the project (including construction) should be considered, so any potential impacts and mitigation can be explicitly stated.	A review of the effects of operational lighting has been prepared (Furness 2018). At the request of NE, construction and operational lighting is considered in the assessment (***sections 12.6.1.1*** and ***12.6.2.1***).
Natural England	18/05/2018 Comments on ETG meeting agreement points and evidence plan supporting	Impacts on migrating non-seabirds can be scoped out.	Migrating non-seabird species scoped out and not considered further.

Consultee	Date / Document	Comment	Response / where addressed in the PEI
	document on non-seabird migrants		
Natural England	18/05/2018 Comments on ETG meeting agreement points	Agree that transboundary impacts on non-UK ornithology receptors can be scoped out subject to consultation with Scottish Natural Heritage (SNH))	Transboundary effects on non-UK receptors have been scoped out. Awaiting feedback from SNH.

9. Ongoing public consultation has been conducted through a series of Public Information Days (PIDs) and Public Meetings. PIDs have been held throughout Suffolk in November 2017, March 2018, and June / July 2018 with further events planned in 2019. A series of stakeholder engagement events were also undertaken in October 2018 as part of consultation phase 3.5. These events were held to inform the public of potential changes to the onshore substation location. This consultation aims to ensure that community concerns are well understood and that site specific issues can be taken into account, where practicable. Consultation phases are explained further in ***Chapter 5 EIA Methodology.*** No public consultation feedback specific to Offshore Ornithology has been raised during any the public consultation undertaken to date. Full details of the proposed East Anglia ONE North project consultation process will be presented in the Consultation Report, which will be submitted as part of the DCO application

12.3 Scope

10. This chapter describes the ornithological interests of the windfarm site and the offshore cable corridor to landfall, and evaluates the potential impacts of the proposed East Anglia ONE North project on these interests.

11. The baseline section describes the distribution and abundance of bird species recorded during surveys of the site. This includes flight characteristics (e.g. height and direction), ecology, seasonality and behaviour.

12. The predicted magnitude of impacts and significance of effects arising due to construction, operation and decommissioning of the windfarm on the ornithological interests of the site are assessed on the basis of the worst case development scenario. Measures to prevent or reduce significance of the possible effects are discussed where appropriate. Cumulative impacts arising from the site and offshore cable corridor and other offshore operations are assessed as appropriate.

12.3.1 Study Area

13. A study area was defined that was relevant to the consideration of potential impacts on offshore ornithological receptors. 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.

14. This study area includes the East Anglia ONE North windfarm site and a 4km buffer placed around it (***Figure 12.1***). Monthly aerial surveys of the study area began in September 2016 and were completed in August 2018 (24 months in total). The final DCO submission will use all of these data, however the analysis and assessment in this PEIR has been undertaken prior to the data from the final aerial surveys being available, so is based on the first 21 monthly surveys (to May 2018) and will be updated when 24 surveys are available.

15. The data collected during these aerial surveys have been used to identify the bird species present and their seasonal abundance.

16. In addition to the windfarm area covered by aerial surveys, the study area over which potential impacts on offshore bird species were considered included the offshore cable corridor to the Mean Low Water Spring (MLWS) at its landfall location in the vicinity of Sizewell and Thorpeness. Refer to ***Chapter 23 Onshore Ornithology*** for assessment of impacts above the MLWS.

12.3.2 Worst Case

17. The design of the proposed East Anglia ONE North project (including number of wind turbines, layout configuration, requirement for scour protection, electrical design, etc.) is not yet fully determined, and may not be known until sometime after the DCO has been granted. Therefore, in accordance with the requirements of the Project Design Envelope (also known as the Rochdale Envelope) approach to Environmental Impact Assessment (EIA) (Planning Inspectorate 2018) (as discussed in ***Chapter 5 EIA Methodology***), realistic worst case scenarios in terms of potential effects upon offshore ornithology are adopted to undertake a precautionary and robust impact assessment.

18. The worst-case scenarios for potential impacts of the proposed project on offshore ornithology receptors from the construction, operation and decommissioning phases are described and presented in ***Table 12.2***. Where percentage areas affected have been calculated, these are based on a total windfarm site area of 208km^2 and an offshore cable corridor area of 133km^2 which results in a total offshore development area for the assessment of 341km^2.

19. Definition of the worst case scenarios has been made from consideration of the proposed East Anglia ONE North project parameters that are presented in

Chapter 6 Project Description, alongside the mitigation measures that have been embedded in the design (***section 12.3.3***).

20. It should be noted that after collision risk modelling (CRM) was conducted for the proposed East Anglia ONE North project, the design envelope was changed so that the maximum number of wind turbines increased from 60 to 67 for the 12MW scenario, and from 42 to 53 for the 15MW scenario. The collision risk modelling presented in this assessment is for the previous scenarios of 60 12MW, 42 15MW and 42 19MW turbines (see ***Appendix 12, Annex 3***). The collision risk model has not been re-run for the updated scenarios because of time constraints however an assessment of the updated parameters will be included within the ES. This model re-run will also incorporate the remaining three months of aerial survey data (see ***section 12.3.1***).

Table 12.2 Project Design: Realistic Worst Case Scenarios for the Proposed East Anglia ONE North Project

Impact	Parameter	Rationale
Construction		
Impact 1 Disturbance and Displacement from increased vessel activity	It is anticipated that the installation of the offshore elements will take a approximately 27 months. Construction works would be undertaken 24 hours a day and seven days a week offshore, dependent upon weather conditions. The maximum number of all types of vessels operating simultaneously within the offshore development area during construction would be 74. There would be up to three foundation installation vessels (i.e. Dynamic Positioning Heavy Lift Vessels) on site at any one time. Maximum of 981 helicopter round trips per annum assumed Installation of the export cable would take place over a twelve month period split into two separate six month periods and up to two cable laying vessels operating simultaneously. Speed of cable laying vessels – maximum speed of 300m per hour for ploughing or jetting and 80m per hour if trenching (see ***Chapter 6 Project Description***.	The worst case scenario is based on the longest construction period and the maximum numbers of plant on site and operational at a given time.

Impact	Parameter	Rationale
Impact 2 Indirect effects as a result of displacement of prey species due to increased noise and disturbance to sea bed	Spatial worst case impact– maximum hammer energy of 4,000 kilo Joules (kJ). Up to three foundation installation vessels (i.e. Dynamic Positioning Heavy Lift Vessels) on site at any one time. Temporal worst case impact No concurrent piling, 67 wind turbine foundations, four offshore electrical and one construction, operation and maintenance platforms, and one operational met mast.	See ***Chapter 10 Fish and Shellfish Ecology*** for a full breakdown of the maximum disturbed area of sea bed.
	The maximum worst case area of disturbance to benthic habitats during construction would be 10,602,179m^2 across the offshore development area, equivalent to 3% of the maximum offshore development footprint.	Breakdown is given in ***Chapter 9 Benthic ecology***.
	Disturbance / displacement from increased suspended sediment concentration from the excavation of up to 4,132,568m^3 of sediment in the offshore development area over the whole 27 month construction period.	Total sediment release over the construction period is given in ***Chapter 9 Benthic Ecology*** and ***Chapter 7 Marine Geology and Physical Processes.*** However, the release on a daily basis would be temporary and localised with sediment settling out quickly.
Operation		
Impact 3 Disturbance and displacement from offshore infrastructure and due to increased vessel and helicopter activity (Includes barrier effect)	A windfarm area of 208km^2 plus 4km buffer with maximum of 67 wind turbines, with a minimum spacing of 800m in row x 1200m between rows Maximum of 647 vessel round trips per annum to support windfarm operations. Maximum of 981 helicopter round trips per annum for scheduled and unscheduled maintenance. Lighting requirements for the offshore windfarm will need to be consistent with maritime and aviation safety requirements, and are expected to consist of:	Maximum density of turbines and structures across the offshore project area, which maximises the potential for avoidance and displacement.

Impact	Parameter	Rationale
	• Obstruction lighting compliant with CAA aviation safety requirements, as a minimum, requiring turbines on the periphery of the windfarm to be lit; • Maritime navigational safety lighting compliant with Trinity House Light House service safety requirements which requires navigational lighting to be visible at a distance of at least 5nm, lights would be required to be placed low on the turbines and electrical platforms. • Search and Rescue (SAR) lighting consistent with MCA safety requirements. These are most likely to be infra-red lighting which would only be activated during search and rescue operations.	
Impact 4 Collision risk	Maximum of 67 12MW (250m) wind turbines, other scenarios are 42 15MW (300m) or 42 19MW (300m) wind turbines.	CRM has been carried out for all turbine scenarios based on the turbine specifications in ***Appendix 12.1, Annex 3, Table 5***. For each species, the turbine scenario which produces the highest collision risk has been used in the assessment (see ***section 12.6.2.3*** below).
Impact 5 Indirect effects due to habitat loss / change for key prey species	The maximum possible sea bed footprint of the project, and therefore habitat loss, would be: **Windfarm Site Infrastructure** 1,857,078m^2 which constitutes 0.89% of the windfarm site (67 turbine foundations, four offshore electrical platforms, one construction, operation and maintenance platform, one meteorological mast, cable protection for platform link cables and inter-array cables. **Export Cable** 175,440m^2. **Total** The overall total footprint which could be subject to permanent habitat loss would	The maximum possible above sea bed footprint of the project including scour or scour protection plus any cable protection. See ***Chapter 9 Benthic Ecology*** *and* ***Chapter 10 Fish and Shellfish Ecology.***

Impact	Parameter	Rationale
	therefore be 2,032,518m^2 (0.59% of the offshore development area).	
Decommissioning		
Impact 6 Disturbance and Displacement from increased vessel activity	Assumed similar to construction and therefore a worst case would be as above in impact 1.	
Impact 7 Indirect effects as a result of displacement of prey species due to increased noise and disturbance to sea bed	There would be habitat disturbance effects over up to 2,635,518m^2 across the offshore development area (0.77% of maximum offshore development area). There would be limited noise disturbance to prey (as no piling and no use of explosives).	See ***Chapter 9 Benthic Ecology*** *and* ***Chapter 10 Fish and Shellfish Ecology.***

12.3.3 Embedded Mitigation

21. A number of mitigation measures which are embedded into the proposed project design are relevant to offshore ornithology receptors.

22. The East Anglia ONE North windfarm site was identified through the Zonal Appraisal and Planning process (***Chapter 4 Site Selection and Alternatives***). The windfarm area avoids European sites, although the cable corridor runs through the Outer Thames Estuary SPA (Royal HaskoningDHV 2018).

23. In order to reduce the spatial extent of potential disturbance and displacement impacts the decision was taken to use only one offshore cable corridor in the near shore for East Anglia ONE North and for East Anglia TWO. This measure avoids potential impacts over a wider area.

12.3.3.1 Best practice protocol for red-throated divers

24. As has been accepted for East Anglia THREE, a best-practice protocol for minimising disturbance to red-throated divers during construction will be adopted. This would comprise some or all of the following measures.

- restricting vessel movements to existing navigation routes (where the densities of divers are typically relatively low);
- where it is necessary to go outside of established navigational routes, selecting routes that avoid known aggregations of birds;
- maintaining direct transit routes (to minimise transit distances through areas used by divers);

- avoidance of over-revving of engines (to minimise noise disturbance); and,
- briefing of vessel crew on the purpose and implications of these vessel management practices (through, for example, tool-box talks).

25. Once further information is available about the port(s) that will be used for construction, operations and maintenance, then appropriate vessel traffic management measures including, where relevant, some or all of the above best practice examples can be formulated in agreement with Natural England.

26. If used, helicopters are a potential source of disturbance to red throated diver in the Outer Thames Estuary SPA. The minimum safe altitude for helicopters operating offshore is 1000 feet above the highest known obstacle within 5nm. It is considered that at these altitudes that any disturbance caused by the visual presence or noise of helicopters will be minimal and will not result in significant disturbance of red-throated diver.

12.3.4 Monitoring

27. Post-consent, the final detailed design of the proposed East Anglia ONE North project and the development of the relevant management plan(s) will refine the worst-case parameters assessed in the EIA. It is recognised that monitoring is an important element in the management and verification of the impacts of the proposed East Anglia ONE North project. Outline management plans, across a number of environmental topics, will be submitted with the DCO application. These outline management plans will contain key principles that provide the framework for any monitoring that could be required. The requirement for and final appropriate design and scope of monitoring will be agreed with the relevant stakeholders and included within the relevant management plan(s), submitted for approval, prior to construction works commencing.

12.4 Assessment Methodology

12.4.1 Legislation, Policy and Guidance

28. Legislation relevant to offshore ornithology is identified in ***Table 12.3*** along with a summary of important measures derived from it.

Table 12.3 Summary of Legislation and Relevant Measures

Legislation	Relevant Measures
Birds Directive - Council Directive 2009/147/EC on the Conservation of Wild Birds	This Directive provides 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 establishes a general scheme of protection for all wild birds (required by Article 5). The Directive requires national Governments

Legislation	Relevant Measures
	to establish SPAs and to have in place mechanisms to protect and manage them. The SPA protection procedures originally set out in Article 4 of the Birds Directive have been replaced by the Article 6 provisions of the Habitats Directive. The UK has triggered article 50 of the Treaty of European Union and is currently in the process of withdrawing from the European Union (EU). Recent UK Government Guidance (September 2018) states that 'The EU Withdrawal Act 2018 will ensure all existing EU environmental law continues to operate in UK law, providing businesses and stakeholders with certainty as we leave the EU.'
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).
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 and / or JNCC, and to not approve an application that would have an adverse effect on the integrity of a SAC or SPA (except under very tightly constrained conditions).
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. 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 under very tightly constrained conditions).

29. Policy relevant to offshore ornithology is identified in ***Table 12.4*** along with a summary of important measures derived from it.

Table 12.4 Summary of Policy and Relevant Measures

Policy	Relevant Measures
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 effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. 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
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.
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".
UK Post-2010 Biodiversity Framework	The 'UK Post-2010 Biodiversity Framework' succeeds the UK Biodiversity Action Plan. The Framework demonstrates how the work of the four countries and the UK contributes to achieving the Aichi Biodiversity Targets, and identifies the activities required to complement the country biodiversity strategies in achieving the targets.
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 recovery of biodiversity; healthy, resilient and adaptable

Policy	Relevant Measures
	marine and coastal ecosystems across their natural range; and oceans supporting viable populations of representative, rare, vulnerable and valued species.

30. The most relevant guidance on Environmental Impact Assessment (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 12.4.3*** and applied in this chapter is based on that CIEEM guidance.

31. 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:

- 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);
- 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); and
- Joint Response from the Statutory Nature Conservation Bodies to the Marine Scotland Science Avoidance Rate Review (JNCC et al., 2014).

12.4.2 Data Sources

12.4.2.1 Site specific surveys

32. Site specific aerial surveys of the East Anglia ONE North windfarm site (and 4km buffer) were conducted between September 2016 and August 2018, to complete 24 months of site-specific data available for assessment. The analysis and assessment in this PEIR has been undertaken prior to the data from the final

aerial surveys being available, so is based on the first 21 monthly surveys and will be updated when 24 surveys are available.

12.4.2.2 Other relevant surveys

33. The former East Anglia Zone has been subject to extensive ornithological surveys as described in this section. The survey data have not been used for quantitative analysis but provide context for the assessment.

34. For the purposes of Zonal Environmental Appraisal (ZEA), 18 months of high resolution aerial survey data were collected across the former East Anglia Zone, including;

- The Crown Estate Enabling Action data (video aerial survey) from November 2009 to March 2010; and
- APEM aerial survey data from April 2010 to April 2011.

35. Surveys of the East Anglia ONE North windfarm site (and 4km buffer) to the southwest were carried out between November 2015 and April 2016, September 2016 and October 2017, and May to August 2018, to complete 24 months of site-specific data. Between November 2009 and March 2011 and September 2011 and December 2012, 33 months of aerial survey were completed of the south-west portion of the former East Anglia Zone, which overlaps the East Anglia ONE North windfarm site by 92%.

36. Surveys of the East Anglia ONE windfarm site to the east were conducted between November 2009 and October 2011, and for the East Anglia THREE windfarm site to the north-east between September 2011 and August 2013.

12.4.2.3 Desk based assessment

37. The desk based assessment has drawn on a wide variety of published literature, covering both peer reviewed scientific literature and the 'grey literature' such as windfarm project submissions and reports. It includes the published literature on seabird ecology and distribution and on the potential impacts of windfarms (both derived from expert judgement and post-construction monitoring studies). The key topics for which the literature has been examined include:

38. Potential impacts of windfarms (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 and b).

- Bird population estimates (Mitchell et al. 2004; BirdLife International 2004; Holling et al. 2011; Holt et al. 2012; Musgrove et al. 2013; Furness 2015).

- Bird breeding ecology (Cramp and Simmons 1977-94; Del Hoyo et al. 1992-2011; Robinson 2005).
- Bird distribution (Stone et al. 1995; Brown and Grice 2005; Kober et al. 2010; Balmer et al. 2013).
- Bird migration and foraging movements (Wernham et al. 2002; Thaxter et al. 2012).
- Red-throated diver densities in the Outer Thames Estuary SPA (JNCC 2013) and data from an unpublished report on surveys carried out in 2013 by APEM for Natural England.
- East Anglia Offshore Wind: Zonal Assessment Report (APEM 2011).

39. Information on statutory 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) and the Natural England and JNCC web sites (www.naturalengland.org.uk; www.jncc.defra.gov.uk).

12.4.3 Impact Assessment Methodology

40. The impact assessment methodology applied in this Chapter is based on that described in ***Chapter 5 EIA Methodology***, adapted to make it applicable to ornithology receptors and aligned with the key guidance document produced on impact assessment on ecological receptors (CIEEM 2018).

41. The methodology applied in this chapter has also been the subject of extensive consultation with Natural England and RSPB through the Evidence Plan process for the proposed East Anglia ONE North project, and informed by discussion during the examination process for the consented East Anglia ONE and East Anglia THREE projects.

42. The assessment approach uses the conceptual 'source-pathway-receptor' model. The model identifies likely environmental impacts resulting from the proposed construction, operation and decommissioning of the offshore infrastructure. This process provides an easy to follow assessment route between impact sources and potentially sensitive receptors, ensuring a transparent impact assessment. The parameters of this model are defined as follows:

- Source – the origin of a potential impact (noting that one source may have several pathways and receptors) e.g. an activity such as cable installation and a resultant effect such as re-suspension of sediments.
- Pathway – the means by which the effect of the activity could impact a receptor e.g. for the example above, re-suspended sediment could settle and smother the sea bed.

- Receptor – the element of the receiving environment that is impacted e.g. for the above example, bird prey species living on or in the sea bed are unavailable to foraging birds.

12.4.3.1 Sensitivity

43. Definitions of the different sensitivity levels for ornithology receptors, using the example of disturbance from construction activity, are included in ***Table 12.5***.

Table 12.5 Definitions of the Different Sensitivity Levels for Ornithology Receptors in Relation to Construction Disturbance

Sensitivity	Definition
High	Ornithology receptor (bird species) has very limited tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people
Medium	Ornithology receptor (bird species) has limited tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people
Low	Ornithology receptor (bird species) has some tolerance of sources of disturbance such as noise, light, vessel movements and the sight of people.
Negligible	Ornithology receptor (bird species) is generally tolerant of sources of disturbance such as noise, light, vessel movements and the sight of people.

12.4.3.2 Conservation Value

44. The conservation value of ornithological receptors is based on the population from which individuals are predicted to be drawn. This reflects current understanding of the movements of 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 windfarm site and protected populations. Using this approach, the conservation importance of a species seen at different times of year may fall into any of the defined categories.

45. Example definitions of the value levels for ornithology receptors are given in ***Table 12.6***. These are related to connectivity with populations that are protected as qualifying species of Special Protection Areas (SPAs). SPAs are internationally designated sites which carry strong protection for populations of qualifying bird species and are a key consideration for the ornithology assessment.

Table 12.6 Definitions of the Conservation Value Levels for an Ornithology Receptor

Value	Definition
High	A species for which individuals at risk can be clearly connected to a particular Special Protection Area (SPA or pSPA).
Medium	A species for which individuals at risk are probably drawn from particular SPA or pSPA populations, although other populations (both SPA and non-SPA) may also contribute to individuals at risk
Low	A species for which individuals at risk on have no known connectivity to SPAs, or for which no SPAs are designated.

12.4.3.3 Magnitude

46. The definitions of the magnitude levels for ornithology receptors are set out in ***Table 12.7***. This set of definitions has been determined on the basis of changes to bird populations.

Table 12.7 Definitions of the Magnitude Levels for Ornithology Receptors

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 not predicted to alter the long-term viability of the population and / or the integrity of the protected site. Recovery from that change predicted to be achieved in the medium-term (i.e. no more than five years) following cessation of the development activity.
Low	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that is sufficiently small-scale or of short duration to cause no long-term harm to the feature / population. Recovery from that change predicted to be achieved in the short-term (i.e. no more than one year) following cessation of the development activity.
Negligible	Very slight change from the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site. Recovery from that change predicted to be rapid (i.e. no more than circa 6 months) following cessation of the development related activity.

Value	Definition
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.

12.4.3.4 Impact Significance

47. Following the identification of the receptor value and sensitivity and the determination of the magnitude of the effect, the significance of the impact will be determined. That determination will be guided by the matrix as presented in ***Table 12.8***. Impacts shaded red or orange represent those with the potential to be significant in EIA terms (see ***paragraph 50*** below).

Table 12.8 Impact Significance Matrix

Sensitivity	Magnitude				
	High	**Medium**	**Low**	**Negligible**	**No change**
High	Major	Major	Moderate	Minor	No change
Medium	Major	Moderate	Minor	Negligible	No change
Low	Moderate	Minor	Minor	Negligible	No change
Negligible	Minor	Negligible	Negligible	Negligible	No change

48. 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.

49. In particular it should be noted that high conservation value and high sensitivity are not necessarily linked for a particular impact. A receptor could be of high conservation value (e.g. an interest feature of a SPA) but have a low or negligible physical/ecological 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 receptor can be used where relevant as a modifier for the sensitivity (to the effect) already assigned to the receptor.

50. For the purpose of this assessment 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.*'

51. Where possible, assessment is based upon quantitative and accepted criteria (for example, guidance from Statutory Nature Conservation Bodies (SNCBs) on collision risk modelling (Band 2012, and displacement (SNCB 2017), 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 impact is significant.

52. The assessment refers to and includes embedded mitigation (***section 12.3.3***). No further requirements for mitigation have been identified and thus there is no assessment of residual impacts post-mitigation.

12.4.4 Project Design Envelope

53. The project design envelope, which sets out a series of design options, is described in ***section 6.1.1*** of ***Chapter 6 Project Description***. In accordance with the Planning Inspectorate (2018), this has a reasoned range and maximum extent for a number of key parameters (for example options for different numbers of wind turbines of different size). The project design envelope is used to establish the maximum extent to which the project would impact on the environment. The final detailed design of the project, including spatial, temporal and installation methodology, could then vary within this 'Rochdale Envelope' without rendering the assessment inadequate.

54. For ornithology receptors, on a precautionary basis, the assessment is based on the aspects of the design envelope considered to be worst case in terms of effects on birds. These are summarised in ***Table 12.2*** above. For example, for collision risk, the worst case scenario is the design option with the highest estimated collision risk for a given bird species.

12.4.5 Cumulative Impact Assessment

55. The impact assessment methodology applied in this Chapter is based on that described in ***Chapter 5 EIA Methodology***, adapted to make it applicable to ornithology receptors.

56. The methodology has also been aligned with the approach to the assessment of cumulative impacts that has been applied by Ministers when consenting offshore windfarms and confirmed in recent consent decisions. It also follows the

approach set out in recent guidance from the Planning Inspectorate (Planning Inspectorate 2015) and from the renewables industry (RenewableUK 2013).

12.4.6 Transboundary Impact Assessment

57. The transboundary impact assessment methodology applied in this Chapter is based on that described in ***Chapter 5 EIA Methodology***, adapted to make it applicable to ornithology receptors.

58. The potential for transboundary impacts is identified by consideration of potential linkages to non-UK protected sites and sites with large concentrations of breeding, migratory or wintering birds (including the use of available information on tagged birds).

12.5 Existing Environment

59. The characterisation of the existing or baseline environment is undertaken based on the site based surveys (listed in ***section 12.4.2.1*** above and as detailed in ***Appendix 12.1***), the desk study (***section 12.4.2.3***), and other relevant literature.

12.5.1 Key Species

60. The bird species recorded during site-specific surveys (digital photographic aerial bird surveys of the windfarm site plus a 4km buffer, described in ***Appendix 12.1***) of the East Anglia ONE North windfarm site to date are listed in ***Table 12.9*** along with details of their conservation status. The locations of all species observed are plotted on figures in ***Appendix 12.1***.

Table 12.9 Species Recorded in the East Anglia ONE North Study Area and Their Conservation Status

Species	Scientific name	Conservation Status
Red-throated diver	*Gavia stellata*	Birds of Conservation Concern (BoCC)[1] Green listed, Birds Directive Annex 1
Fulmar	*Fulmarus glacialis*	BoCC Amber listed, Birds Directive Migratory Species
Gannet	*Morus bassanus*	BoCC Amber listed, Birds Directive Migratory Species
Great skua	*Stercorarius skua*	BoCC Amber listed, Birds Directive Migratory Species
Razorbill	*Alca torda*	BoCC Amber listed, Birds Directive Migratory Species
Guillemot	*Uria aalge*	BoCC Amber listed, Birds Directive Migratory Species
Sandwich tern	*Thalasseus sandvicensis*	BoCC Amber listed, Birds Directive Annex 1

Species	Scientific name	Conservation Status
'Commic' tern[2]	*Tern species*	BoCC Amber listed, Birds Directive Annex 1
Kittiwake	*Rissa tridactyla*	BoCC Red listed, Birds Directive Migratory Species
Black-headed gull	*Chroicocephalus ridibundus*	BoCC Amber listed, Birds Directive Migratory Species
Little gul	*Hydrocoloeus minutus*	BoCC Green listed, Birds Directive Migratory Species
Common gull	*Larus canus*	BoCC Amber listed, Birds Directive Migratory Species
Lesser black-backed gull	*Larus fuscus*	BoCC Amber listed, Birds Directive Migratory Species
Herring gull	*Larus argentatus*	BoCC Red listed, Birds Directive Migratory Species
Great black-backed gull	*Larus marinus*	BoCC Amber listed, Birds Directive Migratory Species

1. Eaton et al. 2015.

2. 'Commic tern' is used as a collective term where Arctic tern *Sterna paradisaea* and common tern *Sterna hirundo* could not be distinguished at distance or from aerial survey images.

61. For the offshore cable corridor, no site-specific ornithology surveys were carried out. The assessment for this component of the development has been carried out with reference to available data (from JNCC (2013) and data from an unpublished report on surveys carried out in 2013 by APEM for NE).

62. Species assessed for impacts are those which were recorded during surveys and which are considered to be at potential risk either due to their abundance, potential sensitivity to windfarm impacts or due to biological characteristics (e.g. tendency to fly at rotor heights) which make them potentially susceptible.

63. Impacts have been assessed in relation to relevant biological seasons, as defined by Furness (2015). For the non-breeding period, the seasons and relevant biologically defined minimum population sizes (BDMPS) were taken from Furness (2015).

64. 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. This suggests that very few breeding birds utilise the East Anglia ONE North windfarm site. 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). Due to the very low presence of breeding birds it was considered appropriate to define breeding as the migration-free breeding period (see ***Table 12.10***), sometimes also referred to as the core breeding period. This ensured that any late or early migration movements which were observed were assessed in relation to the appropriate reference populations. One exception to this was lesser black-backed gull, for which there is potential that breeding adults from the Alde Ore Estuary SPA population may forage on the East Anglia ONE North windfarm site. Hence for this species the full breeding season was applied in the attribution of potential impacts to relevant populations.

Table 12.10 Species Specific Definitions of Biological Seasons and BDMPS (from Furness 2015 or Other Sources) for Bird Species Recorded During Baseline Surveys for the Proposed East Anglia ONE North Project

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)	-
Great skua	May-Aug	May-Jul	Aug-Oct (19,556)	Nov-Feb (143)	Mar-Apr (8,485)	-
Razorbill	Apr-Jul	Apr-Jun	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)
Sandwich tern	Apr-Aug	Jun	Jul-Sept (38,051)		Mar-May (38,051)	
'Commic' tern[2]	May-Aug	Jun	Jul-Sep (308,841)	-	Apr-May (308,841)	-
Kittiwake	Mar-Aug	May-Jul	Aug-Dec	-	Jan-Apr	-

Species	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
			(829,937)		(627,816)	
Black-headed gull[1]	-	Apr-Jul	-	-	-	Aug-Mar
Little gull[1]	Apr-Jul	May-Jul	-	-	-	Aug-Apr
Common gull[1]	-	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)
1. Biological seasons not included within Furness (2015); based on Natural England 2012 (Black throated diver) or Birds of the Western Palearctic (other species). **2. Combined estimate for common and Arctic tern populations from Furness (2015).**						

65. The mean peak abundances within species-specific seasons (as defined in ***Table 12.10***) recorded within the East Anglia ONE North windfarm site are provided in ***Table 12.11***. 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 ***Technical Appendix 12.1*** for further details); (ii) the abundance for each calendar month was calculated as the mean of estimates for each month (e.g. mean of up to 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. These have been identified in italics in ***Table 12.11***.

Table 12.11 Mean Peak Counts (and 95% Confidence Intervals) by Biological Season for Bird Species Within the East Anglia ONE North Windfarm Site Recorded During Baseline Surveys. Figures in Italics Identify the Same Peak Occurring in Different Seasons Due to Overlapping Months

Species	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
Red-throated diver	10.4 (0-38.9)	0 (0-0)	14.6 (0-56.6)	29.1 (0-58.2)	158 (0-383.4)	-
Fulmar	*62.4* *(0-111)*	*62.4* *(0-111)*	428.4 (0-955.6)	79 (36.9-132.2)	29.1 (0-80.5)	-
Gannet	*79* *(0-187.6)*	*79* *(0-187.6)*	266.2 (7.7-528.7)	-	31.2 (0-87.5)	-
Great skua[1]	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	-
Razorbill	*239.2* *(0-497.2)*	*239.2* *(0-497.2)*	58.2 (0-105.1)	37.4 (0-91)	159.3 (0-304.5)	-
Guillemot	*3,084* *(0-5,355.5)*	*3,084* *(0-5,355.5)*	386.8 (0-511.3)	729.9 (68.4-1,540.3)	*1,066.8* *(38.3-2,125.9)*	*1,066.8* *(0-2,125.9)*
'Commic' tern	*35.4* *(0-103.4)*	0 (0-0)	0 (0-0)	-	*35.4* *(0-103.4)*	-
Sandwich tern	*4.2* *(0-25.8)*	0 (0-0)	0 (0-0)	-	*4.2* *(0-25.8)*	-
Kittiwake	*282.8* *(0-431.6)*	178.6 (0-422.2)	104 (0-263.1)	-	*282.8* *(0-431.6)*	-
Black-headed gull	-	-	0 (0-0)	-	-	4.2 (0-28.3)
Little gull	*18.7* *(0-75)*	0 (0-0)	-	-	-	*18.7* *(0-75)*
Common gull	-	8.3 (0-31.3)	-	-	-	18.7 (0-61.9)
Lesser black-backed gull	*45.8*	*45.8*	39.5	8.3	8.3	-

Species	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
	(0-89.7)	*(0-89.7)*	(0-116)	(0-27.4)	(0-29.2)	
Herring gull	*8.3* *(0-29.2)*	0 (0-0)	*58.2* *(0-100.7)*	0 (0-0)	*8.3* *(0-29.2)*	*58.2* *(0-100.7)*
Great black-backed gull	*18.7* *(0-56.3)*	*18.7* *(0-44.9)*	16.6 (0-39.8)	6.2 (0-24.6)	*31.2* *(0-99)*	*31.2* *(0-99)*
1. Recorded on only one occasion in baseline surveys.						

12.5.2 Designated Sites

66. This section considers potential connectivity of the proposed East Anglia ONE North Project with sites with statutory designation for nature conservation which have birds listed as qualifying features. The sites considered are SPAs, pSPAs, Ramsar sites and SSSIs.

67. Sites which may have connectivity to the East Anglia ONE North windfarm site and offshore cable corridor include those designated for breeding seabirds and those for terrestrial / coastal / marine bird interests (typically overwintering aggregations). Discussions held with Natural England and RSPB through the EPP have scoped out connectivity for migratory non-seabird species associated with coastal and terrestrial sites (***Table 12.1***).

68. The assessment therefore focuses on sites designated for breeding seabird colonies and coastal/offshore sites for overwintering seabirds.

69. The offshore ornithology section of the Habitats Regulations Assessment (HRA) Screening Report (Royal HaskoningDHV 2018) considers offshore and coastal designated sites within or adjacent to the southern North Sea within 950km of the East Anglia ONE North windfarm site. These comprise SPAs and Ramsar sites designated for bird interests, with terrestrial areas of coastal sites also designated as SSSIs (to Mean Low Water Springs).

70. The HRA screening identified four sites for 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 East Anglia ONE North project. 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 four sites are identified here. These are listed in ***Table 12.12***.

Table 12.12 Designated Sites for Birds with Potential Connectivity to the Proposed East Anglia ONE North Project

Site	Designation	Ornithological interest features with potential connectivity to the proposed East Anglia ONE North project	Minimum distance to project (km)
The Outer Thames Estuary	SPA	Wintering seabirds – red-throated diver	0 (windfarm site) 0 (offshore cable corridor)
Greater Wash	SPA	Wintering seabirds – red-throated diver, little gull	39 (windfarm site) 32 (offshore cable corridor)
Alde-Ore Estuary	SPA Ramsar SSSI	Breeding seabirds – lesser black-backed gull, Sandwich tern	54 (windfarm site) 3 (offshore cable corridor)
Flamborough and Filey Coast*	SPA SSSI	Breeding seabirds – gannet, kittiwake, razorbill, guillemot	246 (windfarm site) 236 (offshore cable corridor)
***The recently designated Flamborough and Filey Coast SPA includes the Flamborough Head and Bempton Cliffs SPA and is a larger area, so the latter site is not considered as a separate entity as it is encompassed in the revised site**			

71. Where a species that is a qualifying feature of one or more of the designated sites listed in ***Table 12.12*** is screened in for assessment in relation to a potential impact, the potential for connectivity with that site is considered in the assessment.

72. The assessment of likely significant effect on 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 Draft Report to Inform the Habitats Regulations Assessment which accompanies this PEIR.

12.5.3 Anticipated Trends in Baseline Condition

73. 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), 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).

74. 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.

75. 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.

76. Climate change is likely to be the strongest influence on seabird populations in coming years, with anticipated deterioration in conditions for breeding and survival for most species of seabirds (Burthe et al., 2014; Macdonald et al., 2015; Capuzzo et al., 2018) and therefore further declines in numbers of most of our seabird populations are anticipated. 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. 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. 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.

77. 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).

78. 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.

79. 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.

80. For offshore ornithology, the ecological impact assessment is therefore carried out against declining baseline populations of a number of receptor species. Where a receptor 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 receptor species from recovery should environmental conditions become more favourable. 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.

12.6 Potential Impacts

81. Potential impacts to be included within the EIA have been agreed through consultation on a Method Statement (Scottish Power Renewables 2017) with Natural England and RSPB during the Evidence Plan process. They are as follows:

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

82. 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 12.4.3***;
- On the basis of the worst case potential impacts set out in ***section 12.3.2***; and
- Accounting for the embedded mitigation that is described in ***section 12.3.3.***

12.6.1 Potential Impacts During Construction

12.6.1.1 Direct Disturbance and Displacement

83. The construction phase of the proposed project has the potential to affect bird populations in the marine environment through disturbance due to construction activity leading to displacement of birds from construction sites. This would effectively result in temporary habitat loss through reduction in the area available for feeding, loafing and moulting. The worst case scenarios, outlined in ***Table 12.2*** describes the elements of the proposed project considered within this assessment.

84. The maximum duration of offshore construction for the proposed project would be 25 months which would overlap with a maximum of two breeding seasons, two winter periods and up to four spring/autumn migration periods.

85. 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 offshore elements of the proposed East Anglia ONE North project, including the windfarm and the sub-sea cables. Causes of potential disturbance would comprise the presence of construction vessels 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.

86. 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).

87. 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 of the offshore windfarm would be subsea noise from piling works associated with the installation of foundations for wind turbines and associated offshore substations. 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.

88. 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 – a maximum of 72 offshore construction structures and a maximum of 74 offshore vessels may be active within the offshore development area. 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).

89. Considering variation between species 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). 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).

90. 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.

91. 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).

92. 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 12.13***). Any species recorded only in very small numbers within the Study Area (including the offshore cable corridor) or with a low sensitivity to displacement was screened out of further assessment.

93. The species screened in for assessment were red-throated diver, razorbill and guillemot. These were assessed for impacts during the periods and spatial locations where effects were potentially likely.

Table 12.13 Construction Disturbance and Displacement Screening

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Rationale
Red-throated diver	Very High	IN	For the offshore export cable corridor only as this overlaps with the Outer Thames Estuary SPA for which red-throated diver is a qualifying species
Fulmar	Low	OUT	Low susceptibility to disturbance
Gannet	Low	OUT	Low susceptibility to disturbance
Great skua	Low	OUT	Recorded in low numbers during passage migration periods
Razorbill	Medium	IN	Potentially susceptible to disturbance and abundant
Guillemot	Medium	IN	Potentially susceptible to disturbance and abundant
Sandiwch tern	Low	OUT	Low susceptibility to disturbance and recorded in low numbers
'Commic' tern[2]	Low	OUT	Low susceptibility to disturbance and recorded in low numbers
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

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Rationale
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. **2. 'Commic tern' is used where an arctic tern and common tern could not be distinguished at distance or from aerial survey images**			

12.6.1.1.1 Red-throated Diver

94. Red-throated diver has been identified as being particularly sensitive to human activities in marine areas, including through the disturbance effects of ship and helicopter traffic (Garthe and Hüppop 2004; Schwemmer et al. 2011; Furness and Wade 2012; Furness et al. 2013; Bradbury et al. 2014). 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).

95. There is potential for disturbance and displacement of non-breeding red-throated divers resulting from the presence of vessels installing the offshore cable, including when it is laid through the Outer Thames Estuary SPA. The offshore cable corridor extends from the landfall approximately 5km north of Aldeburgh in a North-East orientation, passing through approximately 25km of the SPA in areas that are predominantly not shipping routes so may represent more important habitat for red-throated divers. Where it overlaps with the SPA, the offshore cable corridor width is between 2km and 4km, giving a total potential overlap between the export cable corridor and the SPA of approximately 132km^2 which represents an overlap with the SPA of approximately 3.5%, although this represents the area of search and the actual cable route itself will be much smaller. Cable-laying operations, utilising up to two vessels, have the potential to

displace red-throated divers from an area around each vessel. However, 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.

96. The assessment takes account of embedded mitigation in the form of a best practice protocol for minimising construction disturbance of red-throated divers (see ***section 12.3.3.1***). 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 two cable laying vessels. 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 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 within 300m of vessels.

97. To estimate the number of red-throated divers that would potentially be at risk of displacement from the offshore cable corridor during the cable laying process, the density of red-throated divers along the offshore cable corridor was estimated. Where the export cable overlaps with the SPA, the density of red-throated divers was assumed to be equivalent to the overall density within the Outer Thames Estuary SPA, estimated as 1.7 birds per km^2 (the designated population of 6,466 divided by the total SPA area (for red-throated divers[1]) of 3,792.7 km^2).

98. 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 $25.2km^2$ (2 x $12.6km^2$). If 100% displacement is assumed to occur within this area, then 43 divers would be displaced at any given time. It is considered reasonable to assume that birds will reoccupy areas following passage of the vessel. The cable laying vessels will move at a maximum speed of 300m per hour for ploughing or jetting and 80m per hour if trenching (***Chapter 6 Project Description*** and see also ***Table 12.2***). This represents a maximum speed of 7m per minute. 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). The tide would

[1] Note that the total area of the Outer Thames Estuary SPA, including a recent extension to include coastal and riverine areas used for foraging by breeding little terns, is now $3,924.5km^2$. As the extension was not proposed for red-throated divers, the area of the original SPA has been used as the reference to calculate the density of this species.

therefore be flowing at least four times 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.

99. 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. It is not possible for the proposed East Anglia ONE North project to predict future fishing effort. However, this assessment has assumed the precautionary maximum mortality rate associated with the displacement of red-throated diver in the wintering period is between 1-5% (i.e. 1-5% of displaced individuals suffer mortality as a direct consequence). At this level of mortality then only 0-2 birds would be expected to die 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 12.16*** below). Based on this, 2320 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 two birds to this would increase 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. Thus, this highly precautionary assessment generates an effect of negligible magnitude.

100. The construction works, specifically offshore cable laying, are temporary and localised in nature and the magnitude of effect on red-throated diver has been

determined as negligible. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

101. Natural England has asked for consideration to be given to a seasonal restriction on construction works, between November and February, to minimise effects on red-throated divers (***Table 12.1***). Given the assessment above and the precautionary prediction that a maximum of two birds would die as a result of displacement over this period, a seasonal restriction is not considered to be required in addition to the measures set out in the best practice protocol for red-throated divers in ***section 12.3.3.1*** above.

12.6.1.1.2 Razorbill

102. Razorbills were recorded in the East Anglia ONE North windfarm site in all months of the year, in the highest numbers in March and April (mean density in windfarm site 1.12/km^2 in April) and at their lowest in September (mean density in windfarm site 0.04/km^2). Razorbills are considered to have a medium general 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).

103. There is potential for disturbance and displacement of razorbills 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 no more than three wind turbine foundations expected to be installed at any time. Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire East Anglia ONE North windfarm site.

104. For this precautionary assessment, it has been assumed that 1-10% of displaced individuals could die as a result of displacement by construction vessels (as for displacement from the operational windfarm – see ***section 12.6.2.1*** below).

105. During the autumn migration season, at a mean peak density of 0.28/km^2 and with a highly precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), 10.5 birds (0.28 x 12.56 x 3) could be at risk of displacement, of which 0-1 birds would be predicted to die. 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 12.16*** below). 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 a maximum of 1 bird to this would increase the mortality rate by <0.001%. This magnitude of increase in mortality would not materially alter the

background mortality of the population and would be undetectable. Thus this highly precautionary assessment generates an effect of negligible magnitude.

106. The construction works are temporary and localised in nature and the magnitude of effect has been determined as negligible. As razorbill is of medium sensitivity to disturbance, the impact significance is **negligible**.

107. During the winter period, at a mean peak density of 0.18/km^2 and with a highly precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), seven individual birds (0.18 x 12.56 x 3) could be at risk of displacement, of which 0-1 would be expected to die. 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 1 bird 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. Thus this highly precautionary assessment generates an effect of negligible magnitude.

108. The construction works are temporary and localised in nature and the magnitude of effect has been determined as negligible. As razorbill is of medium sensitivity to disturbance, the impact significance is **negligible**.

109. During the spring migration season, at a mean peak density of 0.74/km^2 and with a highly precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), 28 individual birds (0.74 x 12.56 x 3) could be at risk of displacement, of which 0-3 would be expected to die. 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 3 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. Thus, this highly precautionary assessment generates an effect of negligible magnitude.

110. The construction works are temporary and localised in nature and the magnitude of effect has been determined as negligible. As razorbill is of medium sensitivity to disturbance, the impact significance is **negligible**.

111. During the breeding season, the maximum mean peak density on the site was 1.12/km^2 (April) which suggests that 42 individuals (1.12 x 12.56 x 3) could be at risk of displacement, of which 0-4 would be expected to die.

112. The mean maximum foraging range for breeding razorbill is 48.5km (Thaxter et al. 2012) which places the East Anglia ONE North windfarm site considerably beyond the range of any razorbill breeding colonies. The nearest major breeding

colony is Flamborough Head, 246 km from the site (the minimum distance to the Flamborough and Filey Coast SPA, ***Table 12.12***).

113. It should be noted that some recent tagging studies have recorded larger apparent distances than this (one razorbill was recorded travelling 312 km from Fair Isle) which might indicate connectivity to breeding colonies. However, further consideration of this apparent potential for connectivity indicates how exceptional this result is. A razorbill flies at about 16m per second (Pennycuick 1987) so would take almost eleven hours to complete this round trip even if it spent no time on the water or diving for food. This is incompatible with bringing enough food back to keep a chick alive as razorbill chicks receive about 3 feeds per day (Harris and Wanless 1989). Yet chicks are normally attended and protected by one adult at the nest site while the partner is foraging (Wanless and Harris 1989), so there are simply not enough hours in a single day to allow successfully breeding razorbills to make such long trips to provision a chick. At 16m per second the East Anglia ONE North windfarm site is 4.3 hours direct flight time away from the nearest razorbill breeding colony (Flamborough Head). A return trip would take close to 9 hours, not allowing for foraging. As for the Fair Isle example, travelling such distances is incompatible with successful breeding. On the basis of 3 feeds per day, the furthest away a bird could fly per trip to achieve this in 24 hours is 115km (i.e. a round trip of 230km), with no allowance for foraging time. Even if the bird spends a maximum of only 30 minutes foraging, this reduces the farthest distance to 108km.

114. On the basis of the above evidence, it can be stated with certainty that there are no breeding colonies for razorbill within normal foraging range of the East Anglia ONE North windfarm site, therefore it is reasonable to assume that 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%).

115. 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 four birds predicted to die 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 2 years old is higher than (or survival rates are lower than) that of adult birds, ***Table 12.16***). This magnitude of increase in mortality would not materially alter the background

mortality of the population and would be undetectable. Thus this highly precautionary assessment generates an effect of negligible magnitude.

116. 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 **negligible**.

12.6.1.1.3 Guillemot

117. Guillemots were recorded in the East Anglia ONE North windfarm site year round, with densities peaking in April (mean density in windfarm site 14.83/km^2) and at their lowest in June (mean density in windfarm site 0.06/km^2). Guillemots are considered to have a medium general 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).

118. There is potential for disturbance and displacement of guillemots due to construction activities, including the construction of wind turbines and other infrastructure (offshore electrical platforms, construction operation and maintenance platforms and met 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 no concurrent piling. Other installation vessels would be largely stationary and move short distances between turbine locations. Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire East Anglia ONE North windfarm site.

119. For this precautionary assessment, it has been assumed that 1-10% of displaced individuals could die as a result of displacement by construction vessels (as for displacement from the operational windfarm – see Section 12.6.2.1.3 below).

120. During the nonbreeding season, at a mean peak density of 5.0/km^2 and with a highly precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), 188 individual birds (5 x 12.56 x 3) could be at risk of displacement, of which 2-19 would be expected to die. 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 12.16*** below). 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 a maximum of 19 birds to this 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. Thus, this highly precautionary assessment generates an effect of negligible magnitude.

121. 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 **negligible**.

122. During the breeding season, the maximum mean peak density in the East Anglia ONE North windfarm site was 14.83/km^2 (April) which suggests that 559 individuals (14.83 x 12.56 x 3) could be at risk of displacement, of which 5-56 would be expected to die.

123. The mean maximum foraging range for breeding guillemot is 84.2km (Thaxter et al. 2012) which places the East Anglia ONE North windfarm site considerably beyond the range of any guillemot breeding colonies. The nearest breeding colony is Flamborough Head, 246 km from the site (the minimum distance to the Flamborough and Filey Coast pSPA, ***Table 12.12***).

124. It should be noted that some recent tagging studies have recorded larger apparent distances than the mean maximum from Thaxter et al. 2012, for example one guillemot was recorded travelling 340km from Fair Isle. This might indicate connectivity to breeding colonies. At greater distances. However, further consideration indicates how exceptional this result is. The 340km figure is derived from an individual guillemot on Fair Isle in a year when the local sandeel stock collapsed and breeding success was close to zero (this bird's chick died). A common guillemot flies at about 19m per second (Pennycuick 1987) so would take almost 10 hours to complete this round trip even if it spent no time on the water or diving for food. This is incompatible with bringing enough food back to keep a chick alive. The species carries only one fish at a time and common guillemot chicks need about 5 feeds per day. Yet chicks are normally attended and protected by one adult at the nest site while the partner is foraging (Uttley et al. 1994), so there are simply not enough hours in the day to allow successfully breeding guillemots to make such long trips to provision a chick. At 19m per second the East Anglia ONE North windfarm site is 3.6 hours direct flight time away from the nearest guillemot breeding colony (Flamborough Head). A return trip would take 7.3 hours, not allowing for foraging. As for the Fair Isle example, travelling such distances is incompatible with successful breeding. On the basis of 5 feeds per day, the furthest away a bird could fly per trip to achieve this in 24 hours is 164km (i.e. a round trip of 328km), with no allowance for foraging time. Even if the bird spends a maximum of only 30 minutes foraging, this reduces the farthest distance to 147km.

125. 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 East Anglia ONE North windfarm site, 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%).

126. Based on the average mortality for the species, 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 (94,007; Furness 2015). The addition of 5-56 birds predicted to die from construction disturbance and displacement would increase the mortality rate by 0.01–0.06%. (Use of the average mortality across age classes produces a conservative estimate of % change, as the mortality of birds less than 3 years old is higher than (or survival is lower than) that of adult birds, ***Table 12.16***). This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Thus, this highly precautionary assessment generates an effect of negligible magnitude.

127. 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 **negligible**.

12.6.1.2 Indirect Impacts Through Effects on Habitats and Prey Species

128. 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 ***Chapter 9 Benthic Ecology*** and ***Chapter 10 Fish and Shellfish Ecology*** and the conclusions of those assessments inform this assessment of indirect effects on ornithology receptors.

129. With regard to noise impacts on fish, ***Chapter 10 Fish and Shellfish Ecology*** discusses the potential impacts upon fish relevant to ornithology as prey species of the proposed East Anglia ONE North project. For species such as herring, sprat and sandeel, which are the main prey items of seabirds such as gannet and auks, underwater noise impacts (physical injury or behavioural changes) during construction are considered to be minor or negligible (see ***Tables 10.22*** and ***10.23***). With a minor or negligible impact on fish that are bird prey species, it is

concluded that the indirect impact significance on seabirds occurring in or around the proposed East Anglia ONE North project during the construction phase is similarly a ***minor or negligible adverse*** impact.

130. With regard to changes to the sea bed and to suspended sediment levels, ***Chapter 8 Marine Geology and Physical Processes*** and ***Chapter 9 Benthic Ecology*** discusses the nature of any change and impacts on the sea bed and benthic habitats. Such changes are considered to be temporary, small scale and highly localised (see ***Chapter 9 Benthic Ecology, section 10.6.2***). The consequent indirect impact on fish through habitat loss is considered to be minor or negligible (see ***Table 10.25***) for species such as herring, sprat and sandeel which are the main prey items of seabirds such as gannet and auks. With a minor or negligible impact on fish that are bird prey species, it is concluded that the indirect impact significance on seabirds occurring in or around the proposed East Anglia ONE North project during the construction phase is similarly a ***minor or negligible adverse*** impact.

12.6.2 Potential Impacts During Operation

12.6.2.1 Direct Disturbance and Displacement:

131. The presence of wind turbines and associated infrastructure and operational activities have the potential to directly disturb and displace birds from within and around the offshore development area. 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 wind turbines, associated ancillary structures, vessel activity and factors such as the lighting of wind turbines could also attract certain species of birds.

132. 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). 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.

133. During operation, the wind turbine array 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 wind turbine structures, and as a minimum on wind turbines at the periphery of the windfarm. Navigational lights for shipping will be placed lower on wind turbine structures and other offshore structures. A review 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 (Furness 2018). 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.

134. 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).

135. The assessment below is based on a guidance note on displacement from the UK Statutory Nature Conservation Bodies (SNCB 2017).

136. 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 2017). Birds that do not intend

to utilise a windfarm area but would have previously flown through the area on the way to a feeding, resting or nesting area, and which either stop short or detour around a development, are subject to barrier effects (SNCB 2017).

137. 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.

138. 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.

139. 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 have 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. Therefore, the impacts on birds that only migrate through the site (including seabirds, waders and waterbirds on passage) are considered negligible and these have been scoped out of detailed assessment.

140. Following installation of the offshore cable, the required operational and maintenance activities (in relation to the cable) may have short-term and localised disturbance and displacement impacts on birds using the offshore development area. However, disturbance from operational activities would be temporary and localised, and is 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.

141. The focus of this section is therefore on the disturbance and displacement of birds due to the presence and operation of wind turbines, other offshore infrastructure and any maintenance operations associated with them. The methodology presented in the SNCB Advice Note (SNCB 2017) 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.

142. 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 12.14***), focussing on the main species described in the Baseline Offshore Ornithology Technical Report (***Appendix 12.1***). 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, or recorded only in very small numbers within the East Anglia ONE North windfarm site during the breeding and wintering seasons, was screened out of further assessment. ***Table 12.14*** 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. in press).

Table 12.14 Operational Disturbance and Displacement Screening

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Season(s)	Rationale
Red-throated diver	Very High	IN	Autumn migration, Midwinter, Spring migration	Recorded regularly outside the breeding season and 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 utilises a wide range of habitats over a large area.
Gannet	Considered Low in some studies, but possibly high according to	IN	Autumn and Spring migration	Potentially susceptible to displacement from wind

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Season(s)	Rationale
	Dierschke et al. (2016), and has a high macro-avoidance rate for windfarms			turbines and abundant
Great skua	Low	OUT	N/A	Recorded in low numbers during passage migration periods
Razorbill	Medium	IN	Year round	Potentially susceptible to displacement from wind turbines and abundant
Guillemot	Medium	IN	Year round	Potentially susceptible to displacement from wind turbines and abundant
Sandwich tern	Low	Out	N/A	Recorded in low numbers and not very susceptible to displacement
'Commic' tern[2]	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

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Season(s)	Rationale
				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) **2 'Commic tern' is used where Arctic tern and common tern could not be distinguished at distance or from aerial survey images**				

143. The site population estimate used for each species to assess the displacement effects was the relevant seasonal peak mean (i.e. the highest mean value for the months within each season). 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 SNCB (2017), for divers, the assessment used all data recorded within the 4km buffer, for all other 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 12.15***.

144. 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 (2017) suggests that migration periods should also be assessed using the matrix approach and this has been undertaken where appropriate.

145. 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.

146. 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.

147. 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 12.16***.

Table 12.15 Seasonal Peak Mean Populations for Species Assessed for Displacement

Species	Area considered for displacement	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
Red-throated diver	Windfarm + 4km buffer	64.37	0	14.86	64.37	341.67	-
Gannet	Windfarm + 2km buffer	149.16	149.16	467.81	-	44.07	-
Razorbill	Windfarm + 2km buffer	403.40	403.40	84.75	54.24	206.79	-
Guillemot	Windfarm + 2km buffer	4183.20	4183.20	-	-	-	1888.20

Table 12.16 Average Annual Mortality Across Age Classes Calculated Using Age-Specific Demographic Rates and Age Class Proportions

Species	Parameter	Age class						Productivity	Average mortality
		0-1	1-2	2-3	3-4	5-6	Adult		
Red-throated diver	Survival	0.6	0.62				0.84	0.571	0.228
	Proportion in population	0.179	0.145				0.678		
Gannet	Survival	0.424	0.829	0.891	0.895		0.912	0.7	0.191
	Proportion in population	0.191	0.081	0.067	0.06		0.6		
Guillemot	Survival	0.56	0.792	0.917	0.939	0.939	0.939	0.672	0.14
	Proportion in population	0.168	0.091	0.069	0.062	0.056	0.552		
Razorbill	Survival	0.63	0.63	0.895	0.895		0.895	0.57	0.174
	Proportion in population	0.159	0.102	0.065	0.059		0.613		

148. 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.

12.6.2.1.1 Red-throated Diver

149. Red-throated divers are considered to have a very high general sensitivity to disturbance and displacement and they are prone to avoiding disturbed areas (Garthe and Hüppop 2004; Petersen et al. 2006; Furness and Wade 2012; Percival 2014, Dierschke et al., 2017).

150. Displacement rates of 60% to 80% were reported for Egmond aan Zee offshore windfarm (OWEZ) (Leopold et al. 2011) and the review by Dierschke et al. (2016) also suggested a figure in this range.

151. 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).

152. 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).

153. 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 wind farm 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.

154. 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 16km from the closest operational offshore wind farm (Mendel et al. 2018).

155. The displacement matrices in ***Table 12.17*** through ***Table 12.19*** have been populated with data for red-throated diver during the autumn migration, nonbreeding and spring migration periods within the site and a 4km buffer in line with recommendations (SNCB 2017). It should be noted that the inclusion of all birds within the 4km buffer, to determine the total number of birds subject to 80%

displacement, is considered precautionary, as in reality displacement has been demonstrated to decline with distance from a site.

156. The cells highlighted in green are for displacement rates of 60% to 80% (based on data from the Egmond an Zee Offshore Windpark (OWEZ) and a review by Dierschke et al. 2016, suggesting the actual rate lies between these two figures) and a precautionary range of displacement mortality rates between 1 and 5%. However, the windfarm site is not within foraging range of any breeding areas for red-throated divers, and the largest numbers 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 windfarm, as opposed to being displaced multiple times if it was resident over the three month spring migration period. In reality therefore, mortality associated with displacement of red-throated divers from the East Anglia ONE North windfarm site is very unlikely to be as high as 1 - 5%, and may well be zero (Dierschke et al. 2017). This conclusion is also supported by modelling of individual energy budgets (Topping and Petersen 2011). The assessment therefore considers a range of 1-5 % applied to the population of birds within the windfarm and 4km buffer, with the aim of balancing precaution and evidence in the assessment.

12.6.2.1.1.1 Autumn Migration

157. Within the range of 60-80% displacement and 1- 5% mortality, the number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement from the East Anglia ONE North windfarm site during the autumn migration period has been estimated as 0 - 1 individuals (***Table 12.17***). The BDMPS for red-throated diver in autumn is 13,277 (Furness, 2015).

158. At the average baseline mortality rate for red-throated diver of 0.228 (***Table 12.16***) the number of individuals expected to die in the autumn BDMPS is 3,027 (13,277 x 0.228). The addition of a maximum of one bird 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. In addition, this estimate of increase in mortality is considered highly precautionary as during this period birds would be passing through the site during migration, and the upper range of 5% mortality of displaced birds due to displacement seems very unlikely (Dierschke et al. 2017). Therefore, during the autumn migration period, the magnitude of effect is assessed as negligible, even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

12.6.2.1.1.2 Midwinter

159. Within the range of 60-80% displacement and 1-5% mortality, the maximum number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement from the East Anglia ONE North windfarm site during the midwinter period has been estimated 0 – 3 individuals (***Table 12.18***). The BDMPS for red-throated diver in winter is 10,177 (Furness 2015).

160. 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 three to this increases the mortality rate by 0.1%. 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 effect is assessed as negligible. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

12.6.2.1.1.3 Spring Migration

161. Within the range of 60-80% displacement and 1-5% mortality, the maximum number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement from the East Anglia ONE North windfarm site during the spring migration period has been estimated as 3 - 14 individuals (***Table 12.19***). The BDMPS for red-throated diver in spring is 13,277 (Furness, 2015).

162. 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 3 - 14 birds to this increases the mortality rate by 0.01 - 0.5%. The upper limit of this magnitude of increase in mortality is considered highly unlikely as during this period birds would be passing through the site during migration. Therefore, during the spring migration period, the magnitude of effect is assessed as negligible. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

12.6.2.1.1.4 Year Round

163. Considering the year-round effects, the maximum number of red-throated divers expected to die as a result of displacement from the East Anglia ONE North windfarm site, at a displacement rate of 60-80% and mortality of 1- 5%, would be 3 - 17 (adding the numbers predicted to be displaced during autumn migration, winter, and spring migration in ***Table 12.17***, ***Table 12.18*** and ***Table 12.19***, 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).

164. 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 3 – 17 birds to this increases the mortality rate by 0.05 - 0.3%. 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 effect is assessed as negligible. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

Table 12.17 Displacement Matrix for Red-throated Diver During the Autumn Migration Period. The cells show the number of birds predicted to be die (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	1	1	1
	20%	0	0	0	0	0	0	1	1	1	2	3
	30%	0	0	0	0	0	0	1	1	2	4	4
	40%	0	0	0	0	0	1	1	2	3	5	6
	50%	0	0	0	0	0	1	1	2	4	6	7
	60%	0	0	0	0	0	1	2	3	4	7	9
	70%	0	0	0	0	1	1	2	3	5	8	10
	80%	0	0	0	0	1	1	2	4	6	10	12
	90%	0	0	0	1	1	1	3	4	7	11	13
	100%	0	0	0	1	1	1	3	4	7	12	15

Table 12.18 Displacement Matrix for Red-throated Diver During the Winter Period. The cells show the number of birds predicted to be die (rounded to the nearest integer) at a given rate of displacement and mortality.

Winter		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	0	1	1	2	3	5	6
	20%	0	0	0	1	1	1	3	4	6	10	13
	30%	0	0	1	1	1	2	4	6	10	15	19
	40%	0	1	1	1	1	3	5	8	13	21	26
	50%	0	1	1	1	2	3	6	10	16	26	32
	60%	0	1	1	2	2	4	8	12	19	31	39
	70%	0	1	1	2	2	5	9	14	23	36	45
	80%	1	1	2	2	3	5	10	15	26	41	51
	90%	1	1	2	2	3	6	12	17	29	46	58
	100%	1	1	2	3	3	6	13	19	32	51	64

Table 12.19 Displacement Matrix for Red-throated Diver During the Spring Migration Period. The cells show the number of birds predicted to be die (rounded to the nearest integer) at a given rate of displacement and mortality.

Spring migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	1	1	1	2	3	7	10	17	27	34
	20%	1	1	2	3	3	7	14	21	34	55	68
	30%	1	2	3	4	5	10	21	31	51	82	103
	40%	1	3	4	5	7	14	27	41	68	109	137
	50%	2	3	5	7	9	17	34	51	85	137	171
	60%	2	4	6	8	10	21	41	62	103	164	205
	70%	2	5	7	10	12	24	48	72	120	191	239
	80%	3	5	8	11	14	27	55	82	137	219	273
	90%	3	6	9	12	15	31	62	92	154	246	308
	100%	3	7	10	14	17	34	68	103	171	273	342

12.6.2.1.2 Gannet

165. Gannets show a low level of sensitivity to ship and helicopter traffic (Garthe and Hüppop, 2004, Furness and Wade, 2012, Furness et al. 2013), but appear to be more sensitive to displacement from structures such as offshore wind turbines (Wade et al. 2016) and on this basis SNCB (2017) indicates that a detailed assessment of potential displacement should be carried out as standard.

166. Cook et al. (in press) 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. (in press) 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).

167. Displacement effects for gannets for the East Anglia ONE North windfarm site were assessed during the autumn and spring migration periods, based on respective peak mean populations of 468 and 44 individual birds (***Table 12.20***) calculated for the windfarm site and a 2km buffer in line with recommendations within the SNCB guidance (SNCB 2017). 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 recent study of gannet distribution in relation to the Greater Gabbard windfarm (APEM 2014).

168. Displacement matrices for gannets during the autumn and spring migration periods (calculated for the site and a 2km buffer) are presented in ***Table 12.20*** and ***Table 12.21.*** For this species, the assessment considers predicted displacement rates of 60-80%, based on the recommendations of Cook et al. (*in press*) and also the findings of Skov et al. (2018) (see ***paragraph 166*** above). 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.

12.6.2.1.2.1 Autumn Migration

169. 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 during the autumn migration period has been estimated as 4 individuals (cells highlighted ***Table 12.20***).

170. 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 4 to this increases the mortality rate by <0.01%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the autumn migration period, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.2.1.2.2 Spring Migration

171. 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 individuals (Table 12.21).

172. The BDMPS for gannet in spring is 248,385 (Furness 2015).

173. At the average baseline mortality rate for gannet of 0.191 (***Table 12.22***) the number of individuals expected to die in the spring BDMPS is 47,441 (248,385 x 0.191). As no birds are predicted to die as a result of displacement there is no change to the mortality rate. Therefore, during the spring migration period, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.2.1.2.3 Breeding season

174. Although gannets were recorded within the windfarm and a 2km buffer within the breeding season, and the site lies within potential foraging range of the nearest breeding colony at Bempton Cliffs, tracking data suggest that breeding adults from that colony make very little if any use of the East Anglia ONE North windfarm site during the breeding season (Langston et al. 2013). Thus, it has been assumed that birds present during the breeding season are sub-adults or non-breeding adults, and any displacement of such non-breeding birds would not affect the Bempton Cliffs breeding population. Therefore, the displacement of gannets in summer is more appropriately assessed against the relevant BDMPS component of immature birds. However, the estimated number of birds that might die due to displacement in summer (60-80% displaced, 0-1% mortality of displaced birds) would be one bird (Table 12.22), which would have a negligible effect on the population mortality rate. During the breeding period, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.2.1.2.4 Year Round

175. Considering the year-round effects, the maximum number of gannets expected to die as a result of displacement from the East Anglia ONE North windfarm site,

at a displacement rate of 60-80% and mortality of 0-1%, would be five (four during autumn migration, zero during spring migration, and one during the breeding season, Table 12.20, Table 12.21 and ***Table 12.22***). The biogeographic gannet population with connectivity to UK waters is 1,180,000 (Furness 2015).

176. 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 five to this increases the mortality rate by <0.01%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible**.

Table 12.20 Displacement Matrix for Gannet During the Autumn Migration Period The cells show the number of birds predicted to be die (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	1	1	2	2	5	9	14	23	37	47
	20%	1	2	3	4	5	9	19	28	47	75	94
	30%	1	3	4	6	7	14	28	42	70	112	140
	40%	2	4	6	7	9	19	37	56	94	150	187
	50%	2	5	7	9	12	23	47	70	117	187	234
	60%	3	6	8	11	14	28	56	84	140	225	281
	70%	3	7	10	13	16	33	65	98	164	262	327
	80%	4	7	11	15	19	37	75	112	187	299	374
	90%	4	8	13	17	21	42	84	126	211	337	421
	100%	5	9	14	19	23	47	94	140	234	374	468

Table 12.21 Displacement Matrix for Gannet During the Spring Migration Period The cells show the number of birds predicted to be die (rounded to the nearest integer) at a given rate of displacement and mortality.

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	4	4
	20%	0	0	0	0	0	1	2	3	4	7	9
	30%	0	0	0	1	1	1	3	4	7	11	13
	40%	0	0	1	1	1	2	4	5	9	14	18
	50%	0	0	1	1	1	2	4	7	11	18	22
	60%	0	1	1	1	1	3	5	8	13	21	26
	70%	0	1	1	1	2	3	6	9	15	25	31
	80%	0	1	1	1	2	4	7	11	18	28	35
	90%	0	1	1	2	2	4	8	12	20	32	40
	100%	0	1	1	2	2	4	9	13	22	35	44

Table 12.22 Displacement Matrix for Gannet During the Breeding Period The cells show the number of birds predicted to be die (rounded to the nearest integer) at a given rate of displacement and mortality.

Breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	1	1	1	3	4	7	12	15
	20%	0	1	1	1	1	3	6	9	15	24	30
	30%	0	1	1	2	2	4	9	13	22	36	45
	40%	1	1	2	2	3	6	12	18	30	48	60
	50%	1	1	2	3	4	7	15	22	37	60	75
	60%	1	2	3	4	4	9	18	27	45	72	89
	70%	1	2	3	4	5	10	21	31	52	84	104
	80%	1	2	4	5	6	12	24	36	60	95	119
	90%	1	3	4	5	7	13	27	40	67	107	134
	100%	1	3	4	6	7	15	30	45	75	119	149

12.6.2.1.3 Auks (Razorbill and Guillemot)

177. Auks are considered to have medium sensitivities 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).

178. 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).

179. Common guillemots were displaced at Blighbank (Vanermen et al. 2012, 2014), were displaced 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).

180. Following statutory guidance (SNCB 2017) 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.

181. Each matrix displays displacement rates and mortality rates for each species. 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 (based on advice from Natural England), with the 70% / 10% combination representing a precautionary worst case scenario.

182. As noted previously, there are no breeding colonies for guillemot or razorbill within foraging range of the East Anglia ONE North windfarm site. 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 12.10***. The number of birds which could potentially be displaced has been estimated for each species-specific relevant season.

12.6.2.1.4 Razorbill

12.6.2.1.4.1 Autumn Migration

183. The estimated number of razorbills subject to mortality during the autumn migration period due to displacement from the East Anglia ONE North windfarm site is between zero and six individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, ***Table 12.23***). The BDMPS for the UK North Sea and Channel is 591,874 (Furness 2015).

184. At the average baseline mortality rate for razorbill of 0.174 (***Table 12.16***) 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 six individuals to this increases the mortality rate by < 0.01%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the autumn migration period, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.2.1.4.2 Winter

185. The estimated number of razorbills subject to mortality during the winter period due to displacement from the East Anglia ONE North windfarm site is between zero and four individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, ***Table 12.24***). The BDMPS for the UK North Sea and Channel is 218,622 (Furness 2015).

186. 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 four individuals to this increases the mortality rate by 0.01%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the winter period, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.2.1.4.3 Spring Migration

187. The estimated number of razorbills subject to mortality during the spring migration period due to displacement from the East Anglia ONE North windfarm site is between one and 14 individuals (within the range of displacement/mortality of

30%/1% to 70%/10%,***Table 12.25***). The BDMPS for the UK North Sea and Channel is 591,874 (Furness 2015).

188. 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 14 individuals to this increases the mortality rate by 0.01%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the spring migration period, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.2.1.4.4 Breeding Season

189. The estimated number of razorbills subject to mortality during the breeding period due to displacement from the East Anglia ONE North windfarm site is between one and 28 individuals (from 30%/1% to 70%/10%, ***Table 12.26***). The BDMPS is 94,007 non-breeding individuals (see ***paragraph 182*** above).

190. 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 28 to this increases the mortality rate by 0.17%. 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 effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.2.1.4.5 Year Round

191. The estimated number of razorbills subject to displacement mortality throughout the year from the East Anglia ONE North windfarm site is between 2 and 52 individuals (summing the range of displacement/mortality of 30%/1% to 70%/10% from ***Table 12.23*** through ***Table 12.26***).

192. 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 52 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 non-breeding season, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **negligible**.

Table 12.23 Displacement Matrix for Razorbill During the Autumn Migration Period. The cells show the number of birds predicted to be die (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	1	2	3	4	7	8
	20%	0	0	1	1	1	2	3	5	8	14	17
	30%	0	1	1	1	1	3	5	8	13	20	25
	40%	0	1	1	1	2	3	7	10	17	27	34
	50%	0	1	1	2	2	4	8	13	21	34	42
	60%	1	1	2	2	3	5	10	15	25	41	51
	70%	1	1	2	2	3	6	12	18	30	47	59
	80%	1	1	2	3	3	7	14	20	34	54	68
	90%	1	2	2	3	4	8	15	23	38	61	76
	100%	1	2	3	3	4	8	17	25	42	68	85

Table 12.24 Displacement Matrix for Razorbill During the Winter Period. The cells show the number of birds predicted to be die (rounded to the nearest integer) at a given rate of displacement and mortality.

Winter		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	0	0	0	1	1	2	3	4	5
	20%	0	0	0		1	1	2	3	5	9	11
	30%	0	0	0	1	1	2	3	5	8	13	16
	40%	0	0	1	1	1	2	4	7	11	17	22
	50%	0	1	1	1	1	3	5	8	14	22	27
	60%	0	1	1	1	2	3	7	10	16	26	33
	70%	0	1	1	2	2	4	8	11	19	30	38
	80%	0	1	1	2	2	4	9	13	22	35	43
	90%	0	1	1	2	2	5	10	15	24	39	49
	100%	1	1	2	2	3	5	11	16	27	43	54

Table 12.25 Displacement Matrix for Razorbill During the Spring Migration Period. The cells show the number of birds predicted to be die (rounded to the nearest integer) at a given rate of displacement and mortality.

Spring migration		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	0	0	1	1	1	2	4	6	10	17	21
	20%	0	1	1	2	2	4	8	12	21	33	41
	30%	1	1	2	2	3	6	12	19	31	50	62
	40%	1	2	2	3	4	8	17	25	41	66	83
	50%	1	2	3	4	5	10	21	31	52	83	103
	60%	1	2	4	5	6	12	25	37	62	99	124
	70%	1	3	4	6	7	14	29	43	72	116	145
	80%	2	3	5	7	8	17	33	50	83	132	165
	90%	2	4	6	7	9	19	37	56	93	149	186
	100%	2	4	6	8	10	21	41	62	103	165	207

Table 12.26 Displacement Matrix for Razorbill During the Breeding Period. The cells show the number of birds predicted to be die (rounded to the nearest integer) at a given rate of displacement and mortality.

Breeding		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	40
	20%	1	2	2	3	4	8	16	24	40	65	81
	30%	1	2	4	5	6	12	24	36	61	97	121
	40%	2	3	5	6	8	16	32	48	81	129	161
	50%	2	4	6	8	10	20	40	61	101	161	202
	60%	2	5	7	10	12	24	48	73	121	194	242
	70%	3	6	8	11	14	28	56	85	141	226	282
	80%	3	6	10	13	16	32	65	97	161	258	323
	90%	4	7	11	15	18	36	73	109	182	290	363
	100%	4	8	12	16	20	40	81	121	202	323	403

12.6.2.1.5 Guillemot

12.6.2.1.5.1 Non-Breeding

193. The estimated number of guillemots subject to mortality during the non-breeding period due to displacement from the East Anglia ONE North windfarm site is between six and 132 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, ***Table 12.27***). The BDMPS for the UK North Sea and Channel is 1,617,306 (Furness 2015).

194. At the average baseline mortality rate for guillemot of 0.140 (***Table 12.16***) 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 132 individuals to this increases the mortality rate by 0.06%. 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 effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.2.1.5.2 Breeding Season

195. The estimated number of guillemots subject to mortality during the breeding period due to displacement from the East Anglia ONE North windfarm site is between 13 and 293 individuals (from 30%/1% to 70%/10%, ***Table 12.28***). The BDMPS is 695,441 non-breeding individuals (see ***paragraph 182*** above).

196. 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 293 to this increases the mortality rate by 0.3%. 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 effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.2.1.5.3 Year Round

197. The estimated number of guillemots subject to mortality due to displacement from the East Anglia ONE North windfarm site throughout the year is between 18 and 425 individuals (summing the range of displacement/mortality of 30%/1% to 70%/10% from ***Table 12.27*** and ***Table 12.28***).

198. 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 425 individuals to this increases the mortality rate by 0.19%. 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 **negligible**.

Table 12.27 Displacement Matrix for Guillemot During the Non-Breeding Period. The cells show the number of birds predicted to be die (rounded to the nearest integer) at a given rate of displacement and mortality.

Non-breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	2	4	6	8	9	19	38	57	94	151	189
	20%	4	8	11	15	19	38	76	113	189	302	378
	30%	6	11	17	23	28	57	113	170	283	453	566
	40%	8	15	23	30	38	76	151	227	378	604	755
	50%	9	19	28	38	47	94	189	283	472	755	944
	60%	11	23	34	45	57	113	227	340	566	906	1133
	70%	13	26	40	53	66	132	264	397	661	1057	1322
	80%	15	30	45	60	76	151	302	453	755	1208	1511
	90%	17	34	51	68	85	170	340	510	850	1360	1699
	100%	19	38	57	76	94	189	378	566	944	1511	1888

Table 12.28 Displacement Matrix for Guillemot During the Breeding Period. The cells show the number of birds predicted to be die (rounded to the nearest integer) at a given rate of displacement and mortality.

Breeding		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	4	8	13	17	21	42	84	125	209	335	418
	20%	8	17	25	33	42	84	167	251	418	669	837
	30%	13	25	38	50	63	125	251	376	627	1004	1255
	40%	17	33	50	67	84	167	335	502	837	1339	1673
	50%	21	42	63	84	105	209	418	627	1046	1673	2092
	60%	25	50	75	100	125	251	502	753	1255	2008	2510
	70%	29	59	88	117	146	293	586	878	1464	2343	2928
	80%	33	67	100	134	167	335	669	1004	1673	2677	3347
	90%	38	75	113	151	188	376	753	1129	1882	3012	3765
	100%	42	84	125	167	209	418	837	1255	2092	3347	4183

12.6.2.2 Indirect Impacts Through Effects on Habitats and Prey Species:

199. Indirect disturbance and displacement of birds may occur during the operational phase of the proposed East Anglia ONE North 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 wind turbines), 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.

200. With regard to noise impacts on fish, ***Chapter 10 Fish and Shellfish Ecology*** discusses the potential impacts upon fish relevant to ornithology as prey species. With regard to behavioural changes related to underwater noise impacts on fish during the operation of the proposed East Anglia ONE North project, ***Chapter 10 Fish and Shellfish Ecology, section 10.6.2.4*** identifies that the sensitivity of fish and shellfish species to operational noise is considered to be low and the magnitude of effect negligible. It concludes a minor adverse impact on fish (see ***Chapter 10 Fish and Shellfish Ecology, section 10.6.2.4***). With a negligible impact on fish that are bird prey species, it could be concluded that the indirect impact on seabirds occurring in or around the proposed TWO offshore development area during the operational phase is similarly a **negligible adverse impact**.

201. With regard to changes to the sea bed and to suspended sediment levels, ***Chapter 9 Benthic Ecology*** discusses the nature of any change and impact. It identifies that the small quantities of sediment released due to scour processes would rapidly settle within a few hundred metres of each wind turbine or cable protection structure. Therefore, the magnitude of the impact is likely to be negligible to low (see ***Chapter 9 Benthic Ecology, section 9.6.2.3***) and that smothering due to increased suspended sediment during operation of the project would result in an impact of minor adverse significance. With a minor impact on benthic habitats and species, it could be concluded that the indirect impact on seabirds occurring in or around the East Anglia ONE North windfarm site during the operational phase is similarly a **minor adverse impact**.

202. With regard to EMF effects, these are identified as highly localised with the majority of cables being buried to up to 5m depth, further reducing the effect of EMF (see ***Chapter 9 Benthic Ecology, section 9.6.2.5***). The magnitude of impact is considered negligible on benthic invertebrates and low on fish. With a minor or negligible impact on invertebrates and fish, it could be concluded that the indirect impact on seabirds occurring in or around the offshore development area during the operational phase is similarly a **minor or negligible adverse** impact.

203. 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 in the offshore development area. 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 unlikely to be significant at a wider scale.

12.6.2.3 Collision Risk

204. 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 East Anglia ONE North windfarm site, during migration, whilst foraging for food, or commuting between breeding sites and foraging areas.

205. Collision Risk Modelling (CRM) has been used in this assessment to estimate the risk to birds associated with the East Anglia ONE North windfarm site. CRM, using the Band model (Band 2012) has been used to produce predictions of mortality for particular species across biological seasons and annually. The approach to CRM is summarised here and further details are provided in ***Appendix 12.1***.

206. 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).

207. Collision estimates for Band CRM option 1 are also included in ***Appendix 12.1*** (for information only as agreed through the ETG). This option uses flight height data for the East Anglia ONE North study area. Following a review of data collection and analysis methods, the aerial survey contractors advised ScottishPower Renewables that the flight height estimates from baseline survey data were not reliable. Thus, these data have not been used in the assessment.

208. To take account of uncertainty in the parameters on which the model is based, CRM has been run as a stochastic simulation to incorporate uncertainty in seabird density, flight height (based on the generic dataset in Johnston et al. 2014a, 2014b), avoidance rates and nocturnal activity rates. This approach has been requested by NE because many of the CRM input parameters include both natural variation (e.g. seabird densities) and measurement error.

209. The most efficient method for incorporating uncertainty in multiple parameters is to generate multiple random values for each of the parameters from appropriate distributions and calculate the collision mortality for each combination of random values. To achieve this the Band model equations (Band 2012) were scripted in the R programming language (R Core Team 2016) to enable the Band model to be run as multiple simulations. Summary outputs calculated across the simulations can then be presented (e.g. median and confidence intervals) which incorporate the uncertainty in all the parameters simultaneously. However, as this approach has not been commonly used to date, and to assist readers to understand how variation in each of the parameters contributes to the overall variation, simulations were also conducted with only one of the parameters randomised at a time. In addition, a set of results obtained with no randomised parameters has been included, which are identical to those which are obtained using the Band (2012) spreadsheet.

210. The input parameters are provided in ***Technical Appendix 12.1 Annex 3*** and complete CRM results are provided in ***Technical Appendix 12.1 Annexes 4 and 5***. For both options 1 and 2 the following model runs were undertaken:

- Uncertainty in seabird density, avoidance rate, flight height (Option 2 only) and nocturnal activity (gannet, kittiwake, large gulls only);
- Uncertainty in seabird density only;
- Uncertainty in collision avoidance rates only;
- Uncertainty in flight height (Option 2) only;
- Uncertainty in nocturnal activity only (gannet, kittiwake, large gulls only); and
- No uncertainty in any parameter (i.e. a deterministic run)

211. The densities of birds in flight were calculated from the survey data. To obtain randomised values a nonparametric bootstrap resampling method was applied to each survey's dataset. This generated 1,000 resampled density estimates for each species on each survey. Density values were drawn at random from the resampled data. Runs which did not include uncertainty in density used the median density for each month (i.e. this was the median across all survey data for that month).

212. The avoidance rates used were as advised by Natural England and are set out in ***Table 12.29*** below. These were those recommended by the SNCBs (JNCC et al. 2014) following the review conducted by the British Trust for Ornithology (BTO) on behalf of Marine Scotland (Cook et al., 2014). When modelled with uncertainty the variations recommended in JNCC et al. (2014) were used.

Table 12.29 Avoidance Rates Used in CRM

Species	Avoidance Rate	Standard Deviation (SD)
Gannet	98.9%	0.2%
Kittiwake	98.9%	0.2%
Lesser black-backed gull **Great black-backed gull**	99.5%	0.1%
Little gull **Common gull** **Black-headed gull**	99.2%	0.2%
All other species	98%	0.2%

213. It should be noted that further work on avoidance rates for offshore windfarms is underway. For example, a study on gannet behaviour in relation to offshore windfarms (APEM, 2014) gathered evidence which suggests this species may exhibit a higher avoidance rate than the current recommended rate of 98.9%. This work, conducted during the autumn migration period, indicated an overall wind turbine avoidance of 100%, although a suitably precautionary rate of 99.5% was proposed (for the autumn period at least). Although this rate has not been applied to the estimates presented in this assessment, it indicates that gannet collision mortality estimated at 98.9% is likely to overestimate the risk for this species. The difference between the two rates sounds like a small change, but applying the higher avoidance rate of 99.5% would reduce predicted collision rates considerably, perhaps by as much as 50%. Indeed, as noted in Cook et al. (2014), all the recommended avoidance rates remain precautionary and thus the results presented in this assessment are worst case estimates.

214. A bird flight behaviour study has been conducted for the Offshore Renewables Joint Industry Programme (ORJIP). The study provides further evidence relating to the precautionary nature of current avoidance rates and other parameters used in windfarm assessment (Skov et al. 2018). Empirical avoidance rates were estimated for five seabird species as follows: 99.9% for gannet and herring gull, 99.8% for kittiwake and lesser black-backed gull, and 99.6% for great black-backed gull. The predicted collision rate for gannet is consistent with the findings

of the APEM (2014) study reported above, and all other empirical avoidance rates are higher than the currently recommended rates for CRM for a given species (***Table 12.29***). A thermal animal detection system of daylight and thermal imaging cameras recorded 6 collisions of birds with rotor blades during the course of the study. These were all gulls (not all identified to species), including one kittiwake.

215. The nocturnal activity parameter 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. The values typically used for each species were derived from reviews of seabird activity reported in Garthe and Hüppop (2004). This review ranked species from 1 to 5 (1 low, 5 high) for relative nocturnal activity, and these were subsequently modified for the purposes of CRM into 1 = 0% to 5 = 100%. This approach was not anticipated by Garthe and Hüppop (2004), who considered that their 1 to 5 scores were simply categorical and were not intended to represent a scale of 0 to 100% of daytime activity (not least because the lowest score given was 1 and not 0). This is clear from their descriptions of the scores: for example, for score 1 'hardly any flight activity at night'.

216. Recently however, a number of studies have deployed loggers on seabirds, and data from those studies can provide empirical evidence of the actual flight activity level. These studies indicate that the rates derived from Garthe and Hüppop (2004) almost certainly overestimate the levels of nocturnal activity in the species studied. For example, across four studies of gannet, nocturnal activity relative to daytime was reported as between 0% and 2%, across four studies of kittiwake nocturnal activity relative to daytime was reported as between 0% and 12% and in one study of lesser black-backed gull nocturnal activity relative to daytime was reported as 25%. These compare to the much higher values recommended by SNCBs for use in CRM of 25%, 50% and 50% for gannet, kittiwake and lesser black-backed gull respectively.

217. As the relative proportion of daytime to night-time varies considerably during the year at the UK's latitude, the effect of changes in the nocturnal activity factor for CRM outputs depends on the relative abundance of birds throughout the year. The extent of mortality reduction obtained by reducing the categorical score for five species (gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull) by 1 (i.e. from 3 to 2 for kittiwake) has been investigated previously (EATL, 2015). This work revealed annual mortality estimate reductions of between 14.5% (lesser black-backed gull) and 27.7% (gannet). This indicated that current nocturnal activity factors based on arbitrary conversions of Garthe

and Hüppop (2004) scores into percentages are over-estimated, and consequently CRM outputs are highly precautionary in this regard.

218. In the light of this, recent advice from Natural England has suggested that CRM should use upper and lower nocturnal activity rates of 0% and 25% for gannet and 25% and 50% for kittiwake, lesser black-backed gull, great black-backed gull and herring gull, rather than just the higher value as used previously.

219. In order to more accurately estimate nocturnal activity for gannet, a review of evidence from tracking studies has been undertaken (Furness et al. 2018). This recommended precautionary nocturnal flight activity rates for gannet in the breeding and nonbreeding seasons of 8% and 4% respectively. However, the actual average rates from the study were 7.1% and 2.3% respectively. Furthermore, the breeding season value was very heavily influenced by the results from the smallest study in the review, which was based on three tagged birds in Shetland (Garthe et al. 1999). That study yielded a nocturnal activity rate of 20.9% (compared to daytime) but the total duration of flight activity recorded was 215 hours, which was less than 3% of the > 8,000 hours covered by the remaining studies. If the average rate is calculated without this study a breeding season rate of 4.3% is obtained. This is considered to be more robust. Thus, for the proposed East Anglia ONE North project, appropriate (and still precautionary) values for the breeding and nonbreeding seasons are considered to be 4.3% (SE 2.7%) and 2.3% (SE 0.4%). A similar review and analysis has been conducted for kittiwake (Furness et al. in prep.) which has identified values for the breeding and nonbreeding seasons respectively of 20% (SE 5%) and 17% (SE 1.5%). These values have considerably more merit, being based on empirical evidence, when compared with the categorical values which have been applied in CRM. Therefore, they have been used in the stochastic simulations for gannet and kittiwake in the current assessment. For the large gulls, uncertainty in nocturnal activity was modelled by selecting either 25% or 50% at random for each simulation. For all other species the previous nocturnal activity levels have been used (with no random variation in any run). In CRM runs which did not include uncertainty in nocturnal activity, the previously recommended values of 25% for gannet and 50% for kittiwake and the large gulls were used.

220. The CRM modelling results for all wind turbine scenarios are provided in ***Technical Appendix 12.1 Annexes 4*** and ***5***. The assessment presented here uses the outputs for the worst case wind turbine layout for each species, calculated using CRM option 2. As explained in paragraph 20, after the collision risk modelling was completed the design envelope was changed so that the maximum number of wind turbines increased from 60 to 67 for the 12MW scenario, and from 42 to 53 for the 15MW scenario. The results presented here are for previous scenarios of scenarios of 60 12MW, 42 15MW and 42 19MW

turbines (see Appendix 12, Annex 3) rather than the scenarios presented in Table 12.2. The collision risk model has not been re-run for the updated scenarios because of time constraints, however an assessment of the updated parameters will be included within the ES. This model re-run will also incorporate the remaining three months of aerial survey data (see section 12.3.1).

221. As the numbers of turbines have been increased for the 12MW and 15MW scenarios then the collision risk for these scenarios would also increase, although changes are not considered likely to be of a magnitude that would change the conclusions of the assessment for the project alone and cumulative assessments as presented here.

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

223. The full CRM results for the proposed project are presented in ***Appendix 12.1***. The following sections provide a summary of the outputs for assessment, using the seasons defined in ***Table 12.10***. Annual collision risk estimates for all species assessed are presented in ***Table 12.30***. This table also includes an assessment of the species sensitivity to 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).

224. Several species had very low predicted annual collision risks at East Anglia ONE North (i.e. worst case median prediction was below approximately one bird per year). These were red-throated diver, fulmar, great skua, black-headed gull, little gull, common gull and herring gull. 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 ***Technical Appendix 12.1***). The predicted annual collision risk for lesser black-backed gull was also very low, but this species was taken forward to assessment on a precautionary basis. The East Anglia ONE North windfarm site is 37km from the Alde-Ore Estuary SPA at the nearest point, and within the mean maximum foraging range (141km, Thaxter *et al.* 2012). Thus, lesser black-backed gulls breeding at the Alde-Ore Estuary SPA might forage within or pass through the development and be at risk of collision.

225. The seasonal collision estimates for lesser black-backed gull and species with higher estimated annual collisions (gannet, kittiwake, and great black-backed gull) are presented in ***Table 12.31***. These species are considered in the assessment of collision risk.

226. The full stochastic results have been used for the following assessment of potential effects as these are considered to be the most robust figures, while still being precautionary.

227. 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 12.30 Annual Collision Risk Estimates. Values are the Median number of birds and 95% Confidence Intervals. For species screened in for Assessment, Shaded Cells Indicate the Design Option with the Highest Estimated Collision Risk

Species (sensitivity to collision impacts)	Model run type	Annual 12MW	Annual 15MW	Annual 19MW
Red throated diver **(Low)**	Full stochastic	0 (0-2.3)	0 (0-1.79)	0 (0-1.89)
	Density only	0 (0-1.76)	0 (0-1.67)	0 (0-1.67)
	Avoidance rate only	0 (0-0)	0 (0-0)	0 (0-0)
	Flight height only	0 (0-0)	0 (0-0)	0 (0-0)
	Nocturnal activity only	0 (0-0)	0 (0-0)	0 (0-0)
	Deterministic	0	0	0
Fulmar **(Low)**	Full stochastic	0.54 (0-4.77)	0.53 (0-4.76)	0.53 (0-4.64)
	Density only	0.88 (0-3.36)	0.87 (0-3.23)	0.91 (0-3.29)
	Avoidance rate only	0.89 (0.73-1.07)	0.86 (0.69-1.04)	0.86 (0.69-1.03)
	Flight height only	0.8 (0.22-1.93)	0.78 (0.22-1.9)	0.8 (0.23-1.92)

Species (sensitivity to collision impacts)	Model run type	Annual 12MW	Annual 15MW	Annual 19MW
	Nocturnal activity only	0.88 (0.88-0.88)	0.87 (0.87-0.87)	0.87 (0.87-0.87)
	Deterministic	0.88	0.87	0.87
Gannet (Low/Medium)	Full stochastic	15.62 (1.59-84.83)	13.96 (1.22-82.58)	14.74 (0.95-82.16)
	Density only	18.18 (2.49-60.9)	17.28 (2.56-56.2)	17.58 (2.3-56.34)
	Avoidance rate only	18.52 (12.64-25.87)	17.11 (11.78-24.07)	17.15 (11.68-23.85)
	Flight height only	17.33 (4.93-41.37)	16.17 (4.22-37.98)	15.83 (4.3-38.12)
	Nocturnal activity only	18.68 (18.27-19.42)	17.26 (16.88-17.94)	17.23 (16.88-17.97)
	Deterministic	18.73	17.28	17.28
Kittiwake (Medium)	Full stochastic	27.73 (4.81-152.71)	27.13 (4.14-152.05)	26.89 (4.75-150.54)
	Density only	37.42 (10.95-97.24)	37.26 (10.74-96.47)	35.12 (11.18-96.86)
	Avoidance rate only	37.31 (25.62-52.19)	36.81 (24.85-51.13)	36.72 (24.89-51.64)
	Flight height only	34.7 (9.07-81.94)	34.05 (8.39-80.69)	34.32 (9.02-81.06)
	Nocturnal activity only	37.65 (35.82-39.97)	37.1 (35.27-39.41)	37.05 (35.26-39.37)
	Deterministic	37.74	37.12	37.12
	Full stochastic	0	0	0

Species (sensitivity to collision impacts)	Model run type	Annual 12MW	Annual 15MW	Annual 19MW
Black-headed gull **(Medium)**		(0-1.55)	(0-1.5)	(0-1.4)
	Density only	0 (0-1.23)	0 (0-1.22)	0 (0-1.22)
	Avoidance rate only	0 (0-0)	0 (0-0)	0 (0-0)
	Flight height only	0 (0-0)	0 (0-0)	0 (0-0)
	Nocturnal activity only	0 (0-0)	0 (0-0)	0 (0-0)
	Deterministic	0	0	0
Little gull **(Low)**	Full stochastic	0 (0-5.12)	0 (0-4.93)	0 (0-4.72)
	Density only	0 (0-3.71)	0 (0-3.37)	0 (0-3.37)
	Avoidance rate only	0 (0-0)	0 (0-0)	0 (0-0)
	Flight height only	0 (0-0)	0 (0-0)	0 (0-0)
	Nocturnal activity only	0 (0-0)	0 (0-0)	0 (0-0)
	Deterministic	0	0	0
Common gull **(Medium)**	Full stochastic	0 (0-13.9)	0 (0-13.23)	0 (0-12.64)
	Density only	0 (0-10.15)	0 (0-10.43)	0 (0-10.43)
	Avoidance rate only	0 (0-0)	0 (0-0)	0 (0-0)
	Flight height only	0	0	0

Species (sensitivity to collision impacts)	Model run type	Annual 12MW	Annual 15MW	Annual 19MW
		(0-0)	(0-0)	(0-0)
	Nocturnal activity only	0 (0-0)	0 (0-0)	0 (0-0)
	Deterministic	0	0	0
Lesser black-backed gull **(Medium)**	Full stochastic	0.61 (0-7.03)	0.6 (0-6.75)	0.57 (0-7.14)
	Density only	0.83 (0-5.79)	0.8 (0-5.56)	0.8 (0-6.36)
	Avoidance rate only	0.82 (0.55-1.16)	0.79 (0.52-1.13)	0.8 (0.52-1.14)
	Flight height only	0.78 (0.14-1.91)	0.74 (0.16-1.68)	0.74 (0.18-1.73)
	Nocturnal activity only	0.75 (0.75-0.83)	0.8 (0.72-0.8)	0.72 (0.72-0.8)
	Deterministic	0.83	0.8	0.8
Great black-backed gull **(Medium)**	Full stochastic	0.5 (0-15.7)	0.42 (0-13.67)	0.4 (0-14.5)
	Density only	0.61 (0-13.44)	0.58 (0-13.32)	0.58 (0-12.3)
	Avoidance rate only	0.6 (0.39-0.86)	0.58 (0.37-0.83)	0.57 (0.37-0.8)
	Flight height only	0.56 (0.13-1.29)	0.54 (0.11-1.24)	0.54 (0.11-1.19)
	Nocturnal activity only	0.61 (0.5-0.61)	0.48 (0.48-0.58)	0.58 (0.48-0.58)
	Deterministic	0.61	0.58	0.58
*** with reference to Garthe and Hüppop, 2004; Furness and Wade, 2012, Furness et al., 2013, Wade et al., 2016**				

Table 12.31 Seasonal Collision Risk Estimates. Values are the Median Number of Birds and 95% Confidence Intervals

Species (worst case layout)	Model run type	Breeding season	Autumn migration	Non-breeding	Spring migration	Annual (worst case)
Gannet (12MW)	Full Stochastic	8.83 (2.15-21.8)	8.58 (1.02-57.74)		1.15 (0-17.14)	18.56 (3.17-110.67)
	Density only	10.3 (4.73-21.8)	13.47 (2.34-35.77)		1.62 (0-12.29)	25.39 (7.07-69.86)
	Avoidance rate only	10.19 (7.06-14.65)	13.54 (9.39-19.02)		1.62 (1.09-2.28)	25.35 (17.54-35.95)
	Flight height only	9.75 (2.72-23.17)	12.84 (3.12-30.05)		1.52 (1.6-1.65)	24.11 (6.21-56.84)
	Nocturnal activity only	10.27 (10.08-10.71)	13.76 (13.61-13.95)		1.62 (1.6-1.65)	25.65 (25.29-26.31)
	Deterministic	10.3	13.78		1.62	25.7
Kittiwake (12MW)	Full stochastic	13.61 (2.51-52.77)	2.86 (0-18.89)		9.32 (1.09-43.4)	25.79 (3.6-114.96)
	Density only	16.58 ((5.55-32.63)	3.69 (0-13.9)		11.21 (2.58-26.61)	31.48 (8.13-73.14)
	Avoidance rate only	16.62 (11.32-23.07)	3.71 (2.46-5.2)		11.33 (7.69-15.87)	31.66 (21.47-44.14)

Species (worst case layout)	Model run type	Breeding season	Autumn migration	Non-breeding	Spring migration	Annual (worst case)
	Flight height only	15.36 (3.97-37.3)	3.44 (0.87-8.06)		10.63 (2.83-25.53)	29.43 (7.67-70.89)
	Nocturnal activity only	16.65 (16.03-17.41)	3.73 (3.56-3.93)		11.4 (10.83-12.11)	31.78 (30.42-33.45)
	Deterministic	16.67	3.73		11.42	31.82
Lesser black-backed gull (12 MW)	Full stochastic	0.48 (0-5.64)	0 (0-3.26)	0 (0-1.63)	0 (0-2.12)	0.48 (0-12.65)
	Density only	0.73 (0-4.36)	0 (0-3.07)	0 (0-1.6)	0 (0-1.87)	0.73 (0-10.9)
	Avoidance rate only	0.72 (0.48-1.01)	0 (0-0)	0 (0-0)	0 (0-0)	0.72 (0.48-1.01)
	Flight height only	0.69 (0.15-1.56)	0 (0-0)	0 (0-0)	0 (0-0)	0.69 (0.15-1.56)
	Nocturnal activity only	0.73 (0.66-0.73)	0 (0-0)	0 (0-0)	0 (0-0)	0.73 (0.66-0.73)
	Deterministic	0.73	0	0	0	0.73
Great Black-backed gull	Full stochastic	2.25 (0-17.6)		0.45 (0-18.17)		2.7 (0-35.8)

Species (worst case layout)	Model run type	Breeding season	Autumn migration	Non-breeding	Spring migration	Annual (worst case)
(250m wind turbines)(12 MW)	Density only	2.84 (0-12.93)		0.73 (0-16.3)		3.57 (0-29.23)
	Avoidance rate only	2.8 (1.84-4.05)		0.72 (0.46-1.05)		3.52 (2.3-5.1)
	Flight height only	2.69 (0.61-6.16)		0.66 (0.15-1.51)		3.35 (0.76-7.67)
	Nocturnal activity only	2.56 (2.56-2.84)		0.54 (0.54-0.73)		3.1 (3.1-3.57)
	Deterministic	2.84		0.73		3.57

12.6.2.3.1 Breeding Season Reference Populations for Collision Assessment

12.6.2.3.1.1 Gannet

228. The nearest gannet breeding colony to the proposed development is Bempton Cliffs within the Flamborough and Filey Coast SPA. The SPA is 246km from the East Anglia ONE North windfarm site at the nearest point (Table 12.12). This is outside the mean maximum foraging range of gannets, estimated as 229 km (Thaxter et al. 2012), the usual measure used to identify potential connectivity between a breeding seabird colony and foraging areas, although it is within the estimated maximum foraging range of 590 km. Tracking studies of gannets from Bempton Cliffs during 2010-2012 suggest very little if any use of the East Anglia ONE North windfarm site during the breeding season (Langston et al. 2013).

12.6.2.3.1.2 Kittiwake

229. The East Anglia ONE North windfarm site is beyond the range of kittiwake from any breeding colonies. It is therefore very unlikely that birds present during the breeding season are breeding. 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. Consequently, the breeding season impact on kittiwake has been assessed against a reference population estimated using the same approach as that for the displacement assessment (***section 12.6.1.1***). 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 BDMPS populations of kittiwake (Furness 2015). This yields a breeding season population of nonbreeding kittiwake of 296,956 (Spring BDMPS for the UK North Sea and Channel, 627,816 x 47.3%).

12.6.2.3.1.3 Lesser black-backed gull

230. Lesser black-backed gulls breed at the Alde-Ore Estuary SPA which is within the 141km mean maximum foraging range (Thaxter et al., 2012) of this species from the East Anglia ONE North windfarm site. Thus, there is potential for connectivity with the East Anglia ONE North project during the breeding season.

231. In addition to the Alde-Ore colony, non-SPA colonies of lesser black-backed gulls located within foraging range of the East Anglia ONE North windfarm site include rooftop nesting gulls in several towns in Suffolk and Norfolk. 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. The recent assessment for Norfolk Vanguard (Norfolk Vanguard Ltd 2018) estimated a breeding reference population of 25,700 individuals of lesser black-backed gulls. This comprised breeding adults and non-breeding adults and sub adults associated with the Alde-Ore SPA, and coastal and urban areas of Suffolk and Norfolk with, based on the JNCC Seabird Monitoring Programme (http://jncc.defra.gov.uk/smp/) and a survey of Suffolk breeding colonies in 2012 (Piotrowski 2012). For the purposes of this assessment, the estimated collision risk mortality at the East Anglia ONE North windfarm site during the breeding season has been compared against this reference population.

232. Tracking data for lesser black-backed gulls breeding at the Alde-Ore Estuary SPA indicate that birds sometimes travel as far as the East Anglia ONE North windfarm site, but the core foraging areas for this breeding colony do not overlap with the proposed project (Thaxter et al. 2015).

12.6.2.3.1.4 Great Black-backed Gull

233. There are no breeding colonies for this species within foraging range of the East Anglia ONE North windfarm site. 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 displacement assessment (***section 12.6.1.1***). 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. Thus, 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%).

12.6.2.3.2 Nonbreeding Season Reference Populations for Collision Assessment

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

12.6.2.3.3 Collision Impacts

235. 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.

236. 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 12.32***.

Table 12.32 Average Annual Mortality Across Age Classes Calculated Using Age-Specific Demographic Rates and Age Class Proportions

Species	Parameter	Age class					Productivity	Average mortality
		0-1	1-2	2-3	3-4	Adult		
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		
	Survival	0.815	0.815	0.815	0.815	0.815	1.139	0.185

Great black-backed gull	Proportion in population	0.194	0.156	0.126	0.102	0.422		

237. The percentage increases in background mortality rates of seasonal and annual populations due to predicted collisions with the East Anglia ONE North wind turbines are shown in ***Table 12.33***.

238. The median 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 0.45% or less. Increases of such small magnitude would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of effects due to collision mortality for gannet, kittiwake, lesser black-backed, gull and great black-backed gull are considered to be negligible, resulting in impact significances of **negligible to minor adverse** (based on species' sensitivities to collision risk in ***Table 12.30***).

Table 12.33 Precautionary Estimates of Percentage Increases in the Background Mortality Rate of Seasonal and Annual Populations Due to Predicted Collisions (Option 2) Calculated with Stochasticity in Density, Avoidance Rate, Flight Height and Nocturnal Activity for Species Specific Worst Case Project Scenarios. Note that the Annual Mortalities Have Been Assessed Against Both the Biogeographic Populations and The Largest BDMPS (As Advised by Natural England) to Indicate the Range of Likely Effects.

Species (Worst case layout)		Gannet (12 MW)			Kittiwake (12 MW)			Lesser black-backed gull (12 MW)			Great black-backed gull (12 MW)		
		Median	Lower c.i.	Upper c.i.	Median	Lower c.i.	Upper c.i.	Median	Lower c.i.	Upper c.i.	Median	Lower c.i.	Upper c.i.
Baseline average annual mortality		0.191			0.156			0.126			0.185		
Breeding season	Reference population	44,637			296,956			25,970			52,829		
	Seasonal mortality	8.79	0.9	37.96	6	0.68	60.59	0.61	0	3.38	0	0	5.59
	Increase in background mortality (%)	0.10	0.01	0.45	0.01	0.00	0.13	0.02	0	0.10	0	0	0.06
Autumn	Reference population	456,298			829,937			209,007			N/A		
	Seasonal mortality	5.53	0.69	34.89	4.31	0.23	34.74	0	0	0			
	Increase in background	0.01	0.00	0.04	0.00	0.00	0.03	0	0	0			

Species (Worst case layout)		Gannet (12 MW)			Kittiwake (12 MW)			Lesser black-backed gull (12 MW)			Great black-backed gull (12 MW)		
	mortality (%)												
Winter	Reference population	N/A			N/A			39,316			91,399		
	Seasonal mortality							0	0	2.16	0.5	0	15.7
	Increase in background mortality (%)							0	0	0.04	0.00	0	0.09
Spring	Reference population	248,835			627,816			197,483			N/A		
	Seasonal mortality	1.3	0	11.98	17.42	3.9	57.38	0	0	1.49			
	Increase in background mortality (%)	0.00	0	0.03	0.02	0.00	0.06	0	0	0.01			
	Reference population	456,298			829,937			209,007			91,399		

Species (Worst case layout)		Gannet (12 MW)			Kittiwake (12 MW)			Lesser black-backed gull (12 MW)			Great black-backed gull (12 MW)		
Annual largest BDMPS	Seasonal mortality	15.62	1.59	84.83	27.73	4.81	152.71	0.61	0	7.03	0.5	0	15.7
	Increase in background mortality (%)	0.02	0.00	0.10	0.02	0.00	0.12	0.00	0	0.03	0.00	0	0.09
Annual biogeographic	Reference population	1,180,000			5,100,79000			854,000			235,000		
	Seasonal mortality	15.62	1.59	84.83	27.73	4.81	152.71	0.61	0	7.03	0.5	0	15.7
	Increase in background mortality (%)	0.01	0.00	0.04	0.00	0.00	0.00	0.00	0	0.01	0.00	0	0.04

12.6.3 Potential Impacts During Decommissioning

239. 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:

- Disturbance / displacement; and
- Indirect impacts through effects on habitats and prey species.

240. Any effects generated during the decommissioning phase of the proposed East Anglia ONE North 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.

241. Potential impacts predicted during the decommissioning phase include those associated with disturbance and displacement and indirect effects on birds through effects on habitats and prey species.

242. 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.

12.6.3.1 Direct Disturbance and Displacement

243. Disturbance and displacement is 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.

244. Any impacts generated during the decommissioning phase of the proposed East Anglia ONE North project are expected to be similar, but likely of reduced magnitude compared to those generated during the construction phase; therefore, the magnitude of effect is predicted to be negligible. This magnitude of impact on a range of species of low to high sensitivity to disturbance is of negligible to minor adverse significance.

12.6.3.2 Indirect Impacts Through Effects on Habitats and Prey Species

245. Indirect effects 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.

246. 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 effect is predicted to be negligible. This magnitude of impact on a range of species of low to high sensitivity to disturbance is of negligible to minor adverse significance.

12.7 Cumulative Impacts

12.7.1 Screening for Cumulative Impacts

247. The potential effects from the proposed East Anglia ONE North project that were screened in for assessment for the project alone were further screened for the potential for cumulative effects with other projects (as defined in ***section 12.7.2*** below).

248. Two potential effects, operational displacement and collision risk, were screened in for cumulative assessment (***Table 12.34***).

Table 12.34 Potential Cumulative Impacts

Impact	Potential for cumulative impact	Data confidence[1]	Rationale
Construction			
Direct disturbance and displacement:	No	High	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.
Indirect impacts through effects on habitats and prey species	No	High	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 /

Impact	Potential for cumulative impact	Data confidence[1]	Rationale
			displacement from other plans or projects.
Operation			
Direct disturbance and displacement:	Yes	High	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Indirect impacts through effects on habitats and prey species	No	High	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is small
Collision risk	Yes	High	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Decommissioning			
Direct disturbance and displacement:	No	High	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.
Indirect impacts through effects on habitats and prey species	No	High	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is

Impact	Potential for cumulative impact	Data confidence[1]	Rationale
			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.			

12.7.2 Projects Considered for Cumulative Impacts

249. 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.

250. Of these, only offshore windfarms are considered to have potential to contribute to cumulative operational displacement and collision risk, the effects screened in for cumulative assessment. Thus, the cumulative assessment is focused on offshore windfarms.

251. 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 and may be consented before the proposed East Anglia ONE North project.

252. In addition, other ‘foreseeable’ projects are included: 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. For

such projects, the absence of robust or relevant data could preclude a quantitative cumulative assessment being carried out.

253. The windfarms listed in ***Table 12.35*** have been assigned to Tiers following the approach proposed by Natural England and JNCC (Natural England, 2013) as follows:

1. Built and operational projects;
2. Projects under construction;
3. Consented;
4. Application submitted and not yet determined;
5. In planning (scoped), application not yet submitted; and,
6. Identified in Planning Inspectorate list of projects.

Table 12.35 Summary of Projects Considered for the CIA in Relation to Ornithology

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Greater Gabbard	1	Built and operational	Fully commissioned Aug 2013	43	27	Complete for the ornithology receptors being assessed	Yes	Included as an operational project that does not yet form part of the baseline.
Gunfleet Sands	1	Built and operational	Fully commissioned Jun 2010	95	52	Complete for the ornithology receptors being assessed	Yes	Included as an operational project that does not yet form part of the baseline.
Kentish Flats	1	Built and operational	Fully commissioned Dec 2005	126	85	Complete but limited quantitative species assessment	Yes	Operational for a sufficiently long time that its effects will have been incorporated in surveys but not yet in population responses
Lincs	1	Built and operational	Fully commissioned Sep 2013	144	128	Complete but limited quantitative	Yes	Included as an operational project that does not yet form part of the baseline.

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
						species assessment		
London Array	1	Built and operational	Fully commissioned Apr 2013	89	52	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
Lynn and Inner Dowsing	1	Built and operational	Fully commissioned Mar 2009	145	129	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
Scroby Sands	1	Built and operational	Fully commissioned Dec 2004	40	33	Complete but limited quantitative species assessment	Yes	Operational for a sufficiently long time that its effects will have been incorporated in surveys but not yet in population responses
Sheringham Shoal	1	Built and operational	Fully commissioned Sep 2012	104	98	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Beatrice (demonstrator)	1	Built and operational	Fully commissioned July 2007	715	713	Complete but limited quantitative species assessment	Yes	Due to be decommissioned between 2024 and 2027
Thanet	1	Built and operational	Fully commissioned Sep 2010	106	78	Complete for the ornithology receptors being assessed	Yes	Included as an operational project that does not yet form part of the baseline.
Teesside	1	Built and operational	Fully commissioned Aug 2013	332	324	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
Westermost Rough	1	Built and operational	Fully commissioned May 2015	207	199	Complete for the ornithology receptors being assessed	Yes	Included as an operational project that does not yet form part of the baseline.

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Humber Gateway	1	Built and operational	Fully commissioned May 2015	188	179	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
Galloper	1	Built and operational	Fully commissioned March 2018	39	27	Complete for the ornithology receptors being assessed	Yes	Included as an operational project that does not yet form part of the baseline.
Dudgeon	1	Built and operational	Fully commissioned November 2017	105	103	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
Race Bank	1	Built and operational	Fully commissioned February 2018	129	121	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Beatrice	2	Under construction	Consent Mar 2014. Construction commenced Jan 2017	720	719	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
East Anglia ONE	2	Under construction	Consent Jun 2014, offshore construction due to commence August 2018	1	11	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
EOWDC (Aberdeen OWF)	2	Under construction	Consent August 2014, offshore construction commenced April 2018	599	598	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Hornsea Project 1	2	Under construction	Consent Dec 2014, offshore construction commenced January 2018	154	163	Complete for the ornithology receptors	Yes	Included as a consented project that does not yet form part of the baseline.

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
						being assessed		
Rampion	2	Under construction	Consent Aug 2014. Construction commenced Apr 2017 (expected to be commissioned 2018)	251	207	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Blyth (NaREC Demonstration)	3	Consented	Consent Nov 2013, no construction start date	391	384	Complete but limited quantitative species assessment	Yes	Included as a consented project that does not yet form part of the baseline.
Dogger Bank Creyke Beck A and B	3	Consented	Consent Feb 2015, no construction start date.	249	257	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Inch Cape	3	Consented	Consent Sep 2014, no construction start date, revised application	518	512	Complete for the ornithology receptors	Yes	Included as a consented project that does not yet form part of the baseline.

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
			submitted August 2018			being assessed		
Neart na Gaoithe	3	Consented	Consent Oct 2014, no construction start date, revised application with fewer wind turbines (max 54) submitted August 2018	511	507	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Firth of Forth Alpha and Bravo	3	Consented	Consent Oct 2014, no construction start date, revised application submitted Sept 2018	519	517	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Moray East Offshore Windfarm	3	Consented	Consent Mar 2014, no construction start date	661	659	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Dogger Bank Teesside A and B (now Sofia)	3	Consented	Consent Aug 2015, no construction start date	267	276	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Hornsea Project 2	3	Consented	Consent Aug 2016, no construction start date	162	168	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Triton Knoll	3	Consented	Consent Jul 2013, no construction start date, Non-material variation submitted Feb 2018	140	135	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
East Anglia THREE	3	Consented	Consent Aug 2017. No construction start date	17	35	Complete for the ornithology receptors	Yes	Included as a consented project that does not yet form part of the baseline.

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
						being assessed		
Hornsea Project 3	4	Application accepted	Pre-examination	141	151	Complete for the ornithology receptors being assessed	Yes	Included as a foreseeable project
Thanet Extension	4	Application accepted	Pre-examination	102	77	Complete for the ornithology receptors being assessed	Yes	Included as a foreseeable project
Norfolk Vanguard	4	Application accepted	Pre-examination	38	50	Complete for the ornithology receptors being assessed	Yes	Included as a foreseeable project
East Anglia TWO	5	Pre-planning application	Submission expected Q1 2019	10	0	ES not yet available	Yes	In the absence of final data, the outputs from

Project	Tier	Status	Development status	Distance from East Anglia ONE North windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
								the PEIR have been included.
Norfolk Boreas	5	Pre-planning application	Submission expected Q2 2019	51	64	Not yet available	Yes	In the absence of data, the outputs from the PEIR have been included.
Hornsea Project 4	5	Pre-planning application		167	170	Not yet available	Yes	In the absence of data, the inclusion of this project is only on a qualitative basis.

254. 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.

12.7.3 Cumulative Assessment of Operational Displacement

255. 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).

256. A review of the BDMPS regions for each species indicated that for gannet, guillemot, and razorbill, all the windfarms identified for inclusion in the CIA in ***Table 12.35*** 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.

12.7.3.1 Red-throated Diver

257. The project alone assessment concluded that during the midwinter period when divers are most at risk of impacts due to displacement, the number of individuals at risk of mortality due to displacement was sufficiently small (0 - 3 birds) that there was no risk of a significant impact. Although a higher number was considered to be at risk of displacement-caused mortality during spring migration (3 - 14), this includes birds passing through the site for a brief period on migration and therefore the consequences of displacement are minimal and no significant project alone effects were predicted.

258. The recent Environmental Statement for Norfolk Vanguard Offshore Windfarm (Norfolk Vanguard Ltd 2018) and the PEIR for Norfolk Boreas (Norfolk Boreas Ltd 2018) include estimates of potential displacement mortality for red-throated divers from windfarms in the southern North Sea. These were based on a review of information in environmental statements. Windfarms at which wind turbines were installed before or during 2012 were considered to form part of the baseline, since any displacement effect at these sites would have occurred prior to the baseline surveys for Norfolk Vanguard and Norfolk Boreas and therefore any modifications in red-throated diver distribution as a result of displacement would

be fully reflected in the baseline data. The combined total and the windfarm sites contributing to this total is shown in ***Table 12.36***.

259. As baseline surveys for the proposed East Anglia ONE North project were carried out between September 2016 and August 2018 (***Appendix 12.1***), a similar argument can be applied as for Norfolk Vanguard, that displacement effects of windfarms with wind turbines installed before or during 2012 would be taken account of in baseline surveys. None of the other windfarms included in the cumulative assessment for Norfolk Vanguard has been completed in this timescale, so the cumulative total is applied to this assessment.

260. The predicted cumulative displacement mortality for red-throated divers from offshore windfarms in the southern North Sea, assuming a maximum of 80% displacement from the windfarms and a 4km buffer, and 1-5% mortality of displaced birds, is between 30 and 150.5 birds per year (***Table 12.36***).

261. 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 (***Table 12.16***) the number of individuals expected to die is 3,027 (13,277 x 0.228). The addition of 30-150.5 birds would increase the mortality rate by 1-5%. 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 30-150.5 birds to this would increase the mortality rate by 0.5-2.4% respectively.

262. The cumulative red-throated diver displacement mortality total combines several sources of precaution:

- 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;
- There is some overlap between survey areas for different sites (the Norfolk Vanguard East 4km buffer includes part of the East Anglia THREE windfarm and 4km buffer and vice versa) so including both sites double counts birds in the overlapping area;
- Displacement mortality may be less than 1-5% and could be as low as zero; and
- More than half the total annual mortality (76%) 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.

263. Looking at the winter period, 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 8–28 birds to this would increase the mortality rate by 0.3–1.2%.

264. 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, whereas above 1% there could be detectable effects. Using a range of mortality of 1–5% 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. A review of the possible behavioural, energetic and demographic effects of displacement on red-throated divers (Dierschke et al. 2017) considered that because they use a range of marine habitats and take a variety of prey species, and are generally highly mobile in winter, increased density of birds in area of sea due to displacement from offshore wind farms would be unlikely to limit prey intake, both for displaced individuals and those already present in areas to which displaced birds move. Thus there might not be any effects of displacement on energy budgets, body condition and therefore mortality rates of displaced birds, unless prey abundance is depleted over extensive areas due to environmental conditions such as adverse weather. This was qualified with the evidence that red-throated divers do show a strong behavioural avoidance to anthropogenic disturbance which is likely to reflect a hormonal stress response and could affect their ability to forage normally for a period after displacement, and that some individuals are site faithful during the non-breeding season and if displaced might suffer to a greater extent than more mobile individuals.

265. A further source of precaution is that the assessment methodology makes no allowance for the fact that wind turbine densities (and hence the negative stimulus to which the birds respond) within the built windfarms will 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 is likely to further reduce the magnitude of displacement.

266. Given the various additive sources of precaution in this assessment, 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**.

Table 12.36 Cumulative Numbers of Red-throated Divers at Risk of Displacement Mortality from Offshore Windfarms in the Southern North Sea

Offshore Windfarm(s)	No. red-throated divers at risk of displacement mortality*				Source of information
	Autumn migration	Winter	Spring migration	Annual	
East Anglia One, East Anglia THREE, Norfolk Vanguard, Galloper and Thanet Extension	0 - 6	3 - 19	6 - 27	12 - 59.5	Norfolk Vanguard Ltd (2018); Norfolk Boreas Ltd (2018)
East Anglia TWO	0 - 2	0 - 1	3 - 15	4 - 19	EA2 PEI (Royal HaskoningDHV 2019)
East Anglia ONE North	0 - 1	1 - 3	3 - 14	3 - 17	***Table 12.17, Table 12.18, Table 12.19***
Norfolk Boreas	0 - 1	1 - 5	10 - 49	11 - 55	Norfolk Boreas Ltd (2018)
Totals	2 - 10	8 - 28	22 - 105	30 - -120.5	
*** For the windfarm and a 4km buffer, assuming a maximum of 80% displacement and 1-5% mortality of displaced birds. Numbers for East Anglia TWO and East Anglia ONE North are rounded to the nearest integer, so annual totals may appear to be less or more than the sum of seasonal totals.**					

12.7.3.2 Gannet

267. The East Anglia ONE North windfarm site is located beyond the mean maximum foraging range of gannets from breeding colonies in the North Sea. Therefore, displacement risk is primarily of concern outside the breeding season. There is evidence that gannets avoid flying through windfarms (Krijgsveld et al. 2011; Skov et al. 2018, Cook et al. *in press*). If this prevents them accessing important foraging areas this could have an impact on displaced individuals. However, for the reasons set out below, the potential for the proposed East Anglia ONE North project to contribute to a cumulative effect such as this is considered to be very unlikely. The period when gannet displacement is of potential concern is during autumn migration. At this time, 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). 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). Furthermore, gannets are considered to be highly flexible in their foraging requirements, and exclusion from windfarms in the southern North Sea, on the basis of the low overall numbers of seabirds present, is very unlikely to represent a loss of habitat of any importance. Consequently, the potential for the proposed East Anglia ONE North project to contribute to a significant cumulative displacement effect on gannets during migration is considered to be negligible and the impact significance of cumulative displacement on a receptor of low to medium sensitivity is **negligible**.

12.7.3.3 Razorbill

268. The East Anglia ONE North windfarm site is located beyond the mean maximum foraging range of any razorbill breeding colonies (see ***section 12.6.2.1.4***). 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).

269. The annual total of razorbills at risk of displacement from the East Anglia ONE North windfarm site is estimated as 749 individuals (summing the seasonal peak means on the East Anglia ONE North windfarm site (and 2km buffer) for the migration-free breeding, autumn migration, winter, and spring migration periods; ***Table 12.15***).

270. The recent cumulative assessments for offshore ornithology for East Anglia THREE (EATL 2016) and the Norfolk Vanguard project (Norfolk Vanguard Ltd 2018) include cumulative estimates of the total numbers of razorbills at risk of displacement from other offshore windfarms in the North Sea. These estimates are included in ***Table 12.37***, along with updates for projects where new

information has become available since the publication of Norfolk Vanguard Limited (2018). These totals omit windfarms for which no data are available (Gunfleet Sands, Kentish Flats, Lynn and Inner Dowsing, Scroby Sands), 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.

271. The estimated annual cumulative total of razorbills at risk of displacement from windfarms in the North Sea is 98,927 individuals (***Table 12.37***). 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 297 and 6,925 (***Table 12.38***).

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

273. Post-construction monitoring of auks at offshore windfarms has found evidence of avoidance behaviour, and indications that wind turbine density may affect the magnitude of avoidance (Leopold et al. 2011; Krijgsveld et al. 2011). The estimated macro-avoidance rate of auks from studies at OWEZ was around 68%, although it should be noted that this was based on birds flying towards the windfarm and this value may not be appropriate for swimming birds. During daylight, wintering auks at OWEZ were observed mainly to sit on the water and float with tidal currents, with flight movements considered to be mainly corrections when birds drifted too far from favoured foraging areas (Krijgsveld et al. 2011). Razorbills and guillemots were seen inside OWEZ, although razorbills were never observed inside a neighbouring windfarm (PAWP) with a higher wind turbine density (Leopold et al. 2011).

274. The above studies were conducted at sites with relatively closely spaced wind turbines (e.g. 550m), while the minimum spacing at East Anglia ONE North will be 800m in row and 1200m between rows (see ***Table 12.2***). Thus, a figure of 70% displacement represents a precautionary estimate.

275. Most of the windfarms in ***Table 12.37*** are beyond foraging range of breeding colonies for razorbills, so the majority of birds at risk of displacement would be non-breeding birds. The pressures on nonbreeding birds in terms of energy requirements are lower than during the breeding season, as they only need to obtain sufficient food to maintain their own survival (and not also to feed nestlings). In addition, auks can remain on the sea for extended periods and thus flight costs are minimised. Recoveries of ringed razorbills from UK colonies have indicated a wide distribution in winter, with birds tending to move southwards and spreading throughout the southern and eastern North Sea, Celtic Sea, Channel,

and Bay of Biscay (Furness 2015). It is likely that razorbills are relatively flexible in terms of where they spend the winter and are not dependent on particular foraging locations. There may be variation between years, and long-term changes in migration patterns, relating to prey availability and abundance, as is described for guillemot. Hence, the consequence of winter displacement from windfarms in terms of increased mortality is likely to be minimal. Given that, even when fish stocks have collapsed, survival rates of adult seabirds have shown declines of no more than 6 to 7% (e.g. kittiwake, Frederiksen et al. 2004) an increase in mortality due to displacement from windfarm sites seems likely to be at the low end of the proposed 1 to 10% range, and a value of 1% when combined with the precautionary 70% displacement rate is considered appropriate. On this basis, a precautionary cumulative nonbreeding displacement mortality of 692 is obtained (***Table 12.38***).

276. The largest BDMPS for razorbill in UK North Sea waters is 591,874 (Furness 2015). At the average baseline mortality rate of 0.174 (***Table 12.16***) the number of individuals expected to die in a year is 102,986 (591,874 x 0.174). The addition of a maximum of 692 individuals to this increases the background mortality rate by 0.7%. This magnitude of increase 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 low to medium sensitivity to disturbance, the potential for the proposed East Anglia ONE North project to contribute to a significant cumulative displacement effect on razorbill is considered to be very small and the impact significance of cumulative displacement is **negligible**.

Table 12.37 Cumulative Numbers of Razorbills at Risk of Displacement from Offshore Windfarms in the North Sea

Offshore Windfarm(s)	No. razorbills at risk of displacement*				Source of information
	Breeding	Autumn migration	Winter	Spring migration	
Aberdeen	161	64	7	26	EATL (2016), Norfolk Vanguard Ltd (2018)
Beatrice	873	833	555	833	EATL (2016), Norfolk Vanguard Ltd (2018)
Blyth Demonstration	121	91	61	91	EATL (2016), Norfolk Vanguard Ltd (2018)
Dogger Bank Creyke Beck A	1250	1,576	1,728	4,149	EATL (2016), Norfolk Vanguard Ltd (2018)
Dogger Bank Creyke Beck B	1538	2,097	2,143	5,119	EATL (2016), Norfolk Vanguard Ltd (2018)
Dogger Bank Teesside A	834	310	959	1,919	EATL (2016), Norfolk Vanguard Ltd (2018)
Dogger Bank Teesside B	1153	592	1,426	2,953	EATL (2016), Norfolk Vanguard Ltd (2018)
Dudgeon	256	346	745	346	EATL (2016), Norfolk Vanguard Ltd (2018)
East Anglia ONE	16	26	155	336	EATL (2016), Norfolk Vanguard Ltd (2018)
East Anglia THREE	1807	1,122	1,499	1,524	East Anglia Three Ltd (2015)
Galloper	44	43	106	394	EATL (2016), Norfolk Vanguard Ltd (2018)
Greater Gabbard	0	0	387	84	EATL (2016), Norfolk Vanguard Ltd (2018)
Hornsea Project One	1109	4,812	1,518	1,803	EATL (2016), Norfolk Vanguard Ltd (2018)
Hornsea Project Two	2511	4,221	720	1,668	EATL (2016), Norfolk Vanguard Ltd (2018)
Hornsea Project Three	630	2,020	3,649	1,236	Orsted (2018)

Offshore Windfarm(s)	No. razorbills at risk of displacement*				Source of information
	Breeding	Autumn migration	Winter	Spring migration	
Humber Gateway	27	20	13	20	EATL (2016), Norfolk Vanguard Ltd (2018)
Inch Cape	1436	2,870	651		EATL (2016), Norfolk Vanguard Ltd (2018)
Lincs and LID6	45	34	22	34	EATL (2016), Norfolk Vanguard Ltd (2018)
London Array I and II	14	20	14	20	EATL (2016), Norfolk Vanguard Ltd (2018)
Moray	2423	1,103	30	168	EATL (2016), Norfolk Vanguard Ltd (2018)
Neart na Gaoithe	331	5,492	508		EATL (2016), Norfolk Vanguard Ltd (2018)
Norfolk Vanguard East	599	491	279	752	Norfolk Vanguard Ltd (2018)
Norfolk Vanguard west	280	375	348	172	Norfolk Vanguard Ltd (2018)
Race Bank	28	42	28	42	EATL (2016), Norfolk Vanguard Ltd (2018)
Seagreen A	3208				EATL (2016), Norfolk Vanguard Ltd (2018)
Seagreen B	886				EATL (2016), Norfolk Vanguard Ltd (2018)
Sheringham Shoal	106	1,343	211	30	EATL (2016), Norfolk Vanguard Ltd (2018)
Teesside	16	61	2	20	EATL (2016), Norfolk Vanguard Ltd (2018)
Thanet	3	0	14	21	EATL (2016), Norfolk Vanguard Ltd (2018)
Thanet Extension	0	6	56	124	Vattenfall Wind Power Ltd (2018) Annex 4-3.

Offshore Windfarm(s)	No. razorbills at risk of displacement*				Source of information
	Breeding	Autumn migration	Winter	Spring migration	
Triton Knoll	40	254	855	117	EATL (2016), Norfolk Vanguard Ltd (2018)
Westermost Rough	91	121	152	91	EATL (2016), Norfolk Vanguard Ltd (2018)
East Anglia TWO	288	55	148	263	East Anglia ONE TWO Ltd (2019)
East Anglia ONE North	403	85	54	207	Table 12.15
Norfolk Boreas	750	221	885	414	Norfolk Boreas Ltd. (2018)
Cumulative total	23,277	30,746	19,928	24,967	
Cumulative Annual total				98,927	
***Totals for the windfarm and a 2km buffer; blanks indicate no data available for a particular development and season**					

Table 12.38 Cumulative Displacement Matrix for Razorbill

Annual		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	99	198	297	396	495	989	1979	2968	4946	7914	9893
	20%	198	396	594	791	989	1979	3957	5936	9893	15828	19785
	30%	297	594	890	1187	1484	2968	5936	8903	14839	23743	29678
	40%	396	791	1187	1583	1979	3957	7914	11871	19785	31657	39571
	50%	495	989	1484	1979	2473	4946	9893	14839	24732	39571	49464
	60%	594	1187	1781	2374	2968	5936	11871	17807	29678	47485	59356
	70%	692	1385	2077	2770	3462	6925	13850	20775	34625	55399	69249
	80%	791	1583	2374	3166	3957	7914	15828	23743	39571	63313	79142
	90%	890	1781	2671	3561	4452	8903	17807	26710	44517	71228	89034
	100%	989	1979	2968	3957	4946	9893	19785	29678	49464	79142	98927

12.7.3.4 Guillemot

277. The East Anglia ONE North windfarm site is 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).

278. The annual total of guillemots at risk of displacement from the proposed East Anglia ONE North project is estimated as 6,071 individuals (summing the seasonal peak means on the East Anglia ONE North windfarm site (and 2km buffer) for the breeding and non-breeding periods (***Table 12.15)***.

279. The recent cumulative assessments for offshore ornithology for East Anglia THREE (EATL 2016) and the Norfolk Vanguard project (Norfolk Vanguard Limited 2018) include estimates of the total numbers of guillemots at risk of displacement from other offshore windfarms in the North Sea. These estimates are included in ***Table 12.39***, along with updates for projects where new information has become available since the publication of Norfolk Vanguard Limited (2018). These totals omit windfarms for which no data are available (Gunfleet Sands, Kentish Flats, Lynn and Inner Dowsing, Scroby Sands), 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.

280. The estimated annual cumulative total of guillemots at risk of displacement from windfarms in the North Sea is 240,939 individuals (***Table 12.39***). 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 723 and 16,866 (***Table 12.40***).

281. This is a large range so the assessment considers the most realistic value within this range. As discussed above under razorbill (***paragraphs 273*** to ***275***), a precautionary estimate of 70% displacement and of 1% mortality, 1687 birds (***Table 12.40*****),** is considered most appropriate.

282. 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 (***Table 12.16)*** the number of individuals expected to die in a year is 226,423 (1,617,306 x 0.14). The addition of a maximum of 1,687 individuals to this increases the background mortality rate by 0.7%. This magnitude of increase 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 low to medium sensitivity to disturbance, the potential for the proposed East Anglia ONE

North project to contribute to a significant cumulative displacement effect on guillemot is considered to be very small and the impact significance of cumulative displacement is **negligible**.

Table 12.39 Cumulative Numbers of Guillemots at Risk of Displacement from Offshore Windfarms in the North Sea

Offshore Windfarm(s)	No. guillemots at risk of displacement*		Source of information
	Breeding	Non-breeding	
Aberdeen	547	225	EATL (2016), Norfolk Vanguard Ltd (2018)
Beatrice	13,610	2,755	EATL (2016), Norfolk Vanguard Ltd (2018)
Blyth Demonstration	1,220	1,321	EATL (2016), Norfolk Vanguard Ltd (2018)
Dogger Bank Creyke Beck A	5,407	6,142	EATL (2016), Norfolk Vanguard Ltd (2018)
Dogger Bank Creyke Beck B	9,479	10,621	EATL (2016), Norfolk Vanguard Ltd (2018)
Dogger Bank Teesside A	3,283	2,268	EATL (2016), Norfolk Vanguard Ltd (2018)
Dogger Bank Teesside B	5,211	3,701	EATL (2016), Norfolk Vanguard Ltd (2018)
Dudgeon	334	542	EATL (2016), Norfolk Vanguard Ltd (2018)
East Anglia ONE	274	640	EATL (2016), Norfolk Vanguard Ltd (2018)
East Anglia THREE	1,669	2,859	EATL (2015)
Galloper	305	593	EATL (2016), Norfolk Vanguard Ltd (2018)
Greater Gabbard	345	548	EATL (2016), Norfolk Vanguard Ltd (2018)
Hornsea Project One	9,836	8,097	EATL (2016), Norfolk Vanguard Ltd (2018)
Hornsea Project Two	7,735	13,164	EATL (2016), Norfolk Vanguard Ltd (2018)
Hornsea Project Three	13,374	17,772	Orsted (2018)

Offshore Windfarm(s)	No. guillemots at risk of displacement*		Source of information
	Breeding	Non-breeding	
Humber Gateway	99	138	EATL (2016), Norfolk Vanguard Ltd (2018)
Inch Cape	4,371	3,177	EATL (2016), Norfolk Vanguard Ltd (2018)
Lincs and LID6	582	814	EATL (2016), Norfolk Vanguard Ltd (2018)
London Array I and II	192	377	EATL (2016), Norfolk Vanguard Ltd (2018)
Moray	9,820	547	EATL (2016), Norfolk Vanguard Ltd (2018)
Neart na Gaoithe	1,755	3,761	EATL (2016), Norfolk Vanguard Ltd (2018)
Norfolk Vanguard East	2,931	2,197	Norfolk Vanguard Ltd (2018)
Norfolk Vanguard west	1,389	2,579	Norfolk Vanguard Ltd (2018)
Race Bank	361	708	EATL (2016), Norfolk Vanguard Ltd (2018)
Seagreen A	16500		EATL (2016), Norfolk Vanguard Ltd (2018)
Seagreen B	16054		EATL (2016), Norfolk Vanguard Ltd (2018)
Sheringham Shoal	390	715	EATL (2016), Norfolk Vanguard Ltd (2018)
Teesside	267	901	EATL (2016), Norfolk Vanguard Ltd (2018)
Thanet	18	124	EATL (2016), Norfolk Vanguard Ltd (2018)
Thanet Extension	12	1,178	Vattenfall Wind Power Ltd (2018) Annex 4-3.
Triton Knoll	425	746	EATL (2016), Norfolk Vanguard Ltd (2018)

Offshore Windfarm(s)	No. guillemots at risk of displacement*		Source of information
	Breeding	Non-breeding	
Westermost Rough	347	486	EATL (2016), Norfolk Vanguard Ltd (2018)
East Anglia TWO	2,126	2,020	East Anglai TWO Ltd (2019)
East Anglia ONE North	4,183	1,888	***Table 12.15***
Norfolk Boreas	2,413	10,471	Norfolk Boreas Ltd (2018)
Cumulative total	136,864	104,075	
Cumulative Annual total	240,939		
***Totals for the windfarm and a 2km buffer; blanks indicate no data available for a particular development and season**			

Table 12.40 Cumulative Displacement Matrix for Guillemot

Annual		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	241	482	723	964	1205	2409	4819	7228	12047	19275	24094
	20%	482	964	1446	1928	2409	4819	9638	14456	24094	38550	48188
	30%	723	1446	2168	2891	3614	7228	14456	21685	36141	57825	72282
	40%	964	1928	2891	3855	4819	9638	19275	28913	48188	77101	96376
	50%	1205	2409	3614	4819	6023	12047	24094	36141	60235	96376	120470
	60%	1446	2891	4337	5783	7228	14456	28913	43369	72282	115651	144564
	70%	1687	3373	5060	6746	8433	16866	33732	50597	84329	134926	168658
	80%	1928	3855	5783	7710	9638	19275	38550	57825	96376	154201	192752
	90%	2168	4337	6505	8674	10842	21685	43369	65054	108423	173476	216845
	100%	2409	4819	7228	9638	12047	24094	48188	72282	120470	192752	240939

12.7.4 Cumulative Assessment of Operational Collision Risk

283. The species assessed for project alone collision impacts (and the relevant seasons) were those for which a collision mortality greater than one individual for the project alone was estimated, on the grounds that the potential for the proposed East Anglia ONE North project to contribute to a cumulative mortality effect was negligible for annual mortalities below this. Thus, cumulative collision risk both annually and for key seasons was assessed for gannet, kittiwake, lesser black-backed gull and great black-backed gull.

284. It is considered that all of the windfarms identified for inclusion in the CIA in ***Table 12.35*** have the potential to contribute to a cumulative effect.

12.7.4.1 Gannet

285. The cumulative gannet collision risk prediction is set out in ***Table 12.41***. This collates collision predictions from other windfarms which may contribute to the cumulative total. This table takes the recently submitted windfarm assessment for Norfolk Vanguard as its starting point.

286. The cumulative totals of collision mortality in each season, and summed across seasons, are presented in ***Table 12.41***. Assessments at other windfarms have been conducted using a range of avoidance rates and alternative collision model Options. In order to simplify interpretation of the data across sites and also to bring these assessments up to date with the current Natural England Advice, the values in ***Table 12.41*** are those estimated using the Band Model Option 1 (or 2, if that was the one presented) standardised at an avoidance rate of 98.9%.

287. All windfarm estimates have also been updated to reflect the evidence based nocturnal flight activity rates reported in Furness et al. (2018b). Furness et al. (2018b) recommended precautionary nocturnal activity rates for gannet in the breeding and nonbreeding seasons of 8% and 4% respectively. However, the actual average rates from their study were 7.1% and 2.3% respectively. Furthermore, the breeding season value was very heavily influenced by the results from the smallest study in the review, which was based on only three tagged birds in Shetland (Garthe et al. 1999). This study yielded a nocturnal activity rate of 20.9% (compared to daytime) but the total duration of flight activity recorded was only 215 hours, which was less than 3% of the > 8,000 hours covered by the remaining studies. If the average rate is calculated without this study a breeding season rate of 4.3% (SE 2.7%) is obtained. This is considered to be more robust and has been used in the current assessment. Similarly, the actual nonbreeding season rate of 2.3% (SE 0.4%) has been used here in preference to the rounded-up value of 4% reported in Furness et al. (2018). Use of these evidence-based rates for gannet improves the scientific basis of the assessment while also reducing unnecessary precaution.

Table 12.41 Cumulative Collision Risk Assessment for Gannet

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
1	Beatrice Demonstrator	0.6	0.9	0.7	2.2
1	Greater Gabbard	0	0	0	0
1	Gunfleet Sands	0	0	0	0
1	Kentish Flats	0.2	0	0	0.2
1	Lincs	4.3	0	0	4.3
1	London Array	0	0	0	0
1	Lynn and Inner Dowsing	0	0	0	0
1	Scroby Sands	0	0	0	0
1	Sheringham Shoal	10.3	4.7	0	15
1	Teeside	5.6	0	0	5.6
1	Thanet	0.8	0	0	0.8
1	Humber Gateway	2.9	0	0	2.9
1	Westernmost Rough	0.2	0	0	0.2
2	Beatrice	20.0	48.2	10	78.2
2	Dudgeon	20.1	30.3	15.4	65.8
2	Galloper	9.4	24.9	13.5	47.8
2	Race Bank	29.6	6.9	3.1	39.6
2	Rampion	36.4	50.1	1.1	87.6
2	Hornsea Project One	10.3	23.6	17.5	51.4
3	Blythe Demonstration	0	0	0	0
3	Dogger Bank Creyke Beck Projects A and B	10.0	10.3	6.7	27
3	East Anglia ONE	1.8	66.0	3.6	71.4
3	Aberdeen (EOWDC)	2.9	2.2	0.0	5.1
3	Forth (Seagreen) Alpha and Bravo	742.5	111.1	83.8	937.4
3	Inch Cape	337.5	30.3	7.2	375

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
3	Moray Firth (EDA)	48.3	50.4	30.2	128.9
3	Neart na Gaoithe	130.6	38.6	18.5	187.7
3	Dogger Bank Teeside A and B (now Sofia)	13.6	8.1	8.7	30.4
3	Triton Knoll	24.4	64.6	40.8	129.8
3	Hornsea Project Two	7.9	10.2	4.0	22.1
4	East Anglia THREE	5.2	24.7	7.1	37
4	Hornsea Project three	18.3	12.1	8.1	38.5
4	Thanet Extension	0	2.9	7.1	10.0
4	Norfolk Vanguard	18.3	62.3	29.9	110.5
5	East Anglia TWO	8.8	8.6	1.2	18.6
5	East Anglia ONE North	8.8	5.5	1.3	15.6
5	Norfolk Boreas	15	42.1	11.1	68.2
	TOTALS	**1544.6**	**739.6**	**330.6**	**2614.8**

288. The annual cumulative total for estimated collision mortality is 2,615. Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher total rotor swept areas than have been installed (or are planned), which is a key factor in collision risk. For example, the Beatrice windfarm, which is currently under construction, was consented on the basis of up to 125 x 7MW wind turbines but only 84 (of the same model) will be installed, leading to a reduction in mortality risk of 33%. 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 the Beatrice windfarm using this approach reduces the predicted annual mortality from 96 to 64 (not accounting for revised nocturnal activity rates). Similar reductions in collision mortality are likely to result from changes in windfarm design at other consented but not constructed windfarms in the North Sea which are included in the cumulative and in-combination totals. This could include Firth of Forth Alpha and Bravo, Hornsea Project One and Two, Inch Cape, Moray Firth, Neart na Gaoithe, Race Bank, Rampion, Dogger Bank Creyke Beck A and B and Teesside A and B and Triton

Knoll. Applying similar reductions to these windfarms in ***Table 12.41*** would reduce the cumulative annual mortality by about 400. Therefore, the values presented in ***Table 12.41***, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 15% due to the reduced collision risks for projects which undergo design revisions post-consent.

289. Previous gannet collision assessments for the windfarms listed in ***Table 12.41*** have been made on the basis of Band model Option 1 and a range of avoidance rates between 95% and 99%. The current rate of 98.9% dates from November 2014 (JNCC et al., 2014) and followed the review conducted by Cook et al. (2014). Therefore, the decisions for some of the projects consented prior to this date were on the basis of estimated cumulative collision mortality numbers which were higher than the values presented in ***Table 12.41***. However, given the variation in rates presented in different assessments and the rates used in reaching consent decisions, it is difficult to confidently determine the avoidance rate used for each windfarm consent decision. Nonetheless, it can be stated with a good degree of certainty that none of the previous windfarms have been consented on the basis of an avoidance rate higher than 99%, and many will have been based on assessment at 98%. It therefore follows that the cumulative total including the proposed East Anglia ONE North project (2,615) is almost certainly lower than those on which some recent consent decisions have been granted.

290. Work conducted at the Greater Gabbard windfarm (APEM, 2014) has also found that gannet avoidance of windfarms during the autumn migration period may be even higher than the current estimate of 98.9%. Of 336 gannets observed during this study, only 8 were recorded within the windfarm, indicating a high degree of windfarm (macro) avoidance. Analysis of their data indicated a macro-avoidance rate in excess of 95% compared with the current guidance value of 64% (see ***paragraph 166*** above). When combined with meso- and micro-avoidance this would result in higher overall avoidance than the current 98.9% and would further reduce the total collision mortality prediction.

291. A bird flight behaviour study commissioned by ORJIP provides further evidence relating to the precautionary nature of current avoidance rates and other parameters used in windfarm assessment (Skov et al. 2018). Based on a combination of video, radar and field observations at Thanet Offshore Windfarm, the empirical avoidance rate for gannet was calculated as 99.9%.

292. Demographic data were collated for the British gannet population to produce a population model which was used to consider the potential impact of additional mortality (WWT, 2012). Two versions of the model were developed, with and without density dependence. Of these two models, the density independent one was considered to provide more reliable predictions since it predicted baseline

growth at a rate close to that recently observed (1.28% per year compared with an observed rate of 1.33%) while the density dependent model predicted baseline growth of 0.9%. While density-dependent regulation of populations is to be expected as the norm, in the case of gannet the population has been increasing for many decades, suggesting that the population has not yet reached a level where density-dependent regulation is a major influence on its dynamics.

293. The study concluded that, using the density independent model, population growth, on average, would remain positive until additional mortality exceeded 10,000 individuals per year, while the lower 95% confidence interval on population growth remained positive until additional mortality exceeded 3,500 individuals, which is greater than the cumulative total in ***Table 12.41***. Consideration was also given to the risk of population decline. The risk of a 5% population decline was less than 5% for additional annual mortalities below 5,000 (using either the density dependent or density independent model; WWT, 2012).

294. It is important to note that the gannet model presented in WWT (2012) was based on the entire British population, so collisions at windfarms on the west coast also need to be considered for consistency. However, a review of applications in the Irish Sea and Solway Firth (Barrow, Burbo Bank, Burbo Bank Extension, Gwynt Y Mor, North Hoyle, Ormonde, Rhyl Flats, Robin Rigg, Walney 1 and 2, Walney Extension and West of Duddon Sands) gave a gannet annual collision cumulative total of 243 at an avoidance rate of 98.9%. Therefore, inclusion of these windfarms in the assessment does not alter the conclusion that cumulative collisions are below a level at which a significant impact on the British gannet population would result.

295. Furthermore, the WWT (2012) analysis was conducted using the estimated gannet population in 2004 (the most recent census available at that time), when the British population was estimated to be 261,000 breeding pairs. The most recent census indicates the equivalent number of breeding pairs is now a third higher at 349,498 (Murray et al., 2015). This increase in size will raise the thresholds at which impacts would be predicted and therefore further reduces the risk of significant impacts.

296. In conclusion, 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 East Anglia ONE North project to this cumulative total is small. Gannets are considered to be of low to medium sensitivity to collision mortality and the impact significance is therefore **minor adverse**.

12.7.4.1 Kittiwake

297. The cumulative collision risk predictions for kittiwake are set out in ***Table 12.42***. This collates collision predictions from other windfarms which may contribute to the cumulative total. This table takes the recently submitted windfarm assessment for Norfolk Vanguard as its starting point.

298. The cumulative totals of collision mortality in each season, and summed across seasons, are presented in ***Table 12.42***. Assessments at other windfarms have been conducted using a range of avoidance rates and alternative collision model Options. In order to simplify interpretation of the data across sites and also to bring these assessments up to date with the current Natural England Advice, the values in ***Table 12.42*** are those estimated using the Band Model Option 1 (or 2, if that was the one presented) standardised at an avoidance rate of 98.9%.

299. All windfarm collision estimates have been updated to reflect the evidence based nocturnal flight activity rates estimated by Furness et al. (in prep). This is a review of nocturnal activity in kittiwakes derived from analysis of extensive geolocator tag data from several studies and a limited amount of GPS tracking data. The previous estimated value for nocturnal flight activity (50%) was found to be a considerable overestimate. Evidence-based rates of 20% during the breeding season and 17% during the nonbreeding season were found. It is straightforward to adjust mortality estimates for other windfarms considered in the cumulative assessment 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). Use of these evidence-based rates for kittiwake improves the scientific basis of the assessment while also reducing unnecessary precaution.

Table 12.42 Cumulative Collision Risk Assessment for Kittiwake

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
1	Beatrice Demonstrator	0	2.1	1.7	3.8
1	Greater Gabbard	1.1	15	11.4	27.5
1	Gunfleet Sands	0	0	0	0
1	Kentish Flats	2.4	0	0	2.4
1	Lincs	0	0	0	0
1	London Array	0	0	0	0
1	Lynn and Inner Dowsing	0	0	0	0

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
1	Scroby Sands	0	0	0	0
1	Sheringham Shoal	0	0	0	0
1	Teeside	14.0	0	0	14
1	Thanet	0.8	0	0	0.8
1	Humber Gateway	5.7	0	0	5.7
1	Westernmost Rough	0.4	0	0	0.4
2	Beatrice	62.1	11.2	48.4	121.7
2	Dudgeon	0	0	0	0
2	Galloper	8.6	37.2	12.9	58.7
2	Race Bank	1.3	17.1	4.4	22.8
2	Rampion	62.6	31.3	21.9	115.8
2	Hornsea Project One	39.3	41.8	18.9	120.8
3	Blythe Demonstration	0	0	0	0
3	Dogger Bank Creyke Beck Projects A and B	197	100.1	277.6	574.7
3	East Anglia ONE	0.9	73.7	23.4	98
3	Aberdeen (EOWDC)	14.7	5.7	1.0	21.1
3	Forth (Seagreen) Alpha and Bravo	356.7	229.8	255.6	842.1
3	Inch Cape	10.3	193.1	25	228.4
3	Moray Firth (EDA)	36.6	8.1	25.1	69.8
3	Neart na Gaoithe	9.1	17.9	2.2	29.2
3	Dogger Bank Teesside A and B (now Sofia)	86.7	65.6	197.6	349.9
3	Triton Knoll	12.4	93.3	53.4	159.1
3	Hornsea Project Two	11.0	7.8	3.7	22.5
4	East Anglia THREE	5.2	46.5	27.1	78.8
4	Hornsea Project three	86.0	70.3	71.0	227.3

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
4	Thanet Extension	1.8	2.1	7.3	11.2
4	Norfolk Vanguard	20.8	61.3	76.2	158.3
5	East Anglia TWO	13.6	2.9	9.3	25.8
5	East Anglia ONE North	6.0	4.3	17.4	27.7
5	Norfolk Boreas	28.6	83.4	43.7	155.8
	TOTALS	**1095.7**	**1221.6**	**1236.2**	**3574.1**

300. The estimated annual cumulative total is 3,574. Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher total rotor swept areas than have been installed (or are planned), which is a key factor in collision risk. For example, the Beatrice windfarm, which is currently under construction, was consented on the basis of up to 125 x 7MW wind turbines but only 84 (of the same model) will be installed, leading to a reduction in mortality risk of 33%. A method for updating collision estimates for changes in windfarm design was presented in Macarthur Green (2017). Updating the collision estimates for the Beatrice windfarm using this approach reduces the predicted annual mortality from 145 to 97 (not accounting for revised nocturnal activity rates). Similar reductions in collision mortality are likely to result from changes in windfarm design at other consented but not constructed windfarms in the North Sea which are included in the cumulative and in-combination totals. This could include Firth of Forth Alpha and Bravo, Hornsea Project One and Two, Inch Cape, Moray Firth, Neart na Gaoithe, Race Bank, Rampion, Dogger Bank, Creyke Beck A and B, Teesside A and B and Triton Knoll. Applying the same method to these windfarms could achieve a reduction in the cumulative annual mortality of around 550. Therefore, the values presented in ***Table 12.42***, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 15% due to the reduced collision risks for projects which undergo design revisions post consent.

301. For the assessment of the nearby 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%. 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; 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 -44% (2000 to 2015) (http://jncc.defra.gov.uk/page-3201 accessed 15th October 2018). 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.

302. 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.

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

12.7.4.2 Lesser Black-backed Gull

304. The cumulative collision risk prediction for lesser black-backed gull is set out in ***Table 12.43***. This collates collision predictions from other windfarms which may

contribute to the cumulative total. This table takes the recently submitted windfarm assessment for Norfolk Vanguard as its starting point.

305. The collision values presented in ***Table 12.43*** 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 12.43*** have been multiplied by 0.8 to estimate the nonbreeding component and 0.2 to estimate the breeding component.

306. Assessments for other windfarms have been conducted using a range of avoidance rates and alternative collision model Options. In order to simplify interpretation of the data across sites and also to bring these assessments up to date with the current Natural England advice, the values in ***Table 12.43*** are those estimated using the Band Model Option 1 (or 2, if that was the one presented) at an avoidance rate of 99.5%. (Note that estimates for the Dogger Bank projects have only been presented using Band model Option 3. Therefore, these values in ***Table 12.43*** have been converted to the Natural England advised rate for this model of 98.9%).

Table 12.43 Cumulative Collision Risk Assessment for Lesser Black-backed Gull

Tier	Windfarm	Breeding	Non-breeding	Annual
		CRM	CRM	CRM
1	Beatrice Demonstrator	0	0	0
1	Greater Gabbard	12.4	49.6	62
1	Gunfleet Sands	0	0	0
1	Kentish Flats	0.3	1.3	1.6
1	Lincs	1.7	6.8	8.5
1	London Array	0	0	0
1	Lynn and Inner Dowsing	0	0	0
1	Scroby Sands	0	0	0
1	Sheringham Shoal	1.7	6.6	8.3
1	Teeside	0	0	0

Tier	Windfarm	Breeding	Non-breeding	Annual
		CRM	CRM	CRM
1	Thanet	3.2	12.8	16
1	Humber Gateway	0.2	1.1	1.3
1	Westernmost Rough	0.0	0.3	0.3
2	Beatrice	0	0	0
2	Dudgeon	7.7	30.6	38.3
2	Galloper	27.8	111	138.8
2	Race Bank	43.2	10.8	54
2	Rampion	1.6	6.3	7.9
2	Hornsea Project One	4.4	17.4	21.8
3	Blythe Demonstration	0	0	0
3	Dogger Bank Creyke Beck Projects A and B	2.6	10.4	13
3	East Anglia ONE	4	23	27
3	Aberdeen (EOWDC)	0	0	0
3	Forth (Seagreen) Alpha and Bravo	2.1	8.4	10.5
3	Inch Cape	0	0	0
3	Moray Firth (EDA)	0	0	0
3	Neart na Gaoithe	0.3	1.2	1.5
3	Dogger Bank Teesside A and B (now Sofia)	2.4	9.6	12
3	Triton Knoll	7.4	29.6	37
3	Hornsea Project Two	2	2	4
4	East Anglia THREE	1.8	8.2	10
4	Hornsea Project three	15	3	18
4	Thanet Extension	1.5	0.8	2.3
4	Norfolk Vanguard	23.3	4.1	27.4

Tier	Windfarm	Breeding	Non-breeding	Annual
		CRM	CRM	CRM
5	East Anglia TWO	0.5	0	0.5
5	East Anglia ONE North	0.6	0	0.6
5	Norfolk Boreas	22.0	5.2	27.2
	TOTALS	**189.7**	**360.1**	**549.8**

307. The cumulative predicted annual total is 550. Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher total rotor swept areas than have been installed (or are planned), which is a key factor in collision risk. For example, the Galloper windfarm, which is currently under construction, was consented on the basis of 140 wind turbines but only 56 have been installed. A method for updating collision estimates for changes in windfarm design was presented in MacArthur Green (2017). Updating the collision estimates for the Galloper windfarm using this approach reduces the predicted annual mortality from 139 to 60. Turbine numbers may also be reduced at a number of other windfarms, including Firth of Forth Alpha and Bravo, Hornsea Project One and Two, Inch Cape, Moray Firth, Neart na Gaoithe, Race Bank, Rampion, Dogger Bank Creyke Beck A and B and Teesside A and B and Triton Knoll. Applying the same method to the other windfarms in ***Table 12.43*** can achieve a reduction in the cumulative annual mortality of around 200. Therefore, the values presented in ***Table 12.43***, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 36% due to the reduced collision risks for projects which undergo design revisions post consent.

308. Lesser black-backed gull collision assessments undertaken prior to 2014 were made on the basis of Band Model Option 1 and an avoidance rate of 98%, with the change to 99.5% dating from November 2014 (JNCC et al., 2014). Therefore, projects consented prior to this date were on the basis of a cumulative collision mortality 4 times that presented in ***Table 12.43***. Projects included in the cumulative total at this time were those from Beatrice Demonstrator to Triton Knoll in ***Table 12.43*** (with reference to information on the timing of consents in ***Table 12.35***), with a cumulative total of 461 predicted collisions (adding annual totals for all sites from Beatrice Demonstrator to Triton Knoll in ***Table 12.43*****)**. This total includes four projects consented after November 2014 (Hornsea Project 1, 22 annual collisions at 99.5%; Dogger Bank Creyke Beck A and B, 13 annual collisions at 98.9% Option 3; Dogger Bank Teesside A and B, 12 annual collisions

at 98.9% Option 3). Thus at this time the cumulative collision total (at 98%) excluding these three projects would have been 1,656 (461 – (22+13+12) x 4). The current worst case cumulative total of 550, including all consented and still to be consented projects, is therefore much lower than this previously accepted cumulative total.

309. 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 collision estimates by around 15%. Natural England has recognised this aspect of precaution and advised recent projects to undertake collision modelling with nocturnal activity set to both 25% and 50%. This was included in the proposed East Anglia ONE North project collision modelling (by setting the nocturnal factor in simulated model runs to be randomly selected as one of these two values). However, this adjustment to nocturnal activity is also applicable to the other cumulative collision estimates. 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 further emphasises the precautionary nature of the current assessment.

310. 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 several sources of precaution (e.g. consented vs. built impacts and overestimated nocturnal activity). 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 and lesser black-backed gull is considered to be of medium sensitivity, therefore the impact significance is **minor adverse**.

12.7.4.3 Great Black-backed Gull

311. The cumulative predicted collision risk for great black-backed gull is set out in ***Table 12.44***. This collates collision predictions from other windfarms which may contribute to the cumulative total. This table takes the recently submitted windfarm assessment for Norfolk Vanguard as its starting point.

312. The collision values presented in ***Table 12.44*** 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 12.44*** have been multiplied by 0.8 to estimate the nonbreeding component and 0.2 to estimate the breeding component.

313. Assessments for other windfarms have been conducted using a range of avoidance rates and alternative collision model Options. In order to simplify interpretation of the data across sites and also to bring these assessments up to date with the current Natural England advice, the values in ***Table 12.44*** are those estimated using the Band Model Option 1 (or 2, if that was the one presented) at an avoidance rate of 99.5%. Note that estimates for the Dogger Bank projects have only been presented using Band Model Option 3. Therefore, these values in ***Table 12.44*** have been converted to the Natural England advised rate for this model of 98.9%).

Table 12.44 Cumulative Collision Risk Assessment for Great Black-backed Gull

Tier	Windfarm	Breeding	Non-breeding	Annual
		CRM	CRM	CRM
1	Greater Gabbard	15	60	75
1	Gunfleet Sands	0	0	0
1	Kentish Flats	0.1	0.2	0.3
1	Lincs	0	0	0
1	London Array	0	0	0
1	Lynn and Inner Dowsing	0	0	0
1	Scroby Sands	0	0	0
1	Sheringham Shoal	0	0	0
1	Teeside	8.7	34.8	43.6
1	Thanet	0.1	0.4	0.5
1	Humber Gateway	1.3	5.1	6.3
1	Westernmost Rough	0	0	0.1
2	Beatrice	30.2	120.8	151
2	Dudgeon	0	0	0
2	Galloper	4.5	18	22.5

Tier	Windfarm	Breeding	Non-breeding	Annual
		CRM	CRM	CRM
2	Race Bank	0	0	0
2	Rampion	5.2	20.8	26
2	Hornsea Project One	17.2	68.6	85.8
3	Blythe Demonstration	1.3	5.1	6.3
3	Dogger Bank Creyke Beck Projects A and B	5.8	23.3	29.1
3	East Anglia ONE	0	32	32
3	Aberdeen (EOWDC)	0.6	2.4	3
3	Forth (Seagreen) Alpha and Bravo	13.4	53.4	66.8
3	Inch Cape	0	36.8	36.8
3	Moray Firth (EDA)	9.5	25.5	35
3	Neart na Gaoithe	0.9	3.6	4.5
3	Dogger Bank Teeside A and B (now Sofia)	6.4	25.5	31.9
3	Triton Knoll	24.4	97.6	122
3	Hornsea Project Two	3	20	23
4	East Anglia THREE	4.6	34.4	39
4	Hornsea Project three	16	50	66
4	Thanet Extension	1.3	20.8	22.2
4	Norfolk Vanguard	0	22.2	22.2
5	Norfolk Boreas	16.4	58.3	74.7
5	East Anglia TWO	3	0.6	3.6

Tier	Windfarm	Breeding	Non-breeding	Annual
		CRM	CRM	CRM
5	East Anglia ONE North	0	0.5	0.5
	TOTALS	**188.9**	**840.7**	**1029.7**

314. The annual cumulative total of predicted collisions is 1,030. Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher total rotor swept areas than have been installed (or are planned), which is a key factor in collision risk. For example, the Beatrice windfarm, which is currently under construction, was consented on the basis of 125 wind turbines but only 84 are being installed. A method for updating collision estimates for changes in windfarm design was presented in Macarthur Green (2017). Updating the collision estimates for the Beatrice windfarm using this approach reduces the predicted annual mortality from 151 to 101. Turbine numbers may also be reduced at a number of other windfarms, including Firth of Forth Alpha and Bravo, Hornsea Project One and Two, Inch Cape, Moray Firth, Neart na Gaoithe, Race Bank, Rampion, Dogger Bank Creyke Beck A and B and Teesside A and B and Triton Knoll. Applying the same method to other windfarms can achieve a reduction in the cumulative annual mortality (***Table 12.44***) of around 260. Therefore, the values presented in ***Table 12.44***, as well as being based on precautionary calculations, can be seen to overestimate the total risk by around 25% due to the reduced collision risks for projects which undergo design revisions post consent.

315. 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 great 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 collision estimates by around 15%. 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%. This was included in the proposed East Anglia ONE North project collision modelling (by setting the nocturnal factor in simulated model runs to be randomly selected as one of these two values). However, this adjustment to nocturnal activity is also applicable to the other cumulative collision estimates. 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 further emphasises the precautionary nature of the current assessment.

316. Great black-backed gull collision assessments undertaken prior to 2014 were made on the basis of Band Model Option 1 and an avoidance rate of 98%, with the change to 99.5% dating from November 2014 (JNCC et al., 2014). This has resulted in a large reduction in predicted cumulative totals to the extent that the current cumulative estimate of 1,030 is much lower than cumulative totals for consented developments on which it has previously been concluded there will be no adverse effect on the population in the long term (DECC, 2014).

317. 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 literature) and both 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.

318. Using the density dependent model, application of an additional annual mortality of 900 to the great black-backed gull BDMPS resulted in impacted populations after 25 years which were 6.1% to 7.7% smaller than in the absence of impact. The equivalent density independent predictions generated population reductions of 21.3% to 21.5%. 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 0,5 for the proposed East Anglia ONE North project.

319. 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 medium sensitivity, therefore the impact significance is **minor adverse**.

12.8 Transboundary Impacts

320. 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 operational offshore windfarms in Belgium, the Netherlands and Germany 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 East Anglia ONE). Since the spatial scale and hence seabird populations sizes for a transboundary assessment would be much larger, it is apparent that the scale of windfarm development would be relatively much smaller. 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.

Table 12.45 List of Other EU Member States Retained in the Transboundary Impact Assessment in Relation to the Topic

EU member state	Commentary
Netherlands	Rijkswaterstaat, Ministry of Infrastructure and Water Management, responded to the transboundary consultation requesting a meeting in relation to a number of issues including ornithology. A teleconference was held on 10 September 2018. Rijkswaterstaat provided details of the following offshore windfarm proposals. It is understood that these developments have been consented but not yet constructed and are due to become operational in the period 2019-2025 • Borssele 1,2, 0.7GW • Borssele 3,4, 0.7GW • Hollandse Kust (HK) zuid 1,2, 0.7GW • HK zuid 3,4, 0.7GW • HK noord 1,2 0.7GW • HK west, 1.4GW At the time of writing no specific information has been provided, or appears to be available (based on internet searches) in relation to turbine numbers and specifications, or ornithology assessments (and specifically estimates of collision risk and displacement for bird species) for individual developments.

12.9 Interactions

321. The impacts identified and assessed in this chapter have the potential to interact with each other, which could give rise to synergistic impacts as a result of that interaction. The worst case impacts assessed within the chapter take these interactions into account and therefore the impact assessments are considered

conservative and robust. For clarity, the areas of interaction between impacts are presented in ***Table 12.46.***

Table 12.46 Potential for Interactions Between Ornithology Impacts

Potential interaction between impacts		
Construction	1 Disturbance and displacement from increased vessel activity	2 Indirect effects as a result of displacement of prey species due to increased noise and disturbance to sea bed
1 Disturbance and displacement from increased vessel activity		Yes possible medium to long term effects on birds, but spatial magnitude very small
2 Indirect effects as a result of displacement of prey species due to increased noise and disturbance to sea bed	Yes possible medium to long term effects on birds, but spatial magnitude very small	

Operation	3 Disturbance and displacement from offshore infrastructure and operational activity	4 Collision risk	5 Indirect impacts through effects on habitats and prey species
3 Disturbance and displacement from offshore infrastructure and operational activity		No (birds that are displaced would not be at risk of collision)	No (direct displacement of birds overrides prey effects)
4 Collision risk	No (birds that are displaced would not be at risk of collision)		No
5 Indirect impacts through effects on habitats and prey species	No (mutually exclusive)	No	

Potential interaction between impacts
Decommissioning
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.

12.10 Inter-relationships

322. The construction, operation and decommissioning phases of the proposed East Anglia ONE North project would cause a range of effects on offshore ornithological interests. The magnitude of these effects has been assessed individually above in ***section 12.6*** 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).

323. Impacts to offshore ornithological interests may be inter-related with other receptor groups. With respect to the impacts assessed for offshore ornithology (***section 12.6***), 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.

324. Inter-relationships are summarised in ***Table 12.47***, which indicates where assessments carried out in other ES chapters have been used to inform the offshore ornithology assessment.

Table 12.47 Ornithology Inter-relationships

Impact	Related Chapter	Where addressed in this Chapter	Rationale
2 Indirect impacts through effects on habitats and prey during construction	***Chapter 9 Benthic Ecology*** ***Chapter 10 Fish and Shellfish Ecology***	***Section 12.6.1.2***	Potential impacts on benthic ecology and fish and shellfish during construction could affect the prey resource for birds.
5 Indirect impacts through effects on habitats and prey during operation	***Chapter 9 Benthic Ecology*** ***Chapter 10 Fish and***	***Section 12.6.2.2***	Potential impacts on benthic ecology and fish and shellfish during operation could affect the prey resource for birds.

Impact	Related Chapter	Where addressed in this Chapter	Rationale
	Shellfish Ecology		
7 Indirect impacts through effects on habitats and prey during decommissioning	***Chapter 9 Benthic Ecology*** ***Chapter 10 Fish and Shellfish Ecology***	***Section 12.6.3.2***	Potential impacts on benthic ecology and fish and shellfish during decommissioning could affect the prey resource for birds.

12.11 Summary

325. 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 (offshore windfarm site and export cable corridor to MLWS at the landfall site). It describes the offshore components of the proposed project; 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 survey (Appendix 12.1) and assesses the potential impacts on birds.

326. Detailed consultation and iteration of the overall approach to the impact assessment on ornithology receptors has informed this assessment through the ornithology ETG for East Anglia ONE North, which involved Natural England and the RSPB.

327. A standard survey area for offshore ornithology, covering the East Anglia ONE North offshore windfarm site and a 4km buffer was surveyed using high resolution aerial survey methods over periods of 24 months. The results of these surveys have been used to estimate the abundance and assemblage of birds using or passing across the area. The analysis and assessment in this PEIR has been undertaken prior to the data from the final aerial surveys being available, so is based on the first 21 monthly surveys and will be updated when 24 surveys are available.

328. The impacts that could potentially arise for offshore ornithology during the construction, operation and decommissioning of the proposed East Anglia ONE North project were discussed with Natural England and the RSPB as part of the Evidence Plan process. As a result of those discussions it was agreed that the potential impacts that required detailed assessment were:

- In the construction phase:
  - Impact 1: Disturbance/displacement
  - Impact 2: Indirect impacts through effects on habitats and prey species
- In the operational phase:
  - Impact 3: 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
- In the decommissioning phase:
  - Impact 6: Disturbance/displacement
  - Impact 7: Indirect impacts through effects on habitats and prey species

329. During the construction phase of the proposed project no impacts have been assessed to be greater than of minor adverse significance for any bird species.

330. During operation, displacement effects on red-throated divers, gannets, razorbills and guillemots would not create impacts of more than minor adverse significance during any biological season. The risk to birds from collisions with wind turbines from the proposed East Anglia ONE North 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.

331. Two potential effects of the proposed East Anglia ONE North project were screened in for cumulative assessment: operational displacement and collision risk. Other potential effects 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.

332. A screening process was also carried out for potential plans and projects that might affect ornithological receptors 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 12.35***.

333. The risk to ornithological receptors from cumulative displacement and collisions is assessed as no greater than minor adverse significance for all species.

334. 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 East Anglia ONE North). 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 impact assessed on the larger population present over a larger spatial scale.

335. The identified impacts for the project alone are summarised in ***Table 12.48*** and cumulative impacts in ***Table 12.49***.

Table 12.48 Potential Impacts Identified for Offshore Ornithology

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Direct disturbance and displacement during export cable construction	Red-throated diver	High	Negligible	Minor adverse	N/A	Minor adverse
Direct disturbance and displacement from construction activity on windfarm site	Razorbill	Medium	Negligible	Negligible	N/A	Negligible
	Guillemot	Medium	Negligible	Negligible	N/A	Negligible
Indirect effects due to prey species displacement	All species	Low to high	Negligible	Negligible to minor adverse	N/A	Negligible to minor adverse
Operation						
Direct disturbance and displacement	Red-throated diver	High	Negligible	Minor adverse	N/A	Minor adverse
	Gannet	Low to medium	Negligible	Negligible	N/A	Negligible
	Razorbill	Medium	Negligible	Negligible	N/A	Negligible

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	Guillemot	Medium	Negligible	Negligible	N/A	Negligible
Indirect effects due to prey species displacement	All species	Low to high	Negligible	Negligible to minor adverse	N/A	Negligible to minor adverse
Collision risk	Gannet –	Low to medium	Negligible	Negligible	N/A	Negligible to minor adverse
	Kittiwake	Medium	Negligible	Negligible	N/A	Negligible to minor adverse
	Lesser black-backed gull	Medium	Negligible	Negligible	N/A	Negligible to minor adverse
	Great black-backed gull	Medium	Negligible	Negligible	N/A	Negligible to minor adverse
Decommissioning						
Direct disturbance and displacement	All species	Low to high	Negligible	Negligible to minor adverse	N/A	Negligible to minor adverse
Indirect effects due to prey species displacement	All species	Low to high	Negligible	Negligible to minor adverse	N/A	Negligible to minor adverse

Table 12.49 Potential Cumulative Impacts Identified for Ornithology

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Operation						
Disturbance and displacement	Red-throated diver	High	Negligible	Minor adverse	N/A	Minor adverse
	Gannet	Low to medium	Negligible	Negligible	N/A	Negligible
	Razorbill	Low to medium	Negligible	Negligible	N/A	Negligible

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	Guillemot	Low to medium	Negligible	Negligible	N/A	Negligible
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
	Great black-backed gull	Low to medium	Low	Minor adverse	N/A	Minor adverse

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