East Anglia TWO Offshore Windfarm

Chapter 12
Offshore Ornithology

Environmental Statement Volume 1

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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
EA2	East Anglia TWO
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 TWO 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 TWO project	The proposed project consisting of up to 75 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 TWO 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 TWO windfarm site is located together with East Anglia One, East Anglia THREE, 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.
Landfall	The area (from Mean Low Water Springs) where the offshore export cables would make contact with land, and connect to the onshore cables.
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 development area	The East Anglia TWO windfarm site and offshore cable corridor (up to Mean High Water Springs).
Offshore electrical infrastructure	The transmission assets required to export generated electricity to shore. This includes inter-array cables from the wind turbines to the offshore electrical platforms, offshore electrical platforms, platform link cables and export cables from the offshore electrical platforms to the landfall.
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.
Offshore infrastructure	All of the offshore infrastructure including wind turbines, platforms, and cables.
Offshore platform	A collective term for the construction operation and maintenance platform and the offshore electrical platforms.
Platform link cables	An electrical cable which links one or more offshore platforms., These 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 TWO 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 TWO windfarm site and a 4km buffer can be found in ***Appendix 12.2 Baseline Offshore Ornithology Technical Report***.

12.2 Consultation

5. Consultation is a key feature of the Environmental Impact Assessment (EIA) process, and continues throughout the lifecycle of a project, from its initial stages through to consent and post-consent.

6. To date, consultation with regards to offshore ornithology has been undertaken via Expert Topic Group (ETG) meetings, described within ***Chapter 5 EIA Methodology***, with meetings held in April 2017, March 2018, January 2019 and June 2019. Furthermore, consultation has been carried out through formal submission of the East Anglia TWO Scoping Report (SPR 2017) and the Preliminary Environmental Information Report (PEIR) (SPR 2019). Feedback received through this process has been considered in preparing the ES where appropriate and this chapter has been updated for the final assessment submitted with the Development Consent Order (DCO) application.

7. The responses received from stakeholders with regards to the Scoping Report, PEIR, as well as feedback to date from the offshore ornithology ETG meetings are summarised in ***Appendix 12.1***, including details of how these have been taken account of within this chapter.

8. 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, June / July 2018 and February / March 2019. A series of stakeholder engagement events were also undertaken in October 2018 as part of phase 3.5 consultation. Consultation phases are explained further in ***Chapter 5 EIA Methodology.***

9. ***Table 12.1*** provides public consultation feedback specific to Offshore Ornithology. Full details of the East Anglia TWO project consultation process are presented in the Consultation Report (document reference 5.1), submitted as part of the DCO application

Table 12.1 Public Consultation Responses relevant to Offshore Ornithology

Topic	Response / where addressed in the PEI
Phase 1	
• Bird strikes and availability of information on the Public Information Day displays.	Collision risk impacts are assessed in ***section 12.6.2.3***.
Phase 2 and Phase 3	
None	
Phase 4	
• Impact on protected bird species in the Southern North Sea cSAC. • The impacts on birds are not minor. • Concerned about level of pressure across the site as a whole (in relation to red-throated diver disturbance).	Impacts on red throated diver within the Outer Thames Estuary SPA are provided in ***sections 12.6.1.1.1*** and ***12.6.2.1.1*** and the Information to Support Appropriate Assessment Report (Document Reference 5.3) in which cumulative impacts on the SPA are also assessed..

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 TWO project on these interests.

11. The baseline section describes the distribution and abundance of bird species recorded during surveys of the site. This includes 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 TWO windfarm site and a 4km buffer placed around it (***Figure 12.1***). Compared with the PEIR (ScottishPower Renewables (SPR) 2019) the study area for the proposed East Anglia TWO project considered in this ES has been reduced through removal of the northern part of the East Anglia TWO windfarm site boundary (see ***Chapter 4 Site Selection and Assessment of Alternatives***, ***section 4.7*** for details).

15. Monthly aerial surveys of the study area began in November 2015, ceased in April 2016, re-started in September 2016 until October 2017 (20 months in total). An additional four months of surveys was undertaken in May to August 2018 to provide a complete 24-month dataset. This ES makes use of all of these data analysed for the finalised boundary for the offshore windfarm. Note that the analysis and assessment in the PEIR was undertaken prior to the data from the final aerial surveys becoming available, so was based on the first 21 monthly surveys only.

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

17. 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. Compared with the offshore cable corridor for the proposed East Anglia TWO project assessed in the PEIR, the northern route option for the offshore cable corridor assessed in the current chapter has been amended to take account of the changes to the East Anglia TWO windfarm site boundary (***Figure 12.1,*** also see ***Chapter 4 Site Selection and Assessment of Alternatives***, ***section 4.7*** for details). Refer to ***Chapter 23 Onshore Ornithology*** for assessment of impacts above the MLWS.

12.3.2 Worst Case

18. The detailed design of the proposed East Anglia TWO project (including number of wind turbines, layout configuration, requirement for scour protection, electrical

design, etc.) is not yet fully determined, and will 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.

19. The realistic 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***. For indirect impacts on prey species (see ***sections 12.6.1.2, 12.6.2.2*** and ***12.6.3.2***), where total areas of disturbance footprints and associated percentage areas of the offshore development area affected have been calculated, these are based on a total East Anglia TWO windfarm site area of 218.4km^2 and an offshore cable corridor area of 137.6km^2 which results in a total offshore development area for the assessment of 356km^2. As a worst case, the offshore cable corridor area has been calculated based on the northern route (see ***Figure 9.2***) which has the largest area of the two routes and from which the worst-case export cable length was calculated. It would not be realistic to combine the areas for both route options as in reality only one of these routes will be used following final design of the project.

20. Definition of the worst case scenarios assumptions has been made from consideration of the proposed East Anglia TWO 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***).

Table 12.2 Project Design: Realistic worst-case scenarios for the Proposed East Anglia TWO 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 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 1,005 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 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:	See ***Chapter 10 Fish and Shellfish Ecology*** for a full breakdown of the maximum disturbed area of sea bed. Piling durations based on the worst-case scenario of pin-piles for wind turbines (up to 33.2 days) plus

Impact	Parameter	Rationale
	Maximum total active piling time for wind turbines and platforms - 938hrs (39.2 days) No concurrent piling, 75 wind turbine foundations, five offshore platforms, and one operational met mast.	platforms (up to 6 days). See ***Chapter 11 Marine Mammals*** for further details.
	The maximum worst-case area of temporary disturbance to benthic habitats during construction would be 11,330,050.5m^2 across the offshore development area, equivalent to 3.18% 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 4,091,222.5m^3 of sediment in the offshore development area over the approximate 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 218.4km^2 plus 4km buffer with maximum of 75 wind turbines, with a minimum spacing of 800m in row x 1200m between rows Maximum of 687 vessel round trips per annum to support windfarm operations. Maximum of 1,005 helicopter round trips per annum for scheduled and unscheduled maintenance.	Maximum density of turbines and structures across the offshore project area, which maximises the potential for avoidance and displacement.

Impact	Parameter	Rationale
	Lighting requirements for the proposed East Anglia TWO project will need to be consistent with maritime and aviation safety requirements, and are expected to consist of: • 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 75 x 250m tip height wind turbines (max 250m blade tip above LAT and 220m rotor diameter); other scenarios are 60 x 300m tip height wind turbines (max 300m blade tip above LAT and, 250m rotor diameter)	Collison risk modelling (CRM) has been carried out for all wind turbine scenarios, based on the wind turbine specifications in ***Appendix 12.1, Annex 3, Table 5***. For each bird species, the wind 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**	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
	1,914,471m^2 which constitutes 0.55% of the windfarm site (75 wind turbine foundations, five offshore platforms, one meteorological mast, cable protection for platform link cables and inter-array cables. **Export Cable** 108,800m^2, 0.08% of the northern offshore cable corridor which has been used a worst case as it has the largest area of the two cable route options. **Total** The overall total footprint which could be subject to permanent habitat loss would therefore be 2,023,271.46m^2 (0.57% 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	Any area affected would be less than or at worst equal to the areas of disturbance during construction. 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 Mitigation and Best Practice

12.3.3.1 Embedded Mitigation

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

- The East Anglia TWO windfarm site was identified through the Zonal Appraisal and Planning process (***Chapter 4 Site Selection and Assessment of Alternatives***). The East Anglia TWO windfarm site avoids European Sites as far as possible, however the cable corridor runs through the Outer Thames Estuary SPA (Royal HaskoningDHV 2018).
- A reduction in the spatial extent of potential disturbance and displacement impacts by using only one offshore cable corridor in the near shore for East Anglia TWO and East Anglia ONE North. This measure avoids potential impacts over a wider area.
- In June 2019 the Applicant reduced the north-south extent of the East Anglia TWO windfarm site (see ***Chapter 4 Site Selection and Assessment of Alternatives***). This was undertaken in response to PEIR comments on seascape, but is beneficial for ornithology impacts. This moved the boundary of the East Anglia TWO windfarm site 8.3km from the Outer Thames Estuary SPA therefore avoiding direct displacement effects from the windfarm into the SPA.

12.3.3.2 Additional mitigation

22. 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 below best practice examples can be formulated in agreement with Natural England and the MMO. The implementation of the agreed measures will be secured through the Project Environmental Monitoring Plan (PEMP).

23. 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).

24. 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 1,000 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

25. Post-consent, the final detailed design of the proposed East Anglia TWO project will refine the worst-case parameters assessed in this ES. It is recognised that monitoring is an important element in the management and verification of the actual proposed East Anglia TWO project impacts.

26. As stated in the In-Principle Monitoring Plan (Document Reference 8.13), the Applicant is supportive, in principle, of joint industry projects or alternative site based monitoring of existing seabird activity inside the area(s) within the Order Limits in which it is proposed to carry out construction works with its potential wider benefits and would welcome collaboration opportunities from SNCBs, NGOs or other developers in strategic monitoring programmes.

27. The Project Environmental Management Plan (PEMP) (submitted post-consent), is also relevant to offshore ornithology and will set out the Applicant's intentions for offshore ornithology monitoring and management. The requirement for and final design and scope of monitoring will be agreed with the regulator and relevant stakeholders and included within the relevant Management Plan, 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 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

Legislation	Relevant Measures
	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	Source Reference
Overarching National Policy Statement (NPS) for	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	The potential effects on the species and habitats which have been scoped into the assessment are presented in ***section 12.6***. The East Anglia TWO windfarm site was identified through the Zonal Appraisal and

Policy	Relevant Measures	Source Reference
Energy (NPS EN-1) (July 2011)	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.	Planning process (***Chapter 4 Site Selection and Assessment of Alternatives***) and as far as possible has sought to avoid European Sites, although the cable corridor runs through the Outer Thames Estuary SPA. In June 2019 the Applicant reduced the north-south extent of the East Anglia TWO windfarm site (see ***Chapter 4 Site Selection and Assessment of Alternatives***) which reduced the spatial extent of potential disturbance and displacement impacts. Additionally, the decision was taken to use only one offshore cable corridor in the near shore for East Anglia TWO and East Anglia ONE North. This measure avoids potential impacts over a wider area of the Outer Thames Estuary SPA. Proposed Mitigation measures in the form of a best-practice protocol for red-throated divers (see ***section 12.3.3.2***) have been proposed to reduce construction impacts on red-throated divers.
NPS for Renewable Energy Infrastructure (NPS EN-3) (July 2011)	Paragraph 2.6.64 states that the assessment of offshore ecology and biodiversity should be undertaken by the Applicant for all stages of the lifespan of the proposed offshore windfarm. Paragraph 2.6.102 states that the scope, effort and methods required for ornithological surveys should have been discussed with the relevant statutory advisor. Paragraph 2.6.104 states that it may be appropriate for the assessment to include collision risk modelling for certain bird species.	An assessment of potential impacts during the construction (see ***section 12.6.1***), operation (see ***section 12.6.2***) and decommissioning (see ***section 12.6.3***) has been provided. The scope of the ornithological surveys was agreed with the relevant SNCBs during the ETG process and through submission of the Offshore Ornithology Method Statement (see ***Appendix 12.2***). Collision risk modelling for the bird species that were scoped into that assessment has been conducted (see ***Appendix 12.1***) and an assessment of collision risk provided in ***section 12.6.2.3***).
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,	As stated above, the East Anglia TWO windfarm site was identified through the Zonal Appraisal and Planning process and subsequent refinements to the windfarm site and offshore cable corridor have been made which has helped to reduce the total area over which there is potential for impacts.

Policy	Relevant Measures	Source Reference
	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 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 marine and coastal ecosystems across their natural range; and oceans supporting viable populations of representative, rare, vulnerable and valued species.	The identification of the species most sensitive to the proposed East Anglia TWO project has been undertaken through a comprehensive process involving a lengthy period of consultation with statutory and non-statutory organisations (see ***Appendix 12.2***). A thorough assessment of the potential impacts of the proposed East Anglia TWO project-alone (see ***section 12.6***) and cumulatively with other projects (see ***section 12.7***) has been undertaken to determine the potential for significant environmental effects on these species populations. Where possible, embedded mitigation measures (see ***section 12.3.3***) will be implemented to reduce potential impacts as far as possible.

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 TWO windfarm site (and 4km buffer) were conducted between November 2015 and April 2016, September 2016 and October 2017, and May to August 2018, to complete 24 months of site-specific data available for assessment.

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. 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. These surveys overlapped the East Anglia TWO 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:

- 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).
- Digital video aerial surveys of red-throated diver in the Outer Thames Estuary Special Protection Area 2018 (Irwin et al. 2019).

38. 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

39. The impact assessment methodology applied in this Chapter is based on that described ***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).

40. 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 TWO project. It has been informed by discussion during the examination process for the consented East Anglia ONE and East

Anglia THREE projects, as well as recent DCO examinations for other offshore windfarms in the southern North Sea.

41. The assessment approach uses the conceptual 'source-pathway-receptor' model. The model identifies likely environmental impacts on ornithology receptors 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

42. 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 a potential impact, e.g. strongly displaced by sources of disturbance such as noise, light, vessel movements and the sight of people
Medium	Ornithology receptor (bird species) has limited tolerance of a potential impact, e.g. moderately displaced by sources of disturbance such as noise, light, vessel movements and the sight of people
Low	Ornithology receptor (bird species) has some tolerance of a potential impact, e.g. partially displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.
Negligible	Ornithology receptor (bird species) is generally tolerant of a potential impact e.g. not displaced by sources of disturbance such as noise, light, vessel movements and the sight of people.

12.4.3.2 Conservation Value

43. 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.

44. 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. These SPA qualifying species 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).
Medium	A species for which individuals at risk are probably drawn from particular SPA 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

45. 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.

Value	Definition
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.
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

46. 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 49*** below).

Table 12.8 Impact Significance Matrix

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

47. 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.

48. 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.

49. 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.'*

50. Where possible, assessment is based upon quantitative and accepted criteria and/or methods (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.

51. 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

52. 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.

53. 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

54. 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.

55. 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

56. 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.

57. 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

58. 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

59. 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 TWO 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 TWO 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
Black-throated diver	*Gavia arctica*	BoCC Amber listed, Birds Directive Annex 1

Species	Scientific name	Conservation Status
Great northern diver	*Gavia immer*	BoCC Amber 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
Cormorant	*Phalacrocorax carbo*	BoCC Amber listed, Birds Directive Migratory Species
Shag	*Phalacrocorax aristotelis*	BoCC Red listed, Birds Directive Migratory Species
Great skua	*Stercorarius skua*	BoCC Amber listed, Birds Directive Migratory Species
Puffin	*Fratercula arctica*	BoCC Red 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
'Commic' tern[2]	*Sterna spp.*	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 gull	*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.

60. 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 a report on aerial surveys of the Outer Thames Estuary SPA in 2018 commissioned by Natural England (Irwin et al. 2019).

61. 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, conservation importance and/or potential sensitivity to windfarm impacts for example due to biological characteristics (such as tendency to fly at rotor heights) which make them potentially susceptible.

62. Impacts have been assessed in relation to relevant biological seasons, as defined by Furness (2015). These are given in ***Table 12.10***.

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 Two 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)	-
Black-throated diver[1]	Apr-Aug	May-Aug				Aug-Apr
Great northern diver	-	-	Sep-Nov	Dec-Feb	Mar-May	Sep-May (200)
Fulmar	Jan-Aug	Apr-Aug	Sep-Oct (957,502)	Nov (568,736)	Dec-Mar (957,502)	-
Gannet	Mar-Sep	Apr-Aug	Sep-Nov (456,298)	-	Dec-Mar (248,385)	-
Cormorant	Apr-Aug	May-Jul	Aug-Oct	Nov-Jan	Feb-Apr	Sep-Mar
Shag	Feb-Aug	Mar-Jul	Aug-Oct	Nov	Dec-Feb	Sep-Jan
Great skua	May-Aug	May-Jul	Aug-Oct (19,556)	Nov-Feb (143)	Mar-Apr (8,485)	-
Puffin	Apr-early Aug	May-Jun	Late Jul-Aug	Sep-Feb	Mar-Apr	Mid-Aug-Mar (231,957)
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)
‘Commic’ tern[2]	May-Aug	Jun	Jul-Sep	-	Apr-May	-

Species	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
			(308,841)		(308,841)	
Kittiwake	Mar-Aug	May-Jul	Aug-Dec (829,937)	-	Jan-Apr (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	Late 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).

63. The mean peak abundances within species-specific seasons (as defined in ***Table 12.10***) recorded within the East Anglia TWO 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 ***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 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***.

64. For the non-breeding period, the reference populations used for the impact assessment are the relevant biologically defined minimum population sizes (BDMPS) taken from Furness (2015). These reference populations are included in parentheses in ***Table 12.10***.

65. For the breeding period, the potential for connectivity to known breeding populations has been considered. However, it should be noted that bird abundance was low for most species during the breeding season, with many species absent in one or more of the summer months (Table 12.11). This suggests that very few breeding birds utilise the East Anglia TWO 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 for breeding adults from the Alde Ore Estuary SPA population to forage on the East Anglia TWO windfarm site. Hence for this species the full breeding season was applied in the attribution of potential impacts to relevant populations.

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

Species	Biological Season					
	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
Red-throated diver	*72.2* *(20.7-148.1)*	8.99 (0-44.7)	0 (0-0)	19.5 (0-68.6)	*72.2* *(20.7-148.1)*	-
Black-throated diver[1]	0 (0-0)	0 (0-0)	-	-	-	0 (0-0)
Great northern diver[2]	-	-	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Fulmar	*88.0* *(0-222.7)*	*88.0* *(0-222.7)*	24.1 (0-55.5)	4.1 (0-24.5)	24.8 (0-62.1)	-
Gannet	*123.9* *(51.3-201.6)*	*123.9* *(51.3-201.6)*	619.5 (72 - 1,233.4)	-	120.1 (0-305.2)	-
Cormorant	0	0	0	0	4.6	-

Species	Biological Season					
	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
	(0-0)	(0-0)	(0-0)	(0-0)	(0-27.7)	
Shag[1]	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Great skua	0 (0-0)	0 (0-0)	4.4 (0-26.2)	0 (0-0)	5.3 (0-31.8)	-
Puffin	*13.8 (0.55.1)*	0 (0-0)	0 (0-0)	0 (0-0)	*13.8 (0.55.1)*	0 (0-0)
Razorbill	*116.2 (0-320.8)*	*116.2 (0-320.8)*	24.7 (0-98.9)	63.3 (0-122.6)	118.4 (70.6-200.0)	-
Guillemot	*1,285.9 (627.8-1,993.4)*	*1,285.9 (627.8-1,993.4)*	196.8 (26-438.2)	594.1 (94.7-1,177.3)	*1,002.7 (822-1,188.1)*	*1,002.7 (822-1,188.1)*
'Commic' tern	*23.1 (0-57.6)*	0 (0-0)	7.5 (0-37.2)	-	*23.1 (0-57.6)*	-
Kittiwake	*217.2 (0-505.2)*	122.5 (29.6-240.5)	68.1 (9.3-153.4)	-	*217.2 (0-505.2*	-
Black-headed gull	-	0 (0-0)	-	-	-	77.9 (0-220.7)
Little gull	4.6 (0-27.6)	0 (0-0)	-	-	-	38.5 (0-109.9)
Common gull	-	0 (0-0)	-	-	-	6.1 (0-33.6)
Lesser black-backed gull	*46.2 (0-143.7)*	10 (0-29.5)	*46.2 (0-143.7)*	14.7 (0-58.6)	5.3 (0-31.8)	-
Herring gull	*14.3 (0-51.3)*	4.9 (0-29.6)	*14.3 (0-51.3)*	0 (0-0)	5.0 (0-20.0)	13.9 (0-55.5)
Great black-backed gull	15,5 (0-62.1)	13.9 (0-55.5)	9.2 (0-37)	13.8 (0-46.3)	*19.8 (0-45.1)*	*19.8 (0-45.1)*

Species	Biological Season					
	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
1. Recorded on only one occasion in baseline surveys.						
2. Recorded on only two occasions in baseline surveys.						

12.5.2 Designated Sites

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

67. Sites which may have connectivity to the East Anglia TWO 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 ETG meetings have scoped out connectivity for migratory non-seabird species associated with coastal and terrestrial sites (see ***Appendix 12.2***).

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 (see the ***Report to Inform the Appropriate Assessment*** (document reference 5.3) which accompanies the DCO application) considered 86 offshore and coastal designated sites within or adjacent to the southern North Sea within 950km of the East Anglia TWO windfarm site. These comprised SPAs and Ramsar sites designated for bird interests, with terrestrial areas of coastal sites also designated as SSSIs (to MLWS). Of these, 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 TWO project.

70. 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 TWO Project

Site	Designation	Ornithological interest features with potential connectivity to the proposed East Anglia TWO project	Minimum distance to project (km)
The Outer Thames Estuary	SPA	Wintering seabirds – red-throated diver	8.3 (windfarm site) 0 (offshore cable corridor)
Greater Wash	SPA	Wintering seabirds – red-throated diver, little gull	38 (windfarm site) 23 (offshore cable corridor)
Alde-Ore Estuary	SPA Ramsar SSSI	Breeding seabirds – lesser black-backed gull	36 (windfarm site) 3 (offshore cable corridor)
Flamborough and Filey Coast*	SPA SSSI	Breeding seabirds – gannet, kittiwake, razorbill, guillemot	254 (windfarm site) 237 (offshore cable corridor)
*The recently designated Flamborough and Filey Coast SPA includes the previously designated Flamborough Head and Bempton Cliffs SPA and covers a larger area. 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 and, where an interest feature has been screened in, appropriate assessment of the interest features of the internationally designated sites (SPAs and Ramsar sites) is carried out through the HRA process and this is reported separately in the ***Report to Inform the Appropriate Assessment*** (document reference 5.3) which accompanies the DCO application.

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 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 in a context of 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.

81. 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

82. Potential impacts to be included within the EIA have been agreed through consultation on a Method Statement (Scottish Power Renewables 2017, Appendix 2.4) 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

- o Impact 7: Indirect impacts through effects on habitats and prey species.

83. 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

84. The proposed East Anglia TWO project has the potential to affect bird populations in the marine environment through disturbance due to 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, outlined in ***Table 12.2*** describes the elements of the proposed project considered within this assessment.

85. The duration of offshore construction for the proposed East Anglia TWO project would be approximately 27 months which would overlap with a maximum of two breeding seasons, two winter periods and up to four spring/autumn migration periods for birds.

86. 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 development area. 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.

87. 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).

88. 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.

89. 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).

90. 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).

91. 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.

92. 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 non-breeding periods (seasons following Furness 2015).

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

94. 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	High susceptibility to disturbance and displacement and present in the East Anglia TWO windfarm site and export cable corridor (the latter

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Rationale
			overlapping with the Outer Thames Estuary SPA for which red-throated diver is a qualifying species)
Black-throated diver	Very High	OUT	Recorded on only one occasion in baseline surveys
Great northern diver	Very High	OUT	Recorded on only two occasions in baseline surveys
Fulmar	Low	OUT	Low susceptibility to disturbance
Gannet	Low	OUT	Low susceptibility to disturbance
Cormorant	High	OUT	Recorded on only one occasion in baseline surveys
Shag	Medium	OUT	Recorded on only one occasion in baseline surveys
Great skua	Low	OUT	Recorded in low numbers during passage migration periods
Puffin	Medium	OUT	Recorded on in low numbers during only one baseline survey
Razorbill	Medium	IN	Potentially susceptible to disturbance and abundant in the East Anglia TWO windfarm site
Guillemot	Medium	IN	Potentially susceptible to disturbance and abundant in the East Anglia TWO windfarm site
‘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

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Rationale
Little gull	Low	OUT	Low susceptibility to disturbance
Common gull	Low	OUT	Low susceptibility to disturbance
Lesser black-backed gull	Low	OUT	Low susceptibility to disturbance
Herring gull	Low	OUT	Low susceptibility to disturbance
Great black-backed gull	Low	OUT	Low susceptibility to disturbance
1. With reference to Garthe and Hüppop, 2004; Furness and Wade, 2012; Furness et al., 2013; Wade et al., 2016. 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

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

96. There is potential for disturbance and displacement of non-breeding red-throated divers resulting from the presence of vessels installing the offshore windfarm infrastructure (wind turbines, offshore platforms and met mast) and the offshore

export cables, including when they are 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. The offshore cable corridor then splits into two sections (the northern route, which would be shared with East Anglia ONE North, and southern route options (see ***section 12.3.2*** and ***Figure 12.1***)). The northern route option, with the largest total area of overlap with the Outer Thames Estuary SPA is considered to be the worst case option, 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 (see ***Chapter 6 Project Description section 6.5.10.6***). Cable-laying operations, utilising up to two vessels (see ***Table 12.2***), 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.

97. 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 12.3.3.2***). 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 very precautionary assumption, for example (as noted above) studies of responses of marine birds to disturbance in Orkney inshore waters found that 75% (n=88) red-throated divers flushed within 300m of ferries (Jarett et al. 2018), implying that in this study not all birds were flushed within 300m of vessels.

12.6.1.1.1.1 Offshore Export Cable Corridor

98. The number of red-throated divers that would potentially be at risk of displacement from the offshore cable corridor during the cable laying process was estimated based on the density of red-throated divers along the offshore cable corridor where it overlaps with the Outer Thames Estuary SPA.

99. The most recently available dataset for the SPA derives from two aerial surveys undertaken in February 2018 (Irwin et al. 2019); which found respective densities

of 0.62 and 3.77 red-throated divers per km^2 in the part of the SPA which overlaps most extensively with the export cable corridor for East Anglia TWO (the larger northern section). These two surveys, less than two weeks apart, took place within the spring migration period. The considerable range of densities indicates rapid changes in numbers of birds on site, presumably due to turnover of individuals passing through on migration.

100. 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 based on densities of 0.62 – 3.77 birds per km^2, 16-95 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 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. The numbers displaced are based on density estimates in the spring migration period. Based on the pattern of occurrence of this species during surveys of East Anglia TWO windfarm site (see ***Section 12.6.1.1.1.2*** below), the spring migration period is likely to be the time of highest densities, and also the greatest turnover of individuals as birds pass through the site. Thus, using densities during the spring migration period to estimate the number of birds displaced over the course of an entire winter is highly precautionary.

101. 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.

102. A detailed review of the likely effects of displacement of red-throated divers on mortality during the non-breeding season is included in Norfolk Vanguard Ltd (2019a). The annual mortality rate of red-throated divers is 16% per annum for adults (three years and older) and 38-40% for juveniles (Horswill and Robinson 2015; rates based on population studies in Sweden and Alaska published respectively in 2002 and 2014). These rates will include mortality in the breeding and non-breeding season due to ‘natural’ factors such as weather or predation, as well as mortality (if any) from anthropogenic impacts such as disturbance and displacement by ships. As ships are mobile and red-throated divers will often fly away from approaching vessels (e.g. Schwemmer et al. 2011, Jarrett et al. 2018) the energy costs of displacement from moving vessels may be considerably greater than those of avoiding static structures; and the impact (if any) of disturbance by ships must already be incorporated in the existing estimates of survival.

103. For recent windfarm assessments Natural England have advised that a highly precautionary 10% maximum mortality rate should be used for birds displaced by cable laying vessels. This magnitude of impact is not supported in the literature and given that this would equate to more than half the natural annual adult mortality rate (16%) as a result of what is effectively a single occasion of disturbance, it is highly improbable that such a large magnitude of effect would occur. To illustrate this, it is worth considering the existing level of vessel traffic through the region which has been ongoing for decades. Given the widespread nature of vessel movements it seems likely that most individual red-throated divers using the SPA would encounter at least one vessel per winter. If this species is as susceptible to mortality following individual instances of vessel disturbance as proposed by Natural England, the SPA population would be reduced by 10% per year over and above natural change. In contrast the SPA population estimate has increased since designation by almost three and a half times, from 6,446 individuals to 18,079[1]. It therefore appears to be highly unlikely that the magnitude of effect from vessel disturbance is anything approaching

[1] Natural England supplementary advice for the Outer Thames Estuary SPA, 15 March 2019 https://designatedsites.naturalengland.org.uk/Marine/SupAdvice.aspx?SiteCode=UK9020309&SiteName=&SiteNameDisplay=Outer+Thames+Estuary+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=

10%, and in fact there may be no discernible effect attributed to this potential source of impact.

104. Evidence strongly indicates that red-throated divers are limited by competition for safe breeding sites within range of foraging waters (Merrie 1978, Nummi et al. 2013, Rizzolo et al. 2014, Dahlen and Eriksson 2016), but they are probably not in competition for resources during the non-breeding season (Dierschke et al. 2012, 2017). This would suggest that their population size will be limited by breeding habitat suitability and not by wintering habitat (Newton 1998). Loss of wintering habitat would, therefore, have little or no impact on red-throated diver numbers unless habitat loss was so extensive that non-breeding season habitat became a limiting factor for the population because their density increased so much that interference competition or prey depletion became a driving factor. Norfolk Vanguard Ltd (2019a) concluded that 1% mortality is an appropriately precautionary estimate for displacement for red-throated diver, and that in reality the additional mortality rate may be closer to zero.

105. However, based on advice from Natural England, this assessment has assumed the precautionary maximum mortality rate associated with the displacement of red-throated diver in the wintering period is 1-10% (i.e. 1-10% of displaced individuals suffer mortality as a direct consequence[2]). Based on the displacement of 16-95 divers at any given time (paragraph 100 above), then <1 – 10 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, 2,320 birds would be expected to die each year from the winter BDMPS for this species (10,177; Furness 2015). The addition of a maximum of 10 birds to this would increase the mortality rate by 0.4%. 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, 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**.

107. Natural England asked for consideration to be given to a seasonal restriction on construction works within the offshore cable corridor, between November and February, to minimise effects on red-throated divers (see ***Appendix 12.2***). Given the assessment above and the highly precautionary prediction that a maximum

[2] This assumption was applied for East Anglia THREE

of 10 birds would die as a result of displacement over this period, a seasonal restriction is not considered to be justified (or proportionate) in EIA terms, in addition to the measures set out in the best practice protocol for red-throated divers in ***section 12.3.3.2*** above.

12.6.1.1.1.2 East Anglia TWO Windfarm Site

108. Red-throated divers were recorded in the East Anglia TWO windfarm site between December and May, peaking in March (mean density in windfarm site 0.33/km^2) with the lowest numbers in December (mean density in windfarm site 0.02/km^2).

109. There is potential for disturbance and displacement of red-throated divers due to construction activities, including the construction of wind turbines and other infrastructure (offshore electrical platforms, construction operation and maintenance platforms and meteorological mast) and associated vessel traffic. However, construction will not occur across the whole of the proposed wind turbine array area simultaneously or every day but will be phased, with activity focused on particular wind turbine, offshore platform or cable locations at any time (assumed to be three discrete locations for the purposes of this assessment). Consequently, until wind turbines (and other structures) are placed on foundations, the effects will occur only in the areas where vessels are operating at any given point and not the entire East Anglia TWO windfarm site. At such time as wind turbines (and other infrastructure) are installed onto foundations the impact of displacement would increase incrementally to the same levels as operational impacts (***section 12.6.2.1*** below).

110. No red-throated divers were recorded in the offshore windfarm site during the autumn migration season.

111. During the winter period, at a mean peak density of 0.09/km^2 and with a highly precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), three individual birds (0.09 x 12.56 x 3) could be at risk of displacement, of which <1 bird (0-0.3 birds) would be predicted to die. At the average annual mortality rate of 0.228, 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 0.3 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.

112. The construction works are temporary and localised in nature, and phased across the wind farm site, and the magnitude of effect has been determined as

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

113. During the spring migration season, at a mean peak density of 0.33/km^2 and with a precautionary 2km radius of disturbance around each of three construction areas, 12 individual birds (0.33 x 12.56 x 3) could be at risk of displacement, of which 0-1 would be expected to die. At the average annual mortality rate of 0.228, 3027 birds would be expected to die each year from the spring migration BDMPS for this species (13,277; 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.

114. The construction works are temporary and localised in nature and the magnitude of effect has been determined as negligible. As red-throated diver is of high sensitivity to disturbance, the impact significance is **minor adverse**.

115. The site is beyond the foraging range of any breeding colonies of red-throated diver (mean maximum foraging range of 9km, Thaxter et al. 2012), with the nearest breeding areas located in the south and west of Scotland). Birds recorded on site during March and April are considered to be predominantly birds on spring migration (see ***Table 12.10***). During the migration free breeding season (May until August), red-throated divers were only recorded within the East Anglia TWO offshore windfarm site in May, a mean density of 0.04 birds/km^2, indicating that 2 individual birds (0.04 x 12.56 x 3) could be at risk of displacement, of which <1 (maximum 0.2) would be expected to die. These may comprise immature birds, or potentially birds migrating late to breeding areas.

116. Whether individuals recorded within the East Anglia TWO windfarm site during the (migration-free) breeding season are immature birds, or late-migrating birds, the maximum predicted mortality of 0.2 birds would not be predicted to materially alter the background mortality of the reference population and would be undetectable. Thus, this highly precautionary assessment generates an effect of negligible magnitude.

117. The construction works are temporary and localised in nature and the magnitude of effect has been determined as negligible. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

118. For the East Anglia TWO offshore windfarm site, the estimated number of red-throated divers subject to construction disturbance/displacement throughout the year would be 17, of which between 0.2 and 2 individuals would potentially die.

119. At the average baseline mortality rate of 0.228, the number of individuals expected to die from the largest BDMPS population throughout the year is 3,027 (13,277 x 0.228). The addition of a maximum of 2 individuals to this increases the mortality rate by 0.07%. 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**.

12.6.1.1.1.3 Offshore Cable Corridor and Offshore Windfarm Site

120. Throughout the year, the estimated number of red-throated divers subject to construction disturbance / displacement would be 16-95 in the offshore cable corridor (***Section 12.6.1.1.1.1***) and 17 in the offshore wind farm site (summing the seasonal totals in ***Section 12.6.1.1.1.2*** above, noting that totals in the text are rounded to the nearest integer whereas the sum is based on numbers to one decimal place), a total of 33 -112 birds (assuming construction works in both the offshore cable corridor and the windfarm site overlap in time), of which between <1 and 11 individuals would potentially die at mortality rates of 1% to 10%. It is noted that seasonal density estimates for the export cable corridor are not available, so the total for this area is based on a range of densities recorded during from two surveys the spring migration period in 2018.

121. At the average baseline mortality rate of 0.228, the number of individuals expected to die from the largest BDMPS population throughout the year is 3,027 (13,277 x 0.228). The addition of a maximum of 11 individuals at the highly precautionary rate of 10% mortality of displaced birds, increases the mortality rate by 0.4%. 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**.

12.6.1.1.2 Razorbill

122. Razorbills were recorded in the East Anglia TWO windfarm site in most months throughout the year, in the highest numbers in the non-breeding season, peaking in January (mean density in windfarm site 0.54/km^2) and at their lowest in June (mean density in windfarm site 0.02/km^2). Razorbills are considered to have a medium sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004), Furness and Wade (2012), Furness et al. (2013) and Bradbury et al. (2014).

123. 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 and assumed to occur at three discrete locations for the purposes of this assessment. Consequently, until wind turbines (and other structures) are placed on foundations, the effects will occur only in the areas where vessels are operating at any given point and not the entire East Anglia TWO windfarm site. At such time as wind turbines (and other infrastructure) are installed onto foundations the impact of displacement would increase incrementally to the same levels as operational impacts (***Section 12.6.2.1*** below).

124. 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).

12.6.1.1.2.1 Autumn Migration

125. During the autumn migration season, at a mean peak density of 0.11/km^2 and with a highly precautionary 2km radius of disturbance around each of three construction areas, four individual birds (0.11 x 12.56 x 3) could be at risk of displacement, of which <1 bird (0-0.4 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 UK North Sea and Channel Migration winter BDMPS for this species (591,874; Furness 2015). The addition of 0.4 birds 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.

126. 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**.

12.6.1.1.2.2 Winter

127. During the winter period, at a mean peak density of 0.29/km^2 and with a highly precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), 11 individual birds (0.29 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 one 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.

128. 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**.

12.6.1.1.2.3 Spring migration

129. During the spring migration season, at a mean peak density of 0.54/km^2 and with a highly precautionary 2km radius of disturbance around each of three construction areas, 20 individual birds (0.54 x 12.56 x 3) could be at risk of displacement, of which 0-2 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 two 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.

130. 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**.

12.6.1.1.2.4 Breeding Season

131. During the breeding season, the mean peak density on the site was 0.53/km^2 (April) which suggests that 20 individuals (0.53 x 12.56 x 3) could be at risk of displacement, of which 0-2 would be expected to die.

132. The mean maximum foraging range for breeding razorbill is 48.5km (Thaxter et al. 2012) which places the East Anglia TWO windfarm site considerably beyond the range of any razorbill breeding colonies. The nearest major breeding colony is Flamborough Head, 254km from the East Anglia TWO windfarm site (the minimum distance to the Flamborough and Filey Coast SPA, ***Table 12.12***).

133. 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 TWO 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.

134. 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 TWO windfarm site, therefore it is reasonable to assume that individuals seen during the breeding season are non-breeding (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%).

135. 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 two birds predicted to die from construction disturbance and displacement would increase the mortality rate by 0.01%. (Use of the average mortality produces a conservative estimate of % change, as the mortality of birds less than two years old is higher than (survival rates are lower than) that of adult birds, ***Table 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.

136. 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**.

12.6.1.1.2.5 Year Round

137. The estimated number of razorbills subject to construction disturbance / displacement throughout the year is 55 individuals (summing the seasonal totals above), of which between 0.6 and 5.5 could be at risk of mortality.

138. 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 5.5 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, the magnitude of effect is assessed as

negligible. As the species is of medium sensitivity to disturbance, the impact significance is **negligible**.

12.6.1.1.3 Guillemot

139. Guillemots were recorded in the East Anglia TWO windfarm site year round, with densities peaking in April (mean density in windfarm site 5.89/km^2) and at their lowest in June (mean density in windfarm site 0.24/km^2). Guillemots are considered to have a medium sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004), Furness and Wade (2012), Furness et al. (2013) and Bradbury et al. (2014).

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

141. 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).

12.6.1.1.3.1 Non-breeding

142. During the non-breeding season, at a mean peak density of 4.59/km^2 and with a highly precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), 173 individual birds (4.59 x 12.56 x 3) could be at risk of displacement, of which 2-17 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 17 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.

143. 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**.

12.6.1.1.3.2 Breeding

144. During the breeding season, the maximum mean peak density in the East Anglia TWO windfarm site was 5.89/km^2 (April) which suggests that 222 individuals (5.89 x 12.56 x 3) could be at risk of displacement, of which 2-22 would be expected to die.

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

146. 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. 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 TWO 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.

147. 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 TWO windfarm site, therefore it is reasonable to assume that individuals seen during the breeding season are non-breeding 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%).

148. Based on the average mortality for the species of 0.14, a total of 97,362 birds would be expected to die each year from the sub-adult component of the winter BDMPS for this species. The addition of a maximum of 22 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 3 years old is higher than (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.

149. 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**.

12.6.1.1.3.3 Year round

150. The estimated number of guillemots subject to construction disturbance / displacement throughout the year is 395 individuals (summing the seasonal totals above), of which between 4 and 39 could be at risk of mortality.

151. At the average baseline mortality rate for guillemot of 0.14, the number of individuals expected to die from the largest BDMPS population throughout the year is 226,423 (1,617,306 x 0.14). The addition of a maximum of 39 individuals to this increases the mortality rate by 0.02%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of effect is assessed 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

152. 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.

153. 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 TWO 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 ***Table 10.31***). 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 TWO project during the construction phase is similarly a ***minor*** or ***negligible adverse*** impact.

154. 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 9.6.2***). The consequent indirect impact on fish through habitat loss is considered to be minor or negligible (see ***Table 10.31***) 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 TWO 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:

155. 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.

156. 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.

157. 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.

158. 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).

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

160. 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).

161. 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.

162. 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.

163. The small risk of impact to migrating birds resulting from flying around rather than through, the wind turbine array of an offshore windfarm is considered a potential barrier effect and has been scoped out of the assessment. Masden et al. (2010, 2012) and Speakman et al. (2009) calculated that the costs of one-off avoidances during migration were small, accounting for less than 2% of available fat reserves. 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.

164. 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.

165. 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.

166. 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 12.2***). The species identified as at risk were then assessed within the biological seasons within which effects were potentially likely to occur. Any species with a low sensitivity to displacement and/or recorded only in very small numbers within the East Anglia TWO 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. 2018).

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

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Season(s)	Rationale
Black-throated diver	Very High	OUT	N/A	Recorded on only one occasion in baseline surveys
Great northern diver	Very High	OUT	N/A	Recorded on only two occasions in baseline surveys
Fulmar	Considered Low in some studies, but possibly high according to Dierschke et al. (2016)	OUT	N/A	the species has a maximum habitat flexibility score of 1 in Furness and Wade (2012), suggesting it utilises a wide range of habitats over a large area.
Gannet	Considered Low in some studies, but possibly high according to Dierschke et al. (2016), and has a high macro-avoidance rate for windfarms	IN	Autumn and Spring migration	Potentially susceptible to displacement from wind turbines and abundant
Cormorant	Considered high in some studies but species is attracted to offshore windfarm structures	OUT	N/A	Recorded on only one occasion in baseline surveys
Shag	Medium	OUT	N/A	Recorded on only one occasion in baseline surveys
Great skua	Low	OUT	N/A	Recorded in low numbers during passage migration periods
Puffin	Medium	OUT	N/A	Recorded in low numbers during only one baseline survey

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

167. 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***.

168. 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.

169. 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.

170. 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.

171. 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	253.91*	9.03	4.1	24.47	253.91	-
Gannet	Windfarm + 2km buffer	191.71	191.71	891.05	-	192.18	-
Razorbill	Windfarm + 2km buffer	280.9	280.9	44.1	136.4	229.9	-
Guillemot	Windfarm + 2km buffer	2077	2077	-	-	-	1675
* The East Anglia TWO windfarm site is not within foraging range of any breeding colonies of red-throated diver. Although birds were recorded during the full breeding season (March to August), this overlaps with the spring migration period (February to April). The peak number of birds recorded in the overlapping period (March) is considered to comprise birds on spring migration. During the migration free breeding season (May until August) birds were only recorded in May; these could be birds migrating late to breeding areas and/or sub-adult birds.							

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		

172. 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

173. Red-throated divers are considered to have a very high general sensitivity to disturbance and displacement and they are prone to avoiding disturbed areas such as shipping lanes, as well as offshore windfarms (Garthe and Hüppop 2004; Bellebaum et al. 2006; Petersen et al. 2006; Schwemmer et al. 2011; Furness and Wade 2012; Furness et al. 2013; Bradbury et al. 2014; Percival 2014; Dierschke et al. 2017; Mendell et al. 2019; Irwin et al. 2019).

174. A detailed review of the evidence for displacement of red-throated divers from offshore windfarms, and the likely effects on displacement on population mortality rates, is included in Norfolk Vanguard Ltd (2019a). Based on this review, displacement distances of red-throated divers from offshore windfarms reported in various studies are summarised in ***Table 12.17*** . Most studies found a marked decrease (around 90%) in red-throated diver densities within operational windfarms when compared to pre-construction data, however the distance outside the windfarm over which diver densities were reduced was more variable. At the extremes, Percival (2013) found no reduction in diver density outside Thanet offshore windfarm even within 500m of the outer wind turbines, whereas Mendel et al. (2019) found a statistically detectable reduction in density up to 12km from the outer wind turbines. This variation is unexplained. It might relate to ecological conditions or to the seascape/landscape of the site. Behaviour may vary seasonally, for example, depending on ecological constraints at different times of year, such as may arise during flight-feather moult when birds may become flightless. Birds might show greater avoidance distances where they are unconstrained. At sites where suitable or optimal habitat is limited, birds might show lower displacement distances because of constraints imposed by habitat availability. Alternatively, divers may show stronger avoidance of visible structures at sea where these are against an ‘empty’ background seascape. Where structures are in front of a cluttered background of coast, perhaps

especially a coast with industrial development, wind turbines may appear less prominent and/or may be seen by divers as less threatening. The largest distances from offshore windfarms over which diver densities were reduced were in the German Bight, a very large area of open sea far from the coast. The smallest displacement distances from offshore windfarms were at sites close to the UK coast where anthropogenic influences on the coastal scenery are high (Thanet, Kentish Flats) (MacArthur Green 2019a).

Table 12.17 Summary of reported displacement distances and reductions in density for red-throated diver in relation to offshore wind farms[1]

Windfarm	Distance from outer turbines over which diver density was significantly reduced (km)	Percentage reduction in diver density within windfarm area	Reference
Thanet	0.0	82	Percival 2013
Kentish Flats Extension	0.5	89	Percival and Ford 2018
Greater Gabbard	<1.0	(75)[2]	Gill et al. 2018
Kentish Flats	1.0	-	Percival 2014
Gunfleet Sands	1.0	-	Barker 2011
London Array	<1.5	<50	APEM 2016
Alpha Ventus	1.5	90	Welcker and Nehls 2016
Horns Rev 1	2.0	90	Petersen et al. 2006
North Hoyle	2.5	-	May 2008
Lincs	2-6	-	Webb et al. 2015
Horns Rev 2	5.5	50	Petersen et al. 2014
Butendiek, Amrumbank, Nordsee Ost, Meerwind Süd/Ost, Dan Tysk	12.0	94	Mendel et al. 2019

1. Based on Table 2.1 in Norfolk Vanguard Ltd (2019a).

2. But not statistically significant due to high variance in data so a tentative estimate

175. Displacement rates of 60% to 80% were reported for Egmond aan Zee offshore windfarm (OWEZ) (Leopold et al. 2011). The Offshore Renewables Joint Industry Programme (ORJIP) bird avoidance study at Thanet offshore windfarm Skov et al. (2018) reported records of 82 radar tracks and 42 laser rangefinder tracks of

red-throated divers. This would appear to provide an adequate sample size to assess macro-avoidance of that windfarm, although avoidance behaviour of this species is not assessed in the report, as it was not one of the key species in that study. Two aerial surveys of red-throated divers in the Outer Thames Estuary SPA in February 2018 (Irwin et al. 2019) found that densities were notably increased in waters either side of shipping lanes and the London Array windfarm, indicative of displacement behaviour. There were significant differences in the mean density of birds within areas of the SPA outside the footprints of windfarms (>3 birds per km^2), and those within windfarm footprints (<1 bird per km^2), however these displacement effects were not quantified in any further detail in the survey report.

176. 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).

177. 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).

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

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

180. Modelling of data from pre-construction, construction and post-construction for the London Array Windfarm considered 1km buffers extending around the wind farm up to 15km. Red-throated diver density close to the windfarm was found to decline significantly between the pre-construction and construction periods; preliminary data from the post-construction period, however, may suggest that divers recolonised the windfarm and surrounding areas after construction had

been completed (APEM 2016). It was noted that the densities of divers in the study area may vary to a large extent between years, and, as well as the presence of offshore wind farms and shipping activities, the total numbers of birds present as well as changes in other environmental conditions will influence the distribution of birds in a given year.

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

182. Natural England has advised for red-throated diver that the assessment for displacement from East Anglia TWO offshore windfarm is based on a displacement rate of 100% within the offshore wind farm site and a 4km buffer, and a mortality rate of up to 10% for displaced birds.

183. The assessment below follows this advice. In relation to the degree of displacement from a windfarm and 4km buffer, it is noted that displacement has been demonstrated to decline with distance from a site (e.g. see ***Table 12.17*** above). Norfolk Vanguard Ltd (2019a) recommended a precautionary rate of 90% displacement from an offshore windfarm and a 4km buffer based on a detailed review of available evidence, and this is considered to be a more realistic but still precautionary assumption.

184. At East Anglia TWO, the largest numbers of red-throated divers were recorded during the spring migration period, at which time there is likely to be a turnover of individuals passing through the area, rather than a resident population. Thus, a given individual might only be displaced once from the windfarm, as opposed to being displaced multiple times if it was resident over the three month spring migration period. Taking this into account, and the review above of the likely effects of displacement during the non-breeding season on survival rates of red-throated divers (see ***paragraph 102***) it is considered that 1% mortality is a more appropriate precautionary estimate.

185. The displacement matrices in ***Table 12.18*** through ***Table 12.20*** have been populated with data for red-throated diver during the autumn migration, non-

breeding and spring migration periods within the site and a 4km buffer in line with recommendations (SNCB 2017). The East Anglia TWO windfarm site is not within an area designated for high densities of red-throated divers, suggesting that the habitat is less important to this species than the nearby Outer Thames Estuary SPA (about 8km from the windfarm site at the nearest point), or within foraging range of any breeding areas for red-throated divers.

12.6.2.1.1.1 Autumn Migration

186. Within the range of 100% displacement and 0-10% mortality, the number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement from the East Anglia TWO windfarm site during the autumn migration period has been estimated as 0 individuals (***Table 12.18***). This would not increase the background mortality rate of the autumn BDMPS for red-throated diver (13,277; Furness, 2015).

187. Therefore, during the autumn migration period, there is no magnitude of effect, even on the basis of this highly precautionary approach. Therefore, there is **no impact**.

12.6.2.1.1.2 Midwinter

188. Within the range of 100% displacement and 0-10% mortality, the number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement from the East Anglia TWO windfarm site during the midwinter period has been estimated as 0-2 individuals (***Table 12.19***). The BDMPS for red-throated diver in winter is 10,177 (Furness 2015).

189. At the average baseline mortality rate for red-throated diver of 0.228, the number of individuals expected to die in the midwinter BDMPS is 2,320 (10,177 x 0.228). The addition of a maximum of two to this increases the mortality rate by 0.08%. 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

190. Within the range of 100% displacement and 0-10% mortality, the number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement from the East Anglia TWO windfarm site during the spring migration period has been estimated as 0-25 individuals (***Table 12.19***). The BDMPS for red-throated diver in spring is 13,277 (Furness, 2015).

191. At an average mortality rate of 0.228, the number of individuals expected to die in the spring BDMPS is 3,027 (13,277 x 0.228). The addition of a maximum of 25

to this increases the mortality rate by 0.8%. This magnitude of increase in mortality is considered highly unlikely as during this period birds would be passing through the site during migration. There is likely to be a turnover of individuals passing through the area, rather than a resident population. Thus, a given individual might only be displaced once from the windfarm, as opposed to being displaced multiple times if it was resident over the three-month spring migration period. Therefore, during the spring migration period, the magnitude of 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 (non-breeding period)

192. Considering the year-round effects, which for this species equates to the non-breeding period, the maximum number of red-throated divers expected to die as a result of displacement from the East Anglia TWO windfarm site, at a displacement rate of 100% and mortality of 0-10%, would be 0-28 (adding the numbers predicted to be displaced during autumn migration, winter, and spring migration in ***Table 12.18, Table 12.19*** and ***Table 12.19***, and noting that the totals in each table and the combined total are expressed to the nearest integer).. The largest BDMPS is 13,277 during migration and the biogeographic red-throated diver population with connectivity to UK waters is 27,000 (Furness 2015).

193. At the average baseline mortality rate for red-throated diver of 0.228, the number of individuals expected to die over one year from the BDMPS is 3,027 (13,277 x 0.228). The addition of 0-28 individuals to this increases the mortality rate by 0-0.9%. In relation to the biogeographic population, the number of individuals expected to die over one year is 6,156 (27,000 x 0.228). The addition of 0-28 to this increases the mortality rate by 0-0.5%.

194. As previously discussed, (see ***section 12.6.1.1.1***), the highest mortality rate of 10% is considered unrealistic. 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. Thus, a given individual might only be displaced once from the windfarm, as opposed to being displaced multiple times if it was resident throughout the non-breeding period.

195. These magnitudes 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 12.18 Displacement Matrix for Red-throated Diver During the Autumn Migration Period. The cells show the number of birds predicted to 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	0	0	0
	20%	0	0	0	0	0	0	0	0	0	1	1
	30%	0	0	0	0	0	0	0	0	1	1	1
	40%	0	0	0	0	0	0	0	0	1	1	2
	50%	0	0	0	0	0	0	0	1	1	2	2
	60%	0	0	0	0	0	0	0	1	1	2	2
	70%	0	0	0	0	0	0	1	1	1	2	3
	80%	0	0	0	0	0	0	1	1	2	3	3
	90%	0	0	0	0	0	0	1	1	2	3	4
	100%	0	0	0	0	0	0	1	1	2	3	4

Table 12.19 Displacement Matrix for Red-throated Diver During the Winter Period. The cells show the number of birds predicted to 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	0	0	1	1	2	2
	20%	0	0	0	0	0	0	1	1	2	4	5
	30%	0	0	0	0	0	1	1	2	4	6	7
	40%	0	0	0	0	0	1	2	3	5	8	10
	50%	0	0	0	0	1	1	2	4	6	10	12
	60%	0	0	0	1	1	1	3	4	7	12	15
	70%	0	0	1	1	1	2	3	5	9	14	17
	80%	0	0	1	1	1	2	4	6	10	16	20
	90%	0	0	1	1	1	2	4	7	11	18	22
	100%	0	0	1	1	1	2	5	7	12	20	24

Table 12.20 Displacement Matrix for Red-throated Diver During the Spring Migration Period. The cells show the number of birds predicted to 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	1	3	5	8	13	20	25
	20%	1	1	2	2	3	5	10	15	25	41	51
	30%	1	2	2	3	4	8	15	23	38	61	76
	40%	1	2	3	4	5	10	20	30	51	81	102
	50%	1	3	4	5	6	13	25	38	63	102	127
	60%	2	3	5	6	8	15	30	46	76	122	152
	70%	2	4	5	7	9	18	36	53	89	142	178
	80%	2	4	6	8	10	20	41	61	102	163	203
	90%	2	5	7	9	11	23	46	69	114	183	229
	100%	3	5	8	10	13	25	51	76	127	203	254

12.6.2.1.2 Gannet

196. 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.

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

198. Displacement effects for gannets for the East Anglia TWO windfarm site were assessed during the autumn and spring migration periods, based on respective peak mean populations of 915 and 237 individual birds (***Table 12.21***) 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).

199. Displacement matrices for gannets during the autumn and spring migration periods (calculated for the site and a 2km buffer) are presented in ***Table 12.21*** and ***Table 12.22.*** For this species, based on the recommendations of Cook et al. (2018) and also the findings of Skov et al. (2018) (see ***paragraph 197*** 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

200. Based on displacement rates of 60% to 80% and a precautionary 1% mortality rate, the number of individual gannets which could potentially suffer mortality as a consequence of displacement during the autumn migration period has been estimated as 5 - 7 individuals (cells highlighted ***Table 12.21***).

201. 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 7 to this increases the mortality rate by 0.008%. 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 displacement, the impact significance is **negligible**.

12.6.2.1.2.2 Spring Migration

202. Within the range of 60-80% displacement and a precautionary 1% mortality, the number of individual gannets which could potentially suffer mortality as a consequence of displacement during the spring migration period has been estimated as 1- 2 individuals (***Table 12.22***).

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

204. At the average baseline mortality rate for gannet of 0.191 (***Table 12.23***) the number of individuals expected to die in the spring BDMPS is 47,441 (248,385 x 0.191). The addition of a maximum of 2 to this increases the mortality rate by 0.004%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the spring migration period, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to displacement, the impact significance is **negligible**.

12.6.2.1.2.3 Breeding

205. Within the range of 60-80% displacement and a precautionary 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement during the breeding period has been estimated as 1-2 (***Table 12.23***).

206. The nearest gannet breeding colony to the proposed development is Bempton Cliffs within the Flamborough and Filey Coast SPA. The SPA is 254km from the East Anglia TWO windfarm site at the nearest point (***Table 12.12***). This is outside the mean maximum foraging range of gannets, estimated as 229km (Thaxter et al. 2012), the usual measure used to identify potential connectivity between a breeding seabird colony and foraging areas. Bempton cliffs is within the estimated maximum foraging range of 590km. Tracking data, however, suggest that breeding adults from that colony make very little if any use of the East Anglia TWO windfarm site during the breeding season (Langston et al. 2013).

207. It is most likely that gannets present during the breeding season are sub-adults or non-breeding adults, and any displacement of such birds would not affect the

Bempton Cliffs breeding population. On a precautionary basis, however, predicted displacement mortality of gannet during the breeding season has been compared to the SPA reference population. The SPA population at designation was 11,061 pairs, increasing to 13,392 pairs by 2017 (Aitken et al. 2017). These equate to total population sizes of approximately 40,222 and 48,698 (designated and 2017 count respectively; calculated as individuals and multiplied up to include subadult birds, based on the adult proportion of 0.55 from Furness 2015). As the Bempton Cliffs gannet colony continues to increase (Aitken et al. 2017, Langston et al. 2013) the higher estimate of total numbers of individuals (breeding and non-breeding/sub-adult birds) has been used as a reference population.

208. At the average baseline mortality rate for gannet of 0.191 (***Table 12.16***) the number of individuals expected to die from the breeding season BDMPS is 9,301 (48,698 x 0.191). The addition of 1 - 2 individuals (***Table 12.23***) to this increases the mortality rate by 0.02%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding period, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to displacement, the impact significance is **negligible**.

12.6.2.1.2.4 Year Round

209. Considering the year-round effects, the maximum number of gannets expected to die as a result of displacement from the East Anglia TWO windfarm site, at a displacement rate of 60-80% and a precautionary 1% mortality, would be 10 (adding the numbers predicted to be displaced during autumn migration, winter, and spring migration in ***Table 12.21***, ***Table 12.22***, and ***Table 12.23*** and noting that the totals in each table and the combined total are expressed to the nearest integer). The largest BDMPS for gannet in autumn is 456,298, and the biogeographic gannet population with connectivity to UK waters is 1,180,000 (Furness 2015).

210. 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 10 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.

211. In relation to the biogeographic population, the number of individuals expected to die over one year is 225,380 (1,180,000 x 0.191). The addition of a maximum of 10 to this increases the mortality rate by <0.01%. 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 12.21 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%	1	2	3	4	4	9	18	27	45	71	89
	20%	2	4	5	7	9	18	36	53	89	143	178
	30%	3	5	8	11	13	27	53	80	134	214	267
	40%	4	7	11	14	18	36	71	107	178	285	356
	50%	4	9	13	18	22	45	89	134	223	356	446
	60%	5	11	16	21	27	53	107	160	267	428	535
	70%	6	12	19	25	31	62	125	187	312	499	624
	80%	7	14	21	29	36	71	143	214	356	570	713
	90%	8	16	24	32	40	80	160	241	401	642	802
	100%	9	18	27	36	45	89	178	267	446	713	891

Table 12.22 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	1	1	1	2	4	6	10	15	19
	20%	0	1	1	2	2	4	8	12	19	31	38
	30%	1	1	2	2	3	6	12	17	29	46	58
	40%	1	2	2	3	4	8	15	23	38	61	77
	50%	1	2	3	4	5	10	19	29	48	77	96
	60%	1	2	3	5	6	12	23	35	58	92	115
	70%	1	3	4	5	7	13	27	40	67	108	135
	80%	2	3	5	6	8	15	31	46	77	123	154
	90%	2	3	5	7	9	17	35	52	86	138	173
	100%	2	4	6	8	10	19	38	58	96	154	192

Table 12.23 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	1	1	1	2	4	6	10	15	19
	20%	0	1	1	2	2	4	8	12	19	31	38
	30%	1	1	2	2	3	6	12	17	29	46	58
	40%	1	2	2	3	4	8	15	23	38	61	77
	50%	1	2	3	4	5	10	19	29	48	77	96
	60%	1	2	3	5	6	12	23	35	58	92	115
	70%	1	3	4	5	7	13	27	40	67	107	134
	80%	2	3	5	6	8	15	31	46	77	123	153
	90%	2	3	5	7	9	17	35	52	86	138	173
	100%	2	4	6	8	10	19	38	58	96	153	192

12.6.2.1.3 Auks (Razorbill and Guillemot)

212. 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).

213. 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).

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

215. 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. Each matrix displays displacement rates and mortality rates for each species.

216. For auks, Natural England has advised that a range of mortality rates of 1-10% and displacement rates of 30-70%, should be considered, with 70% displacement and 10% mortality as the worst case. Natural England has also stated that they agree that the mortality for auks is likely to be at the low end of the range.

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

218. A review of available evidence for auk displacement, prepared for the assessment of the Norfolk Vanguard Offshore Wind Farm (Norfolk Vanguard Ltd 2019b) concluded that displacement of guillemots and razorbills by offshore windfarms is incomplete, and may reduce with habituation, and that offshore windfarms may in the long term increase food availability to guillemots and

razorbills through providing enhanced habitat for fish populations. Mortality due to displacement might arise if displacement increased competition for resources in the remaining areas of auk habitat outside the windfarm. The increase in density of auks outside the windfarm area will be negligible (because the rest of the available habitat is vast), Thus the mortality rate due to displacement may well be 0% and is highly unlikely to represent levels of mortality anywhere near to the 6% or 10% total annual mortality that occurs due to the combination of many natural factors plus existing human activities. Norfolk Vanguard Ltd (2019b) suggested that precautionary rates of displacement and mortality from operational wind farms would be 50% and 1% respectively.

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

220. As noted previously, there are no breeding colonies for guillemot or razorbill within foraging range of the East Anglia TWO windfarm site. Therefore, it is reasonable to assume that individuals seen during the breeding season are non-breeding 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 non-breeding 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

221. The estimated number of razorbills subject to mortality during the autumn migration period due to displacement from the East Anglia TWO windfarm site is between zero and three 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 591,874 (Furness 2015).

222. 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 three 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

223. The estimated number of razorbills subject to mortality during the winter period due to displacement from the East Anglia TWO windfarm site is between zero and 10 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 218,622 (Furness 2015).

224. 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 10 individuals to this increases the mortality rate by 0.03%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, 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

225. The estimated number of razorbills subject to mortality during the spring migration period due to displacement from the East Anglia TWO windfarm site is between one and 16 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, ***Table 12.26***). The BDMPS for the UK North Sea and Channel is 591,874 (Furness 2015).

226. 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 16 individuals to this increases the mortality rate by 0.02%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the 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

227. The estimated number of razorbills subject to mortality during the breeding period due to displacement from the East Anglia TWO windfarm site is between one and 20 individuals (from 30%/1% to 70%/10%, ***Table* 12.27**). The BDMPS is 94,007 non-breeding individuals (see ***paragraph 221*** above).

228. 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 20 to this increases the mortality rate by 0.12% (use of the average mortality for a non-breeding / subadult reference population produces a conservative estimate of percentage change, as the mortality of birds less than two years old is higher than (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. Therefore, during the non-breeding 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

229. The estimated number of razorbills subject to displacement mortality throughout the year is between two and 48 individuals (summing the range of displacement/mortality of 30%/1% to 70%/10% from ***Table 10.23*** through ***Table 10.26***, and noting that numbers in the tables are rounded to the nearest integer whereas the sums are based on actual numbers including decimal places).

230. 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 48 individuals to this increases the mortality rate by 0.05%. In relation to the biogeographic population with connectivity to UK waters, 1,707,000 (Furness 2015), the number of individuals expected to die annually is 297,018 (1,707,000 x 0.174). The addition of a maximum of 48 individuals to this increases the mortality rate by 0.02%. These magnitudes 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 12.24 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	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 12.25 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	1	1	1	3	4	7	11	14
	20%	0	1	1		1	3	5	8	14	22	27
	30%	0	1	1	2	2	4	8	12	20	33	41
	40%	1	1	2	2	3	5	11	16	27	44	55
	50%	1	1	2	3	3	7	14	20	34	55	68
	60%	1	2	2	3	4	8	16	25	41	65	82
	70%	1	2	3	4	5	10	19	29	48	76	95
	80%	1	2	3	4	5	11	22	33	55	87	109
	90%	1	2	4	5	6	12	25	37	61	98	123
	100%	1	3	4	5	7	14	27	41	68	109	136

Table 12.26 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	5	7	11	18	23
	20%	0	1	1	2	2	5	9	14	23	37	46
	30%	1	1	2	3	3	7	14	21	34	55	69
	40%	1	2	3	4	5	9	18	28	46	74	92
	50%	1	2	3	5	6	11	23	34	57	92	115
	60%	1	3	4	6	7	14	28	41	69	110	138
	70%	2	3	5	6	8	16	32	48	80	129	161
	80%	2	4	6	7	9	18	37	55	92	147	184
	90%	2	4	6	8	10	21	41	62	103	166	207
	100%	2	5	7	9	11	23	46	69	115	184	230

Table 12.27 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	1	1	3	6	8	14	22	28
	20%	1	1	2	2	3	6	11	17	28	45	56
	30%	1	2	3	3	4	8	17	25	42	67	84
	40%	1	2	3	4	6	11	22	34	56	90	112
	50%	1	3	4	6	7	14	28	42	70	112	140
	60%	2	3	5	7	8	17	34	51	84	135	169
	70%	2	4	6	8	10	20	39	59	98	157	197
	80%	2	4	7	9	11	22	45	67	112	180	225
	90%	3	5	8	10	13	25	51	76	126	202	253
	100%	3	6	8	11	14	28	56	84	140	225	281

12.6.2.1.5 Guillemot

12.6.2.1.5.1 Non-Breeding

231. The estimated number of guillemots subject to mortality during the non-breeding period due to displacement from the East Anglia TWO windfarm site is between five and 117 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%, ***Table 12.28***). The BDMPS for the UK North Sea and Channel is 1,617,306 (Furness 2015).

232. 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 117 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**.

12.6.2.1.5.2 Breeding Season

233. The estimated number of guillemots subject to mortality during the breeding period due to displacement from the East Anglia TWO windfarm site is between six and 145 individuals (from 30%/1% to 70%/10%, ***Table 12.29***). The BDMPS is 695,441 non-breeding individuals (see ***paragraph 221*** above).

234. 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 145 to this increases the mortality rate by 0.15%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding 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

235. The estimated number of guillemots subject to displacement mortality throughout the year is between 11 and 263 individuals (summing the range of displacement/mortality of 30%/1% to 70%/10% from ***Table 12.28*** and ***Table 12.29***, and noting that numbers in the tables are rounded to the nearest integer whereas the annual totals are based on actual numbers including decimal places).

236. 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 263 individuals to this increases the mortality rate by 0.12%. In relation to the biogeographic population with connectivity to UK waters, 4,125,000 (Furness

2015), the number of individuals expected to die annually is 577,500 (4,125,000 x 0.140). The addition of a maximum of 263 individuals to this increases the mortality rate by 0.05%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, the year round the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **negligible**.

Table 12.28 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	3	5	7	8	17	34	50	84	134	168
	20%	3	7	10	13	17	34	67	101	168	268	335
	30%	5	10	15	20	25	50	101	151	251	402	503
	40%	7	13	20	27	34	67	134	201	335	536	670
	50%	8	17	25	34	42	84	168	251	419	670	838
	60%	10	20	30	40	50	101	201	302	503	804	1005
	70%	12	23	35	47	59	117	235	352	586	938	1173
	80%	13	27	40	54	67	134	268	402	670	1072	1340
	90%	15	30	45	60	75	151	302	452	754	1206	1508
	100%	17	34	50	67	84	168	335	503	838	1340	1675

Table 12.29 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%	2	4	6	8	10	21	42	62	104	166	208
	20%	4	8	12	17	21	42	83	125	208	332	415
	30%	6	12	19	25	31	62	125	187	312	498	623
	40%	8	17	25	33	42	83	166	249	415	665	831
	50%	10	21	31	42	52	104	208	312	519	831	1039
	60%	12	25	37	50	62	125	249	374	623	997	1246
	70%	15	29	44	58	73	145	291	436	727	1163	1454
	80%	17	33	50	66	83	166	332	498	831	1329	1662
	90%	19	37	56	75	93	187	374	561	935	1495	1869
	100%	21	42	62	83	104	208	415	623	1039	1662	2077

12.6.2.2 Indirect Impacts Through Effects on Habitats and Prey Species

237. Indirect disturbance and displacement of birds may occur during the operational phase of the proposed East Anglia TWO 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.

238. 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 TWO 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. 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**.

239. 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 TWO windfarm site during the operational phase is similarly a **minor adverse impact**.

240. With regard to EMF effects, these are identified as highly localised with the majority of cables being buried to up to 3m 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.

241. 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 not predicted to be significant (either beneficially or adversely) in EIA terms, at a wider scale.

12.6.2.3 Collision Risk

242. 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 TWO windfarm site, during migration, whilst foraging for food, or commuting between breeding sites and foraging areas.

243. Collision Risk Modelling (CRM) has been used in this assessment to estimate the risk to birds associated with the East Anglia TWO 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 12.2***.

244. 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).

245. Collision estimates for Band CRM option 1 are also included in ***Appendix 12.2*** (for information only as agreed through the ETG). This option uses flight height data for the East Anglia TWO study area. Following a review of data collection and analysis methods, the aerial survey contractors advised the Applicant that the flight height estimates from baseline survey data were not reliable. Thus, these data have not been used in the assessment.

246. CRM has been run using the deterministic Band model (Band 2012). Because many of the CRM input parameters include both natural variation (e.g. seabird densities) and measurement error, multiple runs of the model have been made for each species using mean values and upper and lower intervals for: flight

density (upper and lower 95% confidence intervals); avoidance rate (standard deviations, see ***Table 12.30***); and proportions at collision height (based on the generic dataset in Johnston et al. 2014a, 2014b). In addition, for some species, rates of nocturnal activity were varied. For gannet, CRM was run with nocturnal activity factors of 25% (standard), 0% reduced, and evidence-based seasonal rates (8% in breeding season months and 4% in non-breeding season months; Furness et al. 2018b); and for kittiwake, lesser black-backed gull, herring gull, great black-backed gull standard (50%) and reduced (25%) nocturnal activity factors.

247. For great skua, CRM was run using the migratory species methodology (Wright et al. 2012), to consider the likely turnover of this species through the site during the autumn and spring migration periods.

248. The input parameters are provided in ***Technical Appendix 12.2 Annex 3*** and complete CRM results are provided in ***Technical Appendix 12.2 Annexes 4 and 7***.

249. The mean densities of birds in flight were calculated as average values for a given month (two estimates) from the survey data. The 95% confidence intervals were calculated using a nonparametric bootstrap resampling method applied to each survey dataset which generated 1,000 resampled density estimates for each species on each survey.

250. The avoidance rates recommended by the SNCBs (JNCC et al. 2014) are set out in ***Table 12.30*** below. These were recommended 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 12.30 Avoidance Rates Used in CRM

Species	Avoidance Rate	Standard Deviation (SD)
Gannet	98.9%	0.2%
Kittiwake	98.9%	0.2%
Herring gull 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%

251. 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). This indicates that gannet collision mortality estimated at 98.9% is likely to overestimate the risk for this species. 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.

252. A bird collision avoidance study, funded by ORJIP, was conducted at Thanet Offshore Windfarm, between 2014 and 2016. A detection system of daylight and thermal imaging cameras recorded six collisions of birds with rotor blades during the course of the study. These were all gulls (not all identified to species), including one kittiwake. 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). These empirical avoidance rates (Skov et al. 2018) 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 12.30***).

253. Bowgen and Cook (2019) reviewed the findings of the above study, and recommended avoidance rates for use in the Band model of 99.5% for gannets and large gulls, and 99.0% for kittiwake. Thus, for gannet and kittiwake these indicate higher avoidance than recommended by the JNCC (2014) guidance ***Table 12.30***). The application of these rates to the assessment for East Anglia TWO was discussed at ETG meetings in January and June 2019. Natural England advised that collision risk estimates with these rates could be presented alongside those recommended by SNCBs for the assessment. For these two species the assessment of collision risk (based on ***Table 12.32***, ***Table 12.34*** and ***Table 12.35***below) presents two avoidance rates, from JNCC (2014) and Bowgen and Cook (2019).

254. 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'.

255. Recently however, a number of studies have deployed loggers on seabirds, and data from those studies can provide empirical evidence of the actual nocturnal flight activity level. These studies indicate that the nocturnal activity rates derived from Garthe and Hüppop (2004) almost certainly overestimate the levels of nocturnal activity in the species studied.

256. 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.

257. In the light of this, advice from Natural England in their Section 42 comments on the PEIR indicated 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.

258. In order to more accurately estimate nocturnal activity for gannet, a review of evidence from tracking studies has been undertaken (Furness et al. 2018b). This recommended precautionary nocturnal flight activity rates for gannet in the breeding and non-breeding seasons of 8% and 4% respectively. 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 were to be calculated without this study, a breeding season rate of 4.3% would be obtained. Thus, the recommended rates of 8% and 4% are arguably still precautionary.

259. For kittiwakes and the large gulls, upper and lower limits of nocturnal activity of 25% or 50% have been used in the CRM. For kittiwake, a review and analysis of activity data from tracking studies (Furness et al. in prep.) has identified nocturnal activity rates for the breeding and non-breeding seasons respectively of 20% and 17% based on empirical evidence. This suggests that the lower limit of 25% as applied in the CRM, is precautionary.

260. For all other species only one nocturnal activity level has been used based on nocturnal activity rates derived from Garthe and Hüppop (2004).

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

262. The full CRM results for the proposed project are presented in ***Appendix 12.2, Annex 4***. The following sections provide a summary of the outputs for assessment, using the seasons defined in ***Table 12.10***. An overview of annual collision risk estimates for all species (using the deterministic Band model Option 2) are presented in ***Table 12.31*** for the 75 x 250m and 60 x 300m wind turbine options. This table includes a range of estimates for species where CRM was run for variations in proportions at collision height and/or nocturnal activity. The avoidance rates and variations in ***Table 12.30*** were applied. The annual collision risk estimates presented in ***Table 12.31*** were used to identify species to be scoped in for assessment in relation to collision risk, and to identify the worst case layout for each species scoped in. Each species was assigned a sensitivity rating for collision risk, based on available data on the percentage 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).

263. Several species had very low predicted annual collision risks at the East Anglia TWO windfarm site (i.e. worst case mean prediction was below approximately five birds per year; ***Table 12.31***). These were red-throated diver, fulmar, black-headed gull, little gull, and common 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 ***Appendix 12.2***). The predicted annual collision risks for lesser black-

backed gull and herring gull were also very low, but these species were taken forward to assessment on a precautionary basis. For lesser black-backed gull, the East Anglia TWO windfarm site is 36km 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 area and be at risk of collision. Herring gull was scoped in at the request of Natural England (see ***Appendix 12.1***) to ensure that this species was carried through to the cumulative assessment for collision risk.

264. At the request of Natural England, the collision risk for great skua was run through the migrant collision risk model (Wright et al. 2012) to account for turnover during migration periods. The methodology is described in ***Appendix 12.2*** (***annex 7***). Annual collision risk for this species was found to be 0 for the East Anglia TWO windfarm site at avoidance rates of 95% and above.

265. Consideration was given to running the migrant collision risk model for little gull. However, the numbers and movements of this species, which occurs in the UK primarily in the non-breeding period, are poorly known (and the species was not included in the strategic review of risk of offshore wind farms to migratory birds carried out under the SOSS Steering Group, Wright et al. 2012). Little gull occurs in UK waters in the largest numbers during spring and autumn passage periods, with birds originating from breeding areas in Scandinavia and northwest Russia (Natural England and JNCC 2016). Overwintering concentrations of little gulls occur at a small number of UK sites, including inland waterbodies as well as offshore areas (Natural England and JNCC 2016), with the closest to East Anglia TWO being the Greater Wash SPA (38km from the offshore windfarm site at the nearest point (***Table 12.12***). Available information on flight height also indicates that little gulls are at low risk of collision because they fly low above the sea surface (Johnston et al. 2014 a and b; Wright et al. 2012).

266. The seasonal collision estimates for species scoped in to the collision risk assessment: gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull; are presented in ***Table 12.32***.

267. The collision risk assessment uses the outputs for the worst case wind turbine scenario for each species, calculated using CRM option 2. The mean results (and 95% confidence intervals) have been used in the assessment. For all species these encompass all or most of the variation in different CRM run scenarios varying flight height, avoidance rate and nocturnal activity.

268. 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 12.31 Annual Collision Risk Estimates (deterministic Band model option 2, avoidance rates as per *Table 12.30*). Values are the Mean 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) (see *paragraph 263*)	Model run type	Annual 75 x 250m wind turbine	Annual 60 x 300m wind turbine
Red throated diver (Low)	Mean	0.88 (0-2.21)	0.88 (0-2.19)
	Flight height only	0.88 (0.17-6.88)	0.88 (0.17-6.74)
Fulmar (Low)	Mean	0.56 (0.05-1.36)	0.57 (0.05-1.4)
	Flight height only	0.56 (0-7.07)	0.57 (0-7.12)
Gannet (Low / medium)	Mean (Nocturnal activity 25%)	47.02 (26.06 – 75.3)	45.78 (25.37-73.31)
	Avoidance rate only	47.02 (38.47-55.57)	45.78 (37.46-54.1)
	Flight height only	47.02 (20.47-82.26)	45.78 (20.05-79.84)
	Nocturnal activity, reduced (0%)	35.4 (19.13-57.59)	34.46 (18.63-56.06)
	Nocturnal activity, evidence based[2]	37.59 (20.36-61.07)	36.6 (19.82-59.45)
Kittiwake (Medium)	Mean (Nocturnal activity 50%)	49.51 (19.17-85.93)	49.93 (19.33-86.65)
	Avoidance rate only	49.51 (40.51-58.51)	49.93 (40.85-59)
	Flight height only	49.51	49.93

Species (sensitivity to collision) **(see *paragraph 263*)**	**Model run type**	**Annual 75 x 250m wind turbine**	**Annual 60 x 300m wind turbine**
		(36.68-59.71)	(37.05-60.14)
	Nocturnal activity reduced (25%)	41.9 (16.14-72.69)	42.22 (16.27-73.3)
Black-headed gull (Medium)	Mean	4.46 (2.45-6.88)	4.51 (2.48-6.97)
	Avoidance rate	4.46 (3.9-5.01)	4.51 (3.95-5.08)
	Flight height	4.46 (1.56-9.52)	4.51 (1.59-9.6)
Little gull (Low)	Mean	1.71 (0.51-3.41)	1.75 (0.52-3.49)
	Avoidance rate	1.71 (1.49-1.92)	1.75 (1.53-1.97)
	Flight height	1.71 (0.52-3.53)	1.75 (0.54-3.6)
Common gull (Medium)	Mean	1.09 (0-3.83)	1.09 (0-3.83)
	Avoidance rate	1.09 (0-3.83)	1.09 (0.95-1.22)
	Flight height	1.09 (0.91-1.64)	1.09 (0.91-1.64)
Lesser black-backed gull (Medium)	Mean (Nocturnal activity 50%)	5.18 (1.09-11.7)	5.12 (1.08-11.58)
	Avoidance rate only	5.18 (4.14-6.21)	5.12 (4.1-6.15)
	Flight height only	5.18 (3.48-8.82)	5.12 (3.45-8.72)
	Nocturnal activity reduced (25%)	4.55 (0.96-10.29)	4.5

Species (sensitivity to collision) (see *paragraph 263*)	Model run type	Annual 75 x 250m wind turbine	Annual 60 x 300m wind turbine
			(0.95-10.18)
Herring gull (Medium)	Mean (Nocturnal activity 50%)	0.52 (0-1.57)	0.52 (0-1.55)
	Avoidance rate only	0.52 (0.42-0.63)	0.52 (0.41-0.62)
	Flight height only	0.52 (0.39-0.75)	0.52 (0.39-0.74)
	Nocturnal activity reduced (25%)	0.44 (0-1.33)	0.44 (0-1.31)
Great black-backed gull (Medium)	Mean (Nocturnal activity 50%)	7.56 (0-20.52)	7.41 (0-20.1)
	Avoidance rate only	7.56 (6.05-9.08)	7.41 (5.93-8.89)
	Flight height only	7.56 (6.34-11.19)	7.41 (6.22-10.96)
	Nocturnal activity reduced (25%)	6.37 (0-17.23)	6.25 (0-16.89)

Table 12.32 Seasonal Collision Risk Estimates. Values are the Mean Number of Birds.

Species (worst case wind turbines)	Model run type	Breeding season	Autumn migration	Non-breeding/Winter	Spring migration	Annual
Gannet (75 x 250m)	Deterministic, mean, 98.9% avoidance (± 0.2%)	12.66 (5.01-24.17)	28.74 (19.46-40)	N/A	5.6 (1.6-11.13)	47.02 (26.06-75.3)
	Deterministic, mean, 99.5% avoidance	5.75	13.06	N/A	2.55	21.37
Kittiwake (60 x 300m)	Deterministic, mean, 98.9% avoidance (± 0.2%)	19.77 (7.8-34.08)	9.29 (2.1-18.08)	N/A	20.88 (9.43-34.5)	49.93 (19.33-86.65)
	Deterministic, mean, 99.0% avoidance	17.97	8.45	N/A	18.98	45.39
Lesser black-backed gull (75 x 250m)	Deterministic, mean, 99.5% avoidance (± 0.1%)	4.72 (1.09-10.33)	0 (0-0)	0 (0-0)	0.46 (0-1.37)	5.18 (1.09-11.7)
Herring gull (75 x 250m)	Deterministic, mean, 99.5% avoidance (± 0.1%)	0 (0-0)	N/A	0.52 (0-1.57)	N/A	0.52 (0-1.57)
Great Black-backed gull (75 x 250m)	Deterministic mean, 99.5% avoidance (± 0.1%)	3.84 (0-10.19)	N/A	3.73 (0-10.31)	N/A	7.56 (0-20.52)

12.6.2.3.1 Breeding Season Reference Populations for Collision Assessment

12.6.2.3.1.1 Gannet

269. The nearest gannet breeding colony to the proposed development is Bempton Cliffs within the Flamborough and Filey Coast SPA. The SPA is 254km from the East Anglia TWO windfarm site at the nearest point (***Table 12.12***). This is outside the mean maximum foraging range of gannets, estimated as 229km (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 590km. Tracking studies of gannets from Bempton Cliffs during 2010-2012 suggest very little if any use of the East Anglia TWO windfarm site during the breeding season (Langston et al. 2013).

270. On a precautionary basis, predicted displacement mortality of gannet during the breeding season has been compared to the SPA reference population. The SPA population at designation was 11,061 pairs, increasing to 13,392 pairs by 2017 (Aitken et al. 2017). These equate to total population sizes of approximately 40,222 and 48,698 (designated and 2017 count respectively; calculated as individuals and multiplied up to include subadult birds, based on the adult proportion of 0.55 from Furness 2015). As the Bempton Cliffs gannet colony continues to increase (Aitken et al. 2017, Langston et al. 2013) the higher estimate of total numbers of individuals (breeding and non-breeding/sub-adult birds) has been used as a reference population.

12.6.2.3.1.2 Kittiwake

271. The nearest large breeding concentration of kittiwakes to the proposed development is the Flamborough and Filey Coast SPA, 254km to the northeast of the East Anglia TWO windfarm site. The mean maximum foraging range of kittiwake from breeding colonies is estimated at 60km and the maximum 120km (Thaxter et al. 2012). Using this as a guide to the likely distance that breeding birds travel from a colony indicates that the East Anglia TWO windfarm site is beyond the range of kittiwakes breeding at colonies at Flamborough and Filey Coast. A tracking study of kittiwakes breeding at Flamborough and Filey Coast SPA in 2017 found an average foraging range of 88.65km (range 3.2-324 km), with birds travelling into the North Sea northwest and southwest of the breeding colony (Wischnewski et al. 2017), although none as far south as the East Anglia TWO windfarm site.

272. 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.

273. It is therefore very likely that all or the vast majority of birds present at the East Anglia TWO windfarm site during the breeding season are non-breeding. 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 migration BDMPS population (Furness 2015). This yields a breeding season reference population of 296,956 non-breeding individuals (Spring BDMPS for the UK North Sea and Channel, 627,816 x 47.3%).

12.6.2.3.1.3 Lesser black-backed gull

274. 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 TWO windfarm site. Thus, there is potential for connectivity with the East Anglia TWO project during the breeding season.

275. The Alde-Ore SPA lesser black-backed gull breeding population has been about 2,000 pairs between 2007 and 2014 (minimum 1,580 pairs in 2011, maximum 2,769 pairs in 2008; ***Information to Support Appropriate Assessment Report, Table 4.2*** (document reference 5.3)) which suggests that the total population (all age classes) associated with the SPA is around 6,700 individuals (assuming adults comprise 60% of the population, Furness 2015). In addition to the Alde-Ore colony, the non-SPA breeding population of adult lesser black-backed gulls with potential for connectivity to the East Anglia TWO windfarm site is estimated at about 12,300 adults and 20,500 individuals of all age classes (***Information to Support Appropriate Assessment Report, Section 4.4.1.2, Table 4.4*** (document reference 5.3)). This population includes rooftop nesting gulls in 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.

276. Thus, an estimated breeding season reference population of 27,200 individuals of all age classes has been identified for this species in relation to the proposed East Anglia TWO project. This assumes it is likely that lesser black-backed gull present on the East Anglia TWO windfarm site during the breeding season will include breeding adults from the Alde-Ore Estuary SPA and from non-SPA colonies in East Anglia, mixed with non-breeding / subadult birds from a variety of sources.

277. 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 TWO 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 Herring Gull

278. Herring gulls breed at the Alde-Ore Estuary SPA which is within the 61km mean maximum (92km maximum) foraging range (Thaxter et al. 2012) of this species from the East Anglia TWO windfarm site. Thus, there is potential for connectivity with the East Anglia TWO windfarm site during the breeding season. However, this species was recorded within the East Anglia TWO windfarm site only between the months of July to September and November (***Appendix 12.1***), coinciding mainly with the non-breeding breeding period. These data suggest that herring gulls pass through the East Anglia TWO windfarm site mainly during the non-breeding period.

12.6.2.3.1.5 Great Black-backed Gull

279. There are no breeding colonies for this species within foraging range of the East Anglia TWO 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 non-breeding BDMPS population of great black-backed gull (Furness 2015). This yields a breeding season population of non-breeding great black-backed gull of 52,829 (non-breeding BDMPS for the UK North Sea and Channel, 91,399 x 57.8%).

12.6.2.3.2 Non-breeding Season Reference Populations for Collision Assessment

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

12.6.2.3.3 Collision Impacts

281. 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.

282. 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 12.33***.

Table 12.33 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	0.798	0.834	0.834	0.834	0.834	0.92	0.172

Species	Parameter	Age class					Productivity	Average mortality
		0-1	1-2	2-3	3-4	Adult		
Herring gull	Proportion in population	0.178	0.141	0.117	0.097	0.467		
Great black-backed gull	Survival	0.815	0.815	0.815	0.815	0.815	1.139	0.185
	Proportion in population	0.194	0.156	0.126	0.102	0.422		

283. The percentage increases in background mortality rates of seasonal and annual populations due to predicted collisions with the East Anglia TWO wind turbines are shown in ***Table 12.34*** for all species using avoidance rates recommended by JNCC (2014) (as listed in ***Table 12.30***). In addition, ***Table 12.35*** presents the mortalities for gannet and kittiwake using higher avoidance rates as recommended by Bowgen and Cook (2018).

284. The mean and upper 95% confidence interval collision predictions for all species in all seasons and also summed across the year resulted in increases in background mortality of 0.32% 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, herring gull and great black-backed gull are considered to be negligible. All species are classed as low to medium (gannet), or medium (all others) sensitivity to collision with offshore windfarms (***Table 12.31*****)** resulting in impact significances of **minor adverse.**

Table 12.34 Precautionary Estimates of Percentage Increases in the Background Mortality Rate of Seasonal and Annual Populations Due to Predicted Collisions (Option 2, Avoidance Rates as per JNCC (2014) (*Table 12.30*) Calculated with Deterministic CRM 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) in Order to Indicate the Range of Likely Effects.

Species (Worst case layout, avoidance rate)		Gannet (250m; 98.9% ± 0.2%)			Kittiwake (300m; 98.9% ± 0.2%)			Lesser black-backed gull (250m; 99.5% ± 0.1%)			Herring gull (250m; 99.5% ± 0.1%)			Great black-backed gull (250m; 99.5% ± 0.1%)		
		Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.
Baseline average annual mortality				0.191			0.156			0.126						0.185
Breeding season	Reference population			48,698			296,956			27,200						52,829
	Seasonal mortality	12.66	5.01	24.17	19.77	7.8	34.08	4.72	1.09	10.33	0	0	0	3.84	0.00	10.19
	Increase in background mortality (%)	0.14	0.04	0.26	0.04	0.02	0.07	0.14	0.03	0.30	0	0	0	0.04	0	0.10
Autumn	Reference population			456,298			829,937			209,007			N/A			N/A
	Seasonal mortality	28.74	19.46	40	9.29	2.1	18.08	0	0	0						
	Increase in background	0.03	0.02	0.05	0.01	0.00	0.01	0	0	0						

Species (Worst case layout, avoidance rate)		Gannet (250m; 98.9% ± 0.2%)			Kittiwake (300m; 98.9% ± 0.2%)			Lesser black-backed gull (250m; 99.5% ± 0.1%)			Herring gull (250m; 99.5% ± 0.1%)			Great black-backed gull (250m; 99.5% ± 0.1%)		
	mortality (%)															
Winter / non-breeding	Reference population	N/A			N/A			39,316			466,511			91,399		
	Seasonal mortality							0	0	0	0.52	0	1.57	3.73	0	10.31
	Increase in background mortality (%)							0	0	0	0.00	0.00	0.01	0.02	0.00	0.06
Spring	Reference population	248,835			627,816			197,483			N/A			N/A		
	Seasonal mortality	5.6	1.6	11.13	20.88	9.43	34.5	0.46	0	1.37						
	Increase in background mortality (%)	0.01	0.00	0.02	0.02	0.01	0.04	0.00	0.00	0.01						
	Reference population	456,298			829,937			209,007			466,511			91,399		

Species (Worst case layout, avoidance rate)		Gannet (250m; 98.9% ± 0.2%)			Kittiwake (300m; 98.9% ± 0.2%)			Lesser black-backed gull (250m; 99.5% ± 0.1%)			Herring gull (250m; 99.5% ± 0.1%)			Great black-backed gull (250m; 99.5% ± 0.1%)		
Annual largest BDMPS	Seasonal mortality	47.02	26.06	75.3	49.93	19.33	86.65	5.18	1.09	11.7	0.52	0	1.57	7.56	0	20.52
	Increase in background mortality (%)	0.05	0.03	0.09	0.04	0.01	0.07	0.02	0.00	0.04	0.00	0.00	0.01	0.04	0.00	0.12
Annual biogeographic	Reference population	1,180,000			5,100,000			854,000			1,098,000			235,000		
	Seasonal mortality	47.02	26.06	75.3	49.93	19.33	86.65	5.18	1.09	11.7	0.52	0	1.57	7.56	0	20.52
	Increase in background mortality (%)	0.02	0.01	0.03	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.05

Table 12.35 Precautionary Estimates of Percentage Increases in the Background Mortality Rate of Seasonal and Annual Populations Due to Predicted Collisions (Option 2, Avoidance Rates as per Bowgen & Cook (2018) Calculated with Deterministic CRM for Species Specific Worst Case Project Assumptions. Note that the Annual Mortalities Have Been Assessed Against Both the Biogeographic Populations and the Largest BDMPS (As Advised by Natural England) in Order to Indicate the Range of Likely Effects.

Species (Worst case layout)		Gannet (250m, 99.5% avoidance)	Kittiwake (300m, 99.0% avoidance)
Baseline average annual mortality		0.191	0.156
Breeding season	Reference population	48,698	296,956
	Seasonal mortality (mean)	5.75	17.97
	Increase in background mortality (%)	0.06	0.04
Autumn	Reference population	456,298	829,937
	Seasonal mortality (mean)	13.06	8.45
	Increase in background mortality (%)	0.01	0.01
Spring	Reference population	248,835	627,816
	Seasonal mortality (mean)	2.55	18.98
	Increase in background mortality (%)	0.01	0.02
Annual largest BDMPS	Reference population	456,298	829,937
	Seasonal mortality	21.37	45.39
	Increase in background mortality (%)	0.01	0.01
Annual biogeographic	Reference population	1,180,000	5,100,000
	Seasonal mortality	21.37	45.39
	Increase in background mortality (%)	0.01	0.01

12.6.2.4 Combined Operational Collision Risk and Displacement

12.6.2.4.1 Gannet

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

286. As noted above (***section 12.6.2.3***), the estimated annual gannet collision mortality at East Anglia TWO is 47.02 at 98.9% avoidance and 21.37 at 99.5%. The estimated mortality for gannet displacement is 0-10 birds at a displacement rate of 60-80% and mortality of 0-1% (***section 12.6.2.1.2***).

287. Based on the largest Annual BDMPS for the UK North Sea and Channel, of 456,298 (Furness 2015) and baseline mortality of 0.191 (***Table 12.33***), 87,153 individual gannets would be expected to die each year; the addition of a maximum of 57 individuals would represent an 0.07% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness 2015), 225,380 individuals would be expected to die; the addition of a maximum of 57 individuals would represent an 0.03% increase in mortality. These magnitudes of increase would not materially alter the background mortality of the population and would be undetectable.

288. Thus, the combined impact of displacement and collision risk on gannet would be of negligible magnitude and the impact significance for a receptor of medium sensitivity would be **negligible**.

12.6.3 Potential Impacts During Decommissioning

289. 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.

290. Any effects generated during the decommissioning phase of the proposed East Anglia TWO 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.

291. 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.

292. 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

293. 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.

294. Any impacts generated during the decommissioning phase of the proposed East Anglia TWO 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

295. 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.

296. 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

297. The potential effects from the proposed East Anglia TWO 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).

298. Two potential effects, operational displacement and collision risk, were screened in for cumulative assessment (***Table 12.36***).

Table 12.36 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 / 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

Impact	Potential for cumulative impact	Data confidence[1]	Rationale
			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 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

299. 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.

300. 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.

301. 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 TWO project.

302. 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.

303. The windfarms listed in ***Table 12.37*** 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 12.37 Summary of Projects Considered for the CIA in Relation to Ornithology

Project	Tier	Status	Development status	Distance from East Anglia TWO 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	13	20	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	67	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	96	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

Project	Tier	Status	Development status	Distance from East Anglia TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Lincs	1	Built and operational	Fully commissioned Sep 2013	149	128	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
London Array	1	Built and operational	Fully commissioned Apr 2013	58	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	150	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	49	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

Project	Tier	Status	Development status	Distance from East Anglia TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Sheringham Shoal	1	Built and operational	Fully commissioned Sep 2012	114	98	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
Beatrice (demonstrator)	1	Built and operational	Fully commissioned July 2007	730	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	74	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	342	324	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 TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Westermost Rough	1	Built and operational	Fully commissioned May 2015	217	199	Complete for the ornithology receptors being assessed	Yes	Included as an operational project that does not yet form part of the baseline.
Humber Gateway	1	Built and operational	Fully commissioned May 2015	197	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	7	17	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	119	103	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 TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Race Bank	1	Built and operational	Fully commissioned February 2018	138	121	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
Hywind	1	Built and operational	Fully commissioned	624	608	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
EOWDC (Aberdeen OWF)	1	Built and operational	Consent August 2014, offshore construction commenced April 2018, first power July 2018.	614	598	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Beatrice	1	Built and operational	Consent Mar 2014. Construction commenced Jan 2017	736	719	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 TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Rampion	1	Built and operational	Fully commissioned November 2018	221	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)	1	Built and operational	Consent Nov 2013, fully commissioned 2017	396	379	Complete but limited quantitative species assessment	Yes	Included as a consented project that does not yet form part of the baseline.
Kincardine	2	Under construction	Consented	587	571	Complete but limited quantitative species assessment	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 commenced August 2018	10	15	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 TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Hornsea Project 1	2	Under construction	Consent Dec 2014, offshore construction commenced January 2018	175	165	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	2	Under construction	Consent Mar 2014, construction commenced winter 2018.	722	706	Complete for the ornithology receptors being assessed	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, non-material change 2019, no construction start date.	268	258	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	529	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 TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
			consented June 2019			being assessed		
Neart na Gaoithe	3	Consented	Consent Oct 2014, no construction start date, revised application consented 2018	509	492	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	533	517	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Dogger Bank Teesside A and B (now Sofia)	3	Consented	Consent Aug 2015, no construction start date	288	278	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	Pre-construction	Consent Aug 2016, no	180	168	Complete for the	Yes	Included as a consented project

Project	Tier	Status	Development status	Distance from East Anglia TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
			construction start date			ornithology receptors being assessed		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. Onshore construction commenced, offshore construction due to begin in late 2019, early 2020.	152	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	48	45	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 TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
Moray West	3	Consented	Consented in June 2019. Offshore construction planned for Q1 2023.	724	708	Complete for the ornithology receptors being assessed	Yes	Outputs from the ES have been included.
Hornsea Project 3	4	Examination completed	In-determination	165	156	Complete for the ornithology receptors being assessed	Yes	Included as a foreseeable project
Thanet Extension	4	Examination completed	In-determination	74	78	Complete for the ornithology receptors being assessed	Yes	Included as a foreseeable project
Norfolk Vanguard	4	Examination completed	In-determination	63	55	Complete for the ornithology receptors	Yes	Included as a foreseeable project

Project	Tier	Status	Development status	Distance from East Anglia TWO windfarm site (km)	Distance from offshore cable corridor (km)	Project data status	Included in CIA	Rationale
						being assessed		
East Anglia ONE North	4	Application submitted	Pre-examination	10	10	Complete for the ornithology receptors being assessed	Yes	Outputs from the ES have been included.
Norfolk Boreas	4	Application submitted	Application accepted	78	72	Complete for the ornithology receptors being assessed	Yes	Outputs from the ES have been included
Hornsea Project 4	4	PEIR submitted	PEIR submitted August 2019	184	170	ES not yet available	No	PEIR was published after cut-off for inclusion in this assessment

304. 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.

305. ***Appendix 12.3*** provides detail on the data sources used to underpin the numbers ascribed to each project for each of the species assessed as part of the CIA.

12.7.3 Cumulative Assessment of Operational Displacement

306. 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, non-breeding) and razorbill (breeding, autumn, winter, spring).

307. A review of the BDMPS regions for each species indicated that for gannet, kittiwake, lesser black-backed gull, great black-backed gull, herring gull, guillemot, and razorbill, all the windfarms identified for inclusion in the CIA in ***Table 12.37*** have the potential to contribute a cumulative effect. For red-throated diver, the winter 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

308. Cumulative red-throated diver displacement mortality has been estimated for windfarms in the south-west North Sea BDMPS (Furness 2015) which have the potential to contribute to a cumulative effect. This has been conducted using the precautionary rates of displacement and mortality recommended by the SNCBs (100% displacement and up to 10% mortality within the 4km buffer) as well as those derived from a review of evidence for this species (see ***section 12.6.2.1.1*** above and MacArthur Green 2019a) (90% displacement and up to 1% mortality).

309. A review of the impact assessments for offshore windfarms in the south-west North Sea BDMPS with a potential to contribute to cumulative operational displacement is presented in Norfolk Boreas Ltd (2019). Four categories were identified with respect to red-throated divers: windfarms with no population estimates presented (Dogger Bank sites and Blyth demonstrator), coastal windfarms with low numbers of over-wintering birds reported (Teesside, Humber Gateway and Westernmost Rough), windfarms with sightings made during

months considered to belong to the breeding season (Hornsea projects) and windfarms with quantitative information on over-wintering birds by season (Thanet Extension, Norfolk Vanguard, Norfolk Boreas). The estimated numbers of red-throated divers displaced from these projects (where quantitative information is available) is shown in ***Table 12.38***.

Table 12.38 Red-throated diver cumulative displacement mortality for the South West North Sea BDMPS. The ranges presented for each season and annually are mortality estimated for a precautionary range of 90-100% displacement within 4km of the windfarm and 1% to 10% mortality of displaced individuals.

Project	Autumn	Midwinter	Spring	Annual
Wider region (Norfolk Vanguard Ltd 2019a)	N/A	N/A	N/A	6 – 56
Thanet Extension	0	4 - 43	2 – 26	6 - 69
East Anglia ONE	0.4 - 5	1 - 10	1.4 - 15	2.8 - 30
East Anglia THREE	0.4 - 5	0.2 – 2	2 - 20	2.6 - 27
Norfolk Vanguard East	0.4 - 5	0.2 - 3	1 - 12	1.6 - 20
Norfolk Vanguard West	0 – 3	3 - 36	2 – 20	5 – 59
Norfolk Boreas	0 - 1	1 - 15	5 - 62	6 – 78
East Anglia ONE North	0 - 1	1 - 7	3 - 34	4 - 42
East Anglia TWO	0	0 - 2	2 - 25	3 - 28
Total	**1.2 – 20**	**10.4 – 118**	**18.4 - 214**	**37 – 409**

310. The assessments for a number of offshore windfarms in the south-west North Sea BDMPS did not include the necessary level of detail to permit their inclusion in a quantitative cumulative assessment. In addition, baseline surveys for different projects were carried out over different time-scales, during a period that the distribution of red-throated divers may have been changing as offshore windfarm projects were constructed and became operational. To establish a baseline to inform the cumulative assessment for this species, Natural England's advice was to estimate the abundance of red-throated diver in all windfarms in this area using the SeaMaST spatial dataset (Bradbury et al. 2014). This dataset provides estimated seabird non-breeding season densities (sitting and flying

birds summed) from a density surface model (DSM) of Wildfowl and Wetlands Trust (WWT) visual aerial survey data collected between 2001 - 2011, and JNCC European Seabirds At Sea (ESAS) boat-based survey data collected between 1979 - 2011. The non-breeding season as defined for the SeaMAST data set covers the months September until February; it is not subdivided into spring and autumn migration and winter periods, as has been done for individual species by Furness (2015). Full details of the methods are included in ***Appendix 12.3***. In summary the approach was as follows:

- The GIS data source selected for the analysis was the SeaMaST "BDMPS_Non_Breeding_Boat_Plus_Aerial_D" 3x3km grid of density estimates for the North Sea;
- Windfarm boundaries for projects in the south-west North Sea BDMPS were overlaid on the density data to obtain consistent abundance estimates for each site;
- The number of red-throated divers estimated to be present within the boundary of each OWF and 4km buffer, and thus potentially displaced, was calculated as well as the percentage of the total reference population.

311. Based on the SeaMAST data, the estimated number of red-throated divers within areas occupied by offshore wind farms (Tier 1 to 4) in the South West North Sea, and within wind farms and 4km buffers, is respectively 3.2% and 16.2% of the total reference population of red-throated divers in this area in the non-breeding season (***Appendix 12.3***). For East Anglia TWO alone, the total estimated numbers within the windfarm site and windfarm plus 4km buffer from SeaMAST data are respectively 0.095% and 0.45% of the total reference population. Thus based on the SeaMAST data, under the worst case scenario of 100% displacement from a windfarm and a 4km buffer, 16.2% of the population of the South West North Sea population would be displaced. The relative contribution of East Anglia TWO to the total number of birds predicted to be displaced would be 2.8%, compared to 83.7% for all Tier I wind farms, 0.7% for Tier 2, 0.6% for Tier 3 and 12.9% for Tier 4 (minus East Anglia TWO) (***Appendix 12.3***).

312. The predicted cumulative displacement mortality for red-throated divers from offshore windfarms in the southern North Sea, assuming a range of 90-100% displacement from the windfarms and a 4km buffer, and 1-10% mortality of displaced birds, is between 37 and 409 birds per year (***Table 12.38***.

313. 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 37-409 to this would increase the mortality rate by 1.2-13.5%. 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 37-409 to this would increase the mortality rate by 0.6-6.6%.

314. Looking at the winter period alone, the BDMPS is 10,177 (Furness 2015). At the average baseline mortality rate for red-throated diver of 0.228 the number of individuals expected to die is 2,320 (10,177 x 0.228). The addition of a maximum of 10.4-118 birds to this (***Table 12.38***) would increase the mortality rate by 0.4-5.1%.

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

- An evidence review of effects of displacement on red-throated divers (Norfolk Vanguard Ltd 2019a; see also ***section 12.6.2.1.1*** above) found that 90% displacement and 1% mortality are more appropriate (and still precautionary) than the 100% and 10% recommended by the SNCBs. Displacement mortality may be less than 1% and could be as low as zero;
- Each windfarm assessment has assumed that all birds within 4km of the windfarm lease boundary are potentially affected to the same extent, whereas there is evidence that displacement declines with distance from windfarm boundaries and in some cases has been reported as zero by 2km;
- It includes an unknown degree of double counting across seasons since some individuals will be present within more than one season and could also potentially move between sites;
- The Norfolk Boreas, Norfolk Vanguard East and East Anglia THREE 4km buffers overlap with each other therefore including the buffer for all three sites leads to double counting birds in the overlapping areas (by approximately 15%);
- The inclusion of total displacement within the 4km buffers from both Norfolk Vanguard East and Norfolk Vanguard West is highly precautionary since no allowance is made for the division of turbines across the two windfarm sites and the consequent reduction in developed area or increase in wind turbine spacing;
- About fifty percent of the total annual mortality is predicted to occur during the autumn and spring migration periods when the potential consequences of displacement are expected to be much lower due to the brief duration that birds spend in the area at this time; and
- It is probable that the South West North Sea BDMPS for spring and autumn migration (13,277) is an underestimate. Aerial surveys of the Outer Thames Estuary SPA in 2013 and 2018 produced respective peak population estimates of 14,161 and 22,280 birds (Irwin et al. 2019). Based on these

surveys, the SPA population estimate has recently been revised upwards to 18,079 individuals (Natural England 2019) compared with 6,446 when the site was first designated in 2010. Natural England (2019) commented that this change in the estimated SPA population – nearly a three-fold increase – is thought to reflect the use of digital aerial surveys which have provided more accurate counts and that previous counts (based on visual aerial and boat-based surveys) may have been significant underestimates. The SPA lies within the wider BDMPS region, and is recognised as an important area for red-throated divers (hence the designation), but its extent is small compared with the wider BDMPS region (which also includes the Greater Wash SPA with a cited population of 1,407 red-throated divers overwinter during the period 2002-2006, Natural England 2018). If the revised population estimate for the Outer Thames Estuary SPA was taken as a minimum estimate of the BDMPS population during the spring migration period, 4,122 individuals would be expected to die each year (0.228 x 18,079). The predicted annual cumulative mortality from displacement (37-409), would represent 0.9% - 10%.

316. A further potential 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 may be much lower than the worst case designs on which the projects were consented. For example, East Anglia ONE was originally assessed on the basis of 333 wind turbines, reduced to 240 for consent and currently being constructed with 102. Thus, the final windfarm will have less than one third the original number of proposed (and assessed) wind turbines. Similar reductions are likely for other consented windfarms which have not yet been built. This is likely to further reduce the magnitude of displacement.

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

318. On the basis of the worst case approach recommended by Natural England (100% displacement from the site and a 4km buffer and 10% mortality of displaced birds, see ***section 12.6.1.1.1.1*** for discussion), the cumulative red-throated diver operational displacement impact magnitude is assessed as medium.

319. However, on the basis of the evidence review (see ***section 12.6.1.1.1*** above and Norfolk Vanguard Ltd 2019a) it is considered that the most realistic (and still precautionary) combination of displacement and consequent mortality rates is 90% and 1%. This, combined with the various additive sources of precaution in this assessment suggests there is a very high likelihood that cumulative displacement would be lower than the worst case totals presented here, resulting in increases in background mortality below 1%, and thus the magnitude of cumulative displacement is assessed as negligible. Therefore, as the species is of high sensitivity to disturbance, the cumulative impact significance would be **minor adverse**.

12.7.3.2 Gannet

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

321. The East Anglia TWO 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. During autumn migration, very large numbers of gannets are migrating from breeding colonies in Northern Europe to wintering areas farther south, predominantly off the coast of West Africa (Kubetzki et al. 2009; Furness et al. 2018a). Spring migration routes differ from those in autumn as very few birds migrate through the southern North Sea in spring (Furness 2015). Thus, displacement due to windfarms in the North Sea is trivial when compared with the range over which individuals of this species travel (Garthe et al. 2012, see also Masden et al. 2010, 2012).

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

323. Natural England has nevertheless requested that quantitative cumulative estimates of gannet displacement are presented. A table showing the number of birds at risk of displacement from offshore wind farms in the UK North Sea and Channel BDMPS (Furness 2015) is included in ***Appendix 12.3***. The cumulative annual total is 47,589 of which East Anglia TWO contributes 1,275 birds.

324. At displacement rates of 60-80%, and 0-1% mortality of displaced birds (see ***Section 12.6.2.1.2*** above) between 0 and 381 gannets would be predicted to die from cumulative displacement. Based on the largest Annual BDMPS of 456,298

(Furness 2015) and baseline mortality of 0.191 (***Table 12.33***), 87,153 individual gannets would be expected to die each year; the addition of a maximum of 381 individuals would represent an 0.44% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness 2015), 225,380 individuals would be expected to die; the addition of a maximum of 380 individuals would represent an 0.17% increase in mortality.

325. Thus, precautionary estimates of the number of gannets which might die as a result of cumulative displacement from offshore wind farms UK North Sea and Channel BDMPS represent a change in mortality rate of 0.44% or less, which would not be detectable at the population level. In reality, given the wide-ranging behaviour of gannets and their flexibility in foraging behaviour, displacement from offshore wind farms is considered unlikely to cause any increase in the population mortality rate.

326. The magnitude of cumulative displacement for gannet is considered to be negligible and the impact significance of cumulative displacement on a receptor of low to medium sensitivity is **negligible**.

12.7.3.3 Razorbill

327. The East Anglia TWO 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).

328. The annual total of razorbills at risk of displacement from the East Anglia TWO windfarm site is estimated as 691 individuals (summing the seasonal peak means on the East Anglia TWO windfarm site (and 2km buffer) for the migration-free breeding, autumn migration, winter, and spring migration periods; ***Table 12.15***).

329. Estimates of the number of razorbills at risk of displacement from other offshore windfarms included in the cumulative assessment are given in ***Table 12.39***. The source of these estimates is given in ***Appendix 12.3***. The cumulative totals omit windfarms for which no data are available (as indicated in ***Table 12.39***), 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.

330. The estimated annual cumulative total of razorbills at risk of displacement from windfarms in the North Sea is 120,175 individuals (***Table 12.39***). 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 361 and 8,412 (***Table 12.40***).

331. 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 361 and 8412 individuals to this increases the background mortality rate by respectively 0.35% and 8.2%.

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

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

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

335. A detailed review of the potential effects of displacement from offshore windfarms on auks (Norfolk Vanguard Ltd 2019b) acknowledged that that the impact of displacement of razorbills and guillemots by offshore windfarms is uncertain. The existing information indicates that annual mortality of adults (including impacts of existing human activities) is very low (10% and 6% per annum respectively), and that displacement of razorbills and guillemots by offshore windfarms is likely to be incomplete, may reduce with habituation, and offshore windfarms may in the long-term increase food availability to guillemots and razorbills through providing enhanced habitat for fish populations. This suggests that impacts of displacement from offshore windfarms are unlikely to represent levels of mortality anywhere near to the 6% or 10% total annual mortality that occurs due to the combination of many natural factors plus existing human activities. This evidence-based review recommended a displacement rate of 50% for auks within an offshore windfarm and 30% within a 1km buffer, both combined with a highly precautionary maximum mortality of 1%.

336. On the basis of the worst case approach recommended by Natural England (70% displacement and a maximum 10% mortality), the cumulative operational displacement impact on razorbill is assessed as of medium magnitude.

337. However, on the basis of the evidence review (Norfolk Vanguard Ltd 2019b) it is considered that a more realistic (and still precautionary) combination of displacement and consequent mortality rates is 50% and 1%. This would result in a predicted total of 601 deaths annually from displacement (***Table 12.40***) and an 0.6% increase in mortality. This, combined with the various additive sources of precaution in this assessment, indicates there is a very high likelihood that cumulative displacement would be lower than the worst case totals presented here, resulting in increases in background mortality below 1%. The magnitude of cumulative displacement is assessed as negligible. Therefore, as the species is of medium sensitivity to disturbance, the cumulative impact significance would be **negligible**.

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

Offshore Windfarm(s)	No. razorbills at risk of displacement*			
	Breeding	Autumn migration	Winter	Spring migration
Aberdeen (EOWDC)	161	64.4	7.3	25.7
Beatrice Demonstrator	No data	No data	No data	No data
Blyth Demonstration	121	90.9	60.6	90.9
Dudgeon	256	346.1	745.4	346.1
Galloper	44	43	105.5	394
Greater Gabbard	0	0	387.3	83.8
Gunfleet Sands	No data	No data	No data	No data
Humber Gateway	27	20	13.4	20
Hywind	30	719	10	0
Kentish Flats	No data	No data	No data	No data
Lynn and Inner Dowsing & Lincs	45	33.5	22.3	33.5
London Array	14	20.4	13.6	20.4
Race Bank	28	42	28	42
Scroby Sands	No data	No data	No data	No data
Sheringham Shoal	106	1343	211.3	30.2
Teeside	16	61.5	1.9	20
Thanet	3	0	13.6	20.9

Offshore Windfarm(s)	No. razorbills at risk of displacement*			
	Breeding	Autumn migration	Winter	Spring migration
Westermost Rough	91	121.3	151.6	90.9
Beatrice	873	833	555.3	833
East Anglia ONE	16	26	154.5	336
Hornsea Project One	1109	4812.3	1517.5	1802.8
Kincardine	22	0	0	0
Dogger Bank Creyke Beck Projects A and B	2788	3673	3871	9267.7
Dogger Bank Teeside A and B (now Sofia)	1987	902.6	2384.5	4872.3
East Anglia THREE	1807	1122	1499	1524
Forth (Seagreen) Alpha and Bravo	9574	853.1	568.8	853.1
Hornsea Project Two	2511	4220.5	719.5	1668
Inch Cape	4671	1839.4	1226.3	1839.4
Moray Firth East	2423	1102.6	30.2	168.3
Neart na Gaoithe	1248	1162.9	775.3	1162.9
Triton Knoll	40	253.7	854.5	116.7
East Anglia ONE North	403	85	54	207
East Anglia TWO	280.9	44.1	136.4	229.9
Hornsea Project Three	630	2020	3649	1236
Moray Firth West	2808	3544	184	3585
Norfolk Boreas	345	630	263	1065
Norfolk Vanguard	879	866	839	769
Thanet Extension	0	6	56	124
Cumulative total	35,285	30,901	21,110	32,879
Cumulative Annual total	120,175			
*Sources of information in ***Appendix 12.3***				

Table 12.40 Cumulative Annual Displacement Matrix for Razorbill

Annual		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	120	240	361	481	601	1202	2404	3605	6009	9614	12018
	20%	240	481	721	961	1202	2404	4807	7211	12018	19228	24035
	30%	361	721	1082	1442	1803	3605	7211	10816	18026	28842	36053
	40%	481	961	1442	1923	2404	4807	9614	14421	24035	38456	48070
	50%	601	1202	1803	2404	3004	6009	12018	18026	30044	48070	60088
	60%	721	1442	2163	2884	3605	7211	14421	21632	36053	57684	72105
	70%	841	1682	2524	3365	4206	8412	16825	25237	42061	67298	84123
	80%	961	1923	2884	3846	4807	9614	19228	28842	48070	76912	96140
	90%	1082	2163	3245	4326	5408	10816	21632	32447	54079	86526	108158
	100%	1202	2404	3605	4807	6009	12018	24035	36053	60088	96140	120175

12.7.3.4 Guillemot

338. The East Anglia TWO 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 non-breeding season (defined as August to February, Furness 2015).

339. The annual total of guillemots at risk of displacement from the proposed East Anglia TWO project is estimated as 3,752 individuals (summing the seasonal peak means on the East Anglia TWO windfarm site (and 2km buffer) for the breeding and non-breeding periods (***Table 12.15)***.

340. The latest available estimates of the total numbers of guillemots at risk of displacement from other offshore windfarms in the North Sea are included in ***Table 12.41***. These totals omit windfarms for which no data are available (as indicated in the table), but they are also likely to over-estimate the numbers present due to the precautionary use of seasonal peak numbers at each site rather than average numbers, which is likely to lead to double counting as birds move through the North Sea.

341. The estimated annual cumulative total of guillemots at risk of displacement from windfarms in the North Sea is 327,338 individuals (***Table 12.41***). 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 982 and 22,914 (***Table 12.42***).

342. 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 between 982 and 22,914 individuals to this increases the background mortality rate by between 0.4 and 10.1%.

343. This is a large range, so the assessment considers the most realistic value within this range. Recommendations of an evidence-based review (Vattenfall 2019b), described above for razorbill (***paragraphs 335*** and ***336***), are for a displacement rate of 50% for auks within an offshore windfarm and 30% within a 1km buffer, both combined with a highly precautionary maximum mortality of 1%.

344. On the basis of the worst case approach recommended by Natural England (70% displacement and a maximum 10% mortality), the cumulative operational displacement impact on guillemot is assessed as of medium magnitude.

345. However, on the basis of the evidence review (Vattenfall 2019b) it is considered that a more realistic (and still precautionary) combination of displacement and

consequent mortality rates is 50% and 1%. This would result in a predicted total of 1,637 deaths annually from displacement (***Table 12.42***) and a 0.7% increase in mortality. This, combined with the various additive sources of precaution in this assessment, indicates there is a very high likelihood that cumulative displacement would be lower than the worst case totals presented here, resulting in increases in background mortality below 1%. The magnitude of cumulative displacement is assessed as negligible. Therefore, as the species is of medium sensitivity to disturbance, the cumulative impact significance would be **negligible**.

Table 12.41 Cumulative Numbers of Guillemots at Risk of Displacement from Offshore Windfarms in the North Sea

Offshore Windfarm(s)	No. guillemots at risk of displacement*	
	Breeding	Non-breeding
Aberdeen (EOWDC)	547	225
Beatrice Demonstrator	No data	No data
Blyth Demonstration	1220	1321
Dudgeon	334	542
Galloper	305	593
Greater Gabbard	345	548
Gunfleet Sands	No data	No data
Humber Gateway	99	138
Hywind	249	2136
Kentish Flats	No data	No data
Lynn and Inner Dowsing & Lincs	582	814
London Array	192	377
Race Bank	361	708
Scroby Sands	No data	No data
Sheringham Shoal	390	715
Teeside	267	901
Thanet	18	124
Westermost Rough	347	486
Beatrice	13610	2755

Offshore Windfarm(s)	No. guillemots at risk of displacement*	
	Breeding	Non-breeding
East Anglia ONE	274	640
Hornsea Project One	9836	8097
Kincardine	632	0
Dogger Bank Creyke Beck Projects A and B	14886	16763
Dogger Bank Teeside A and B (now Sofia)	8494	5969
East Anglia THREE	1744	2859
Forth (Seagreen) Alpha and Bravo	24724	8800
Hornsea Project Two	7735	13164
Inch Cape	8184	3912
Moray Firth East	9820	547
Neart na Gaoithe	4894	7618
Triton Knoll	425	746
East Anglia ONE North	4183	1888
East Anglia TWO	2077	1675
Hornsea Project Three	13374	17772
Moray Firth West	24426	38174
Norfolk Boreas	7767	13777
Norfolk Vanguard	4320	4776
Thanet Extension	12	1105
Cumulative total	166,673	160,665
Cumulative Annual total	327,338	

Table 12.42 Cumulative Annual Displacement Matrix for Guillemot

Annual		Mortality rate										
		1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
Displacement	10%	327	655	982	1309	1637	3273	6547	9820	16367	26187	32734
	20%	655	1309	1964	2619	3273	6547	13094	19640	32734	52374	65468
	30%	982	1964	2946	3928	4910	9820	19640	29460	49101	78561	98201
	40%	1309	2619	3928	5237	6547	13094	26187	39281	65468	104748	130935
	50%	1637	3273	4910	6547	8183	16367	32734	49101	81835	130935	163669
	60%	1964	3928	5892	7856	9820	19640	39281	58921	98201	157122	196403
	70%	2291	4583	6874	9165	11457	22914	45827	68741	114568	183309	229137
	80%	2619	5237	7856	10475	13094	26187	52374	78561	130935	209496	261870
	90%	2946	5892	8838	11784	14730	29460	58921	88381	147302	235683	294604
	100%	3273	6547	9820	13094	16367	32734	65468	98201	163669	261870	327338

12.7.4 Cumulative Assessment of Operational Collision Risk

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

347. It is considered that all of the windfarms identified for inclusion in the CIA in ***Table 12.37*** have the potential to contribute to a cumulative effect.

348. ***Appendix 12.3*** provides detail of the projects that have been included in the CIA and which of the design options (e.g. non-material change or consented) were used in the assessment.

12.7.4.1 Gannet

349. The cumulative gannet collision risk prediction is set out in ***Table 12.43***. This collates collision predictions from other windfarms which may contribute to the cumulative total. Sources of information for each site (including Band model option and avoidance rate) are included in ***Appendix 12.3***.

Table 12.43 Cumulative Collision Risk Assessment for Gannet

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
1	Aberdeen (EOWDC)	4.2	5.1	0.1	9.3
1	Beatrice Demonstrator	0.6	0.9	0.7	2.2
1	Beatrice	37.4	48.8	9.5	95.7
1	Blyth Demonstration	3.5	2.1	2.8	8.4
1	Dudgeon	22.3	38.9	19.1	80.3
1	Galloper	18.1	30.9	12.6	61.6
1	Greater Gabbard	14	8.8	4.8	27.5
1	Gunfleet Sands	0	0	0	0
1	Humber Gateway	1.9	1.1	1.5	4.5
1	Hywind	5.6	0.8	0.8	7.2
1	Kentish Flats	1.4	0.8	1.1	3.3
1	Lincs	2.1	1.3	1.7	5.1
1	London Array	2.3	1.4	1.8	5.5
1	Lynn and Inner Dowsing	0.2	0.1	0.2	0.5
1	Race Bank	33.7	11.7	4.1	49.5
1	Rampion	36.2	63.5	2.1	101.8

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
1	Scroby Sands	0	0	0	0
1	Sheringham Shoal	14.1	3.5	0	17.6
1	Teeside	4.9	1.7	0	6.6
1	Thanet	1.1	0	0	1.1
1	Westermost Rough	0.2	0.1	0.2	0.5
2	East Anglia ONE	3.4	131	6.3	140.7
2	Hornsea Project One	5.0	14.1	9.9	29
2	Kincardine	3	0	0	3
2	Moray Firth East	80.6	35.4	8.9	124.9
3	Dogger Bank Creyke Beck Projects A and B	66.7	68.7	44.7	180
3	Dogger Bank Teeside A and B (now Sofia)	14.8	8.8	9.4	33
3	East Anglia THREE	5.7	31.1	9.0	45.8
3	Forth (Seagreen) Alpha and Bravo	800.8	49.3	65.8	915.9
3	Hornsea Project Two	7	14	6	27
3	Inch Cape	46	1	1	48
3	Moray Firth West	10	2	1	13
3	Neart na Gaoithe	93	7	7	107
3	Triton Knoll	26.8	64.1	30.1	121
4	Hornsea Project Three	18	12	8	38
4	Norfolk Boreas	54.13	48.5	14.99	117.62
4	Norfolk Vanguard	16.97	38.44	10.89	66.31
4	Thanet Extension	0	11.1	22.9	34
4	East Anglia TWO	12.66	28.74	5.6	47.02
4	East Anglia ONE North	11.02	12.85	3.4	27.27
	TOTALS	**1479.4**	**799.6**	**328.0**	**2607.0**

350. The annual cumulative total for estimated collision mortality is 2,607 of which East Anglia TWO contributes 47 birds. Based on the largest Annual BDMPS of 456,298 (Furness 2015) and baseline mortality of 0.191 (***Table 12.33***), 87,153 individual gannets would be expected to die each year; the addition of 2,607 individuals would represent a 3% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness 2015), 225,380 individuals would be expected to die; the addition of 2,607 individuals would represent 1.2% increase in mortality.

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

352. Note, however that many of the collision estimates for other windfarms were calculated for designs with higher numbers of wind turbines (and total rotor swept areas) than have been installed (or are planned), which is a key factor in collision risk. A method for updating collision estimates for changes in windfarm design such as this was presented in MacArthur Green (2017). This uses ratios of consented and as-built turbine parameters to adjust the collision risk mortality estimates for a consented windfarm. Updating the collision estimates for windfarms in the North Sea which have been or will be built out with a smaller rotor swept area than the consented worst-case reduces the cumulative annual mortality to 1896 (***Appendix 12.3***). 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 27% due to the reduced collision risks for projects which undergo design revisions post-consent.

353. Recent studies have found that gannet avoidance of windfarms may be higher than the currently recommended rate of 98.9%. At the Greater Gabbard windfarm during the autumn migration period 336 gannets were observed of which only 8 were recorded within the windfarm (APEM, 2014), 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 197*** 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. 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%. A review of this study by Bowgen and Cook

(2018) recommended a higher avoidance rate for gannet of 99.5%. While the difference seems small, this change in avoidance rate would reduce predicted collisions by more than half: at 98.9% avoidance 11 birds in 1,000 would be predicted to collide with a windfarm, whereas at 99.5% avoidance this would reduce to 5. Applying this change pro-rata would reduce the annual cumulative total from ***Table 12.43*** to 1,185 at 99.5% avoidance.

354. A review of nocturnal activity in gannets (Furness et al., 2018) has found that the value previously used for this parameter (25%) to estimate flight activity at night is a considerable overestimate and has identified evidence based rates of 8% during the breeding season and 4% during the non-breeding season. Application of the lower evidence based rate would reduce estimates of collision mortality (e.g. compare the mean and reduced nocturnal activity collision risk estimates for gannet at East Anglia TWO in ***Table 12.31***). It is straightforward to adjust existing mortality estimates using the new and old nocturnal activity rates and the monthly number of daytime and night-time hours (i.e. it is not necessary to rerun the collision model for this update). However, it is necessary to calculate a mortality adjustment rate for each month at each windfarm because the duration of night varies with month and latitude (both of which are inputs to the collision model). This has not been undertaken for the current assessment but would be expected to reduce the cumulative total by at least 10%. This further emphasises the precautionary nature of the current assessment.

355. 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.

356. 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 12.43***. 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).

357. 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 32.4 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.

358. 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.

359. 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 TWO 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**.

12.7.4.2 Kittiwake

360. The cumulative collision risk predictions for kittiwake are set out in ***Table 12.44***. This collates collision predictions from other windfarms which may contribute to the cumulative total. Sources of information for each site (including Band model option and avoidance rate) are included in ***Appendix 12.3***.

Table 12.44 Cumulative Collision Risk Assessment for Kittiwake

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
1	Beatrice	37.66	4.3	15.9	57.86
1	Beatrice Demonstrator	1.15	2.1	1.7	4.95
1	Blyth (NaREC Demonstration)	1.69	2.3	1.4	5.39
1	Dudgeon	0	0	0	0

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
1	EOWDC (Aberdeen OWF)	11.8	5.8	1.1	18.7
1	Galloper	6.29	27.8	31.8	65.89
1	Greater Gabbard	1.1	15	11.4	27.5
1	Gunfleet Sands	0	0	0	0
1	Humber Gateway	2.55	3.19	1.9	7.64
1	Hywind	16.6	0.85	0.85	18.3
1	Kentish Flats	0.6	0.9	0.7	2.2
1	Lincs	0.92	1.16	0.69	2.77
1	London Array (Phase 1)	1.4	2.3	1.8	5.5
1	Lynn and Inner Dowsing	0	0	0	0
1	Race Bank	1.86	23.9	5.59	31.35
1	Rampion	54.4	37.4	29.7	121.5
1	Scroby Sands	0	0	0	0
1	Sheringham Shoal	0	0	0	0
1	Teesside	50.58	24	2.5	77.08
1	Thanet	0.2	0.5	0.4	1.1
1	Westermost Rough	0.176	0.22	0.132	0.528
2	East Anglia ONE	46.7	1.5	161	209.2
2	Hornsea Project 1	6.9	8.1	3	18
2	Kincardine	22	9	3	34
2	Moray Firth (EDA)	24.1	2	19.3	45.4
3	Dogger Bank Creyke Beck A & B	55.4	25.9	56.7	138
3	Dogger Bank Teesside A & B	88.7	67.1	202.2	358
3	East Anglia THREE	6.1	68.4	37.2	111.7

Tier	Windfarm	Breeding	Autumn	Spring	Annual
		CRM	CRM	CRM	CRM
3	Firth of Forth Alpha and Bravo	153.2	313.5	247.8	714.5
3	Hornsea Project 2	16	9	3	28
3	Inch Cape	40	26	6	72
3	Moray Firth West	79	24	7	110
3	Neart na Goithe	9	17	2	28
3	Triton Knoll	24.6	139	45.4	209
4	Hornsea Project 3	165.3	61.3	11.4	238
4	Norfolk Boreas	29.9	116.6	56.3	202.8
4	Norfolk Vanguard	43.81	32.93	38.66	115.4
4	Thanet Extension	2.3	5.3	15.3	22.9
4	East Anglia ONE North	18.65	12.05	27.31	58.01
4	East Anglia TWO	19.77	9.29	20.88	49.94
	TOTALS	**1040.4**	**1099.7**	**1070.1**	**3210.6**

361. The estimated annual cumulative total is 3,211 of which East Anglia TWO contributes 50 birds. Based on the largest Annual BDMPS of 829,937 (Furness 2015) and baseline mortality of 0.156 (***Table 12.34***), 129,470 individual kittiwakes would be expected to die each year; the addition of 3,211 individuals would represent a 2.5% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 5,100,000 (Furness 2015), 795,600 individuals would be expected to die; the addition of 3,211 individuals would represent an 0.4% increase in mortality.

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

363. Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher numbers of wind turbines (and total

rotor swept areas) than have been installed (or are planned), which is a key factor in collision risk. Updating the collision estimates for windfarms which have been built out or are due to be built out with a smaller rotor swept area than the consented worst-case design (as per MacArthur Green 2017) achieves a reduction in the cumulative annual mortality to 2,535 (***Appendix 12.3***). Therefore, the values presented in ***Table 12.44***, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 21% due to the reduced collision risks for projects which undergo design revisions post consent.

364. Recent studies have found that kittiwake avoidance of windfarms may be higher than the currently recommended rate of 98.9% (see previous discussion in ***section 12.6.2.3***). A review of avoidance behaviour at an operational windfarm (Bowgen and Cook 2018) has also recommended a higher avoidance rate for kittiwake of 99%. Use of this higher rate would reduce the cumulative total by 10% (i.e. the cumulative total at this rate would be 2,890 or 2,282 taking into account as built reductions in rotor swept area).

365. A review of nocturnal activity in kittiwakes (Furness et al., in prep.) has found that the value previously used for this parameter (50%) to estimate flight activity at night is a considerable overestimate and has identified evidence-based rates of 20% during the breeding season and 17% during the non-breeding season. Natural England have recognised this aspect of precaution and advised recent projects to undertake collision modelling with nocturnal activity set to both 25% and 50%. Reducing the nocturnal activity factor to 25% reduced collision estimates for kittiwake at East Anglia TWO by around 15% (***Table 12.31***). Applying the same approach to other windfarms in ***Table 12.44*** would reduce the cumulative collision estimate by a significant amount (e.g. between 7% and 25%; note the magnitude of reduction varies depending on the time of year and windfarm latitude due to the variation in day and night length). This further emphasises the precautionary nature of the current assessment.

366. 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 windfarms, 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; Trinder 2014, Carroll et al. 2017), and therefore the density-dependent model is more appropriate for this species. To place these predicted magnitudes of change in context, over three approximately 15 year periods (between censuses) the British kittiwake population changed by +24% (1969 to 1985), -25% (1985 to 1998) and -44% (2000 to 2015) (http://jncc.defra.gov.uk/page-3201 accessed 15th October 2018). Declines of between 3-4% (using the density dependent model) 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.

367. 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. In relation to this modelling therefore, the precautionary annual mortality predicted in this cumulative assessment (3,211) falls within the level of change likely to be undetectable given the historic fluctuations in the kittiwake population described above.

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

12.7.4.3 Lesser Black-backed Gull

369. The cumulative collision risk prediction for lesser black-backed gull is set out in ***Table 12.45***. This collates collision predictions from other windfarms which may contribute to the cumulative total. Sources of information for each site (including Band model option and avoidance rate) are included in ***Appendix 12.3***.

370. The collision values presented in ***Table 12.45*** include totals for breeding, non-breeding 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 non-breeding 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 12.45*** have been multiplied by 0.8 to estimate the non-breeding component and 0.2 to estimate the breeding component.

Table 12.45 Cumulative Collision Risk Assessment for Lesser Black-backed Gull

Tier	Windfarm	Number of collisions		
		Breeding	Non-breeding	Annual
1	Beatrice	0	0.0	0.0
1	Beatrice Demonstrator	0	0.0	0.0
1	Blyth (NaREC Demonstration)	0	0.0	0.0
1	Dudgeon	7.7	30.6	38.3
1	EOWDC (Aberdeen OWF)	0	0.0	0.0
1	Galloper	27.8	111.0	138.8
1	Greater Gabbard	12.4	49.6	62.0
1	Gunfleet Sands	1	1	2
1	Humber Gateway	0.2	1.1	1.3
1	HyWind	0	0	0
1	Kentish Flats	0.3	1.3	1.6
1	Lincs	1.7	6.8	8.5
1	London Array (Phase 1)	0	0.0	0.0
1	Lynn and Inner Dowsing	0	0.0	0.0
1	Race Bank	43.2	10.8	54.0
1	Rampion	1.6	6.3	7.9
1	Scroby Sands	0	0.0	0.0
1	Sheringham Shoal	2	6	8
1	Teesside	0	0.0	0.0

Tier	Windfarm	Number of collisions		
		Breeding	Non-breeding	Annual
1	Thanet	3.2	12.8	16.0
1	Westermost Rough	0	0.3	0.3
2	East Anglia ONE	5.9	33.8	39.7
2	Hornsea Project 1	4.4	17.4	21.8
2	Kincardine	0	0	0
2	Moray Firth (EDA)	0	0.0	0.0
3	Dogger Bank Creyke Beck A & B	2.6	10.4	13.0
3	Dogger Bank Teesside A & B	2.4	9.6	12.0
3	East Anglia THREE	1.6	7.4	9
3	Firth of Forth Alpha and Bravo	2.1	8.4	10.5
3	Hornsea Project 2	2.0	2.0	4.0
3	Inch Cape	0	0.0	0.0
3	Moray Firth (WDA)	0	0	0
3	Neart na Goithe	0	0	0
3	Triton Knoll	7.4	29.6	37
4	Hornsea Project 3	17.3	0	17.3
4	Thanet Extension	1.5	0.8	2.3
4	Norfolk Boreas	8.0	31.8	39.8
4	Norfolk Vanguard	15.6	7.5	23
4	East Anglia ONE North	1.0	0.6	1.6
4	East Anglia TWO	4.7	0.5	5.2
	TOTALS	**177.8**	**397.3**	**574.9**

371. The cumulative predicted annual total is 575 of which East Anglia TWO contributes 5 birds. Based on the largest Annual BDMPS of 209,007 (Furness 2015) and baseline mortality of 0.126 (***Table 12.34***), 26,335 individual lesser black-backed gulls would be expected to die each year; the addition of 575 individuals would represent a 2% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 854,000

(Furness 2015), 107,604 individuals would be expected to die; the addition of 575 individuals would represent an 0.5% increase in mortality.

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

373. Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher numbers of wind turbines (and total rotor swept areas) than have been installed (or are planned), which is a key factor in collision risk. Updating the collision estimates for windfarms which have been built out or are due to be built out with a smaller rotor swept area that the consented worst-case design (as per MacArthur Green 2017) achieves a reduction in the cumulative annual mortality to 410 (***Appendix 12.3***). Therefore, the values presented in ***Table 12.45***, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 29% due to the reduced collision risks for projects which undergo design revisions post consent.

374. 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). Natural England have recognised this aspect of precaution and advised recent projects to undertake collision modelling with nocturnal activity set to both 25% and 50%. Reducing the nocturnal activity factor to 25% reduced the collision estimate for East Anglia TWO by around 12% (***Table 12.31***). 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.

375. 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. Lesser black-backed

gull is considered to be of medium sensitivity, therefore the impact significance is **minor adverse**.

12.7.4.4 Herring Gull

376. The cumulative herring gull collision risk prediction is set out in ***Table 12.46***.

377. Assessments at other windfarms have been conducted using a range of avoidance rates and alternative collision model Options. Sources of information for each site are included in ***Appendix 12.3***.

Table 12.46 Cumulative Collision Risk Assessment for Herring Gull

Tier	Windfarm	Number of collisions		
		Breeding	Non-breeding	Annual
1	Aberdeen (EOWDC)	4.8	0	4.8
1	Beatrice Demonstrator	0	0	0
1	Blyth Demonstration	7.9	34.5	42.4
1	Dudgeon	0	0	0
1	Galloper	10.4	0	10.4
1	Greater Gabbard	0	0	0
1	Gunfleet Sands	0	0	0
1	Humber Gateway	0.2	0.5	0.7
1	Hywind	0.6	7.8	8.4
1	Kentish Flats	0.5	1.7	2.2
1	Lincs	0	0	0
1	London Array	0	0	0
1	Lynn and Inner Dowsing	0	0	0
1	Race Bank	0	0	0
1	Rampion	48	48	96
1	Scroby Sands	0	0	0
1	Sheringham Shoal	0	0	0
1	Teeside	5.2	20.7	26.0
1	Thanet	2.5	9.9	12.3
1	Westermost Rough	0.1	0	0.1

Tier	Windfarm	Number of collisions		
		Breeding	Non-breeding	Annual
2	Beatrice	26.1	104.4	130.6
2	East Anglia ONE	0	28	28
2	Hornsea Project One	2.9	11.6	14.5
2	Kincardine	1	0	1
3	Dogger Bank Creyke Beck Projects A and B	0	0	0
3	Forth (Seagreen) Alpha and Bravo	10	21	31
3	Inch Cape	1	1	2
3	Moray Firth East	52	0	52
3	Neart na Gaoithe	2	4	6
3	Dogger Bank Teeside A and B (now Sofia)	0	0	0
3	East Anglia THREE	0	0	24
3	Hornsea Project Two	23.8	0	23.8
3	Triton Knoll	0	0	0
4	Hornsea Project Three	0	22.7	22.7
4	Moray Firth West	12	1	13
4	Norfolk Boreas	1.18	17.26	18.44
4	Norfolk Vanguard	0.76	12.69	13.45
4	Thanet Extension	5	9	14
4	East Anglia TWO	0	0.52	0.52
4	East Anglia ONE North	0	0	0
	TOTALS	**217.9**	**356.3**	**598.3**

378. The annual cumulative total for estimated collision mortality is 598 of which East Anglia TWO contributes less than one bird. Based on the largest Annual BDMPS of 466,511 (Furness 2015) and baseline mortality of 0.172 (***Table 12.33***), 80,240 individual herring gulls would be expected to die each year; the addition of 598 individuals would represent a 0.7% increase in annual mortality. Based on the

annual biogeographic population with connectivity to UK waters of 1,098,000 (Furness 2015), 188,856 individuals would be expected to die; the addition of 594 individuals would represent a 0.3 % increase in mortality.

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

380. A review of nocturnal activity in seabirds (EATL 2015) has indicated that the value currently used to estimate collision risk at night for herring gull (50%) is almost certainly an overestimate, possibly by as much as a factor of two (i.e. empirical data from logger deployments suggest that 25% is more appropriate). Natural England have recognised this aspect of precaution and advised recent projects to undertake collision modelling with nocturnal activity set to both 25% and 50%. Reducing the nocturnal activity factor to 25% reduced collision estimates for herring gull at East Anglia TWO by around 15% (***Table 12.31***). Applying the same approach to other wind farms in ***Table 12.46*** would reduce the cumulative collision estimate by a significant amount (e.g. between 7% and 25%; note the magnitude of reduction varies depending on the time of year and wind farm latitude due to the variation in day and night length). This further emphasises the precautionary nature of the current assessment.

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

12.7.4.5 Great Black-backed Gull

382. The cumulative predicted collision risk for great black-backed gull is set out in ***Table 12.47***. Sources of information for each site (including Band model option and avoidance rate) are included in ***Appendix 12.3***.

383. The collision values presented in ***Table 12.47*** include breeding, non-breeding 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 non-breeding 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 12.47*** have been multiplied by 0.8 to estimate the non-breeding component and 0.2 to estimate the breeding component.

Table 12.47 Cumulative Collision Risk Assessment for Great Black-backed Gull

Tier	Windfarm	Breeding CRM	Non-breeding CRM	Annual CRM
1	Aberdeen (EOWDC)	0.6	0.4	1.0
1	Beatrice Demonstrator	0	0	0
1	Beatrice	30.2	120.8	151
1	Blyth Demonstration	1.3	5.1	6.3
1	Dudgeon	0	0	0
1	Galloper	4.5	18	22.5
1	Greater Gabbard	15.0	60.0	75.0
1	Gunfleet Sands	0	0	0
1	Hywind	0.3	4.5	4.8
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	Race Bank	0	0	0
1	Rampion	5.2	20.8	26.0
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	Westermost Rough	0	0	0.1

Tier	Windfarm	Breeding CRM	Non-breeding CRM	Annual CRM
2	Hornsea Project One	17.2	68.6	85.8
2	East Anglia ONE	0.5	31.5	32.0
2	Kincardine	0	0	0
2	Moray Firth East	9.5	25.5	35.0
3	Dogger Bank Creyke Beck Projects A and B	5.8	23.3	29.1
3	Dogger Bank Teeside A and B (now Sofia)	11	26	37
3	Forth (Seagreen) Alpha and Bravo	13.4	53.4	66.8
3	Hornsea Project Two	3	20	23
3	Inch Cape	0	36.8	36.8
3	Moray Firth West	4	5	9
3	Neart na Gaoithe	0	3	3
3	East Anglia THREE	4.3	32.1	36.4
3	Triton Knoll	24.4	97.6	122.0
4	Hornsea Project Three	7	25	32
4	Norfolk Boreas	7.75	85.35	93.11
4	Norfolk Vanguard	8.09	39.25	46.84
4	Thanet Extension	2	20	22
4	East Anglia TWO	3.84	3.73	7.56
4	East Anglia ONE North	3.92	1.28	5.2
	TOTALS	**193.0**	**867.5**	**1060.0**

384. The annual cumulative total of predicted collisions is 1,060 of which East Anglia TWO contributes 8 birds. Based on the largest Annual BDMPS of 91,399 (Furness 2015) and baseline mortality of 0.185 (***Table 12.34***), 16,909 individual greater black-backed gulls would be expected to die each year; the addition of 1,060 individuals would represent a 6% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 235,000 (Furness 2015), 43,475 individuals would be expected to die; the addition of 1,060 individuals would represent a 2% increase in mortality.

385. 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.

386. Note, however that many of the collision estimates for other windfarms were calculated on the basis of designs with higher numbers of wind turbines (and total rotor swept areas) than have been installed (or are planned), which is a key factor in collision risk. Updating the collision estimates for windfarms which have been built out or are due to be built out with a smaller rotor swept area that the consented worst-case design (as per MacArthur Green 2017) achieves a reduction in the cumulative annual mortality to 868 (***Appendix 12.3***). Therefore, the values presented in ***Table 12.47***, as well as being based on precautionary calculations, can be seen to overestimate the total risk by around 18% due to the reduced collision risks for projects which undergo design revisions post consent.

387. 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). Natural England has recognised this aspect of precaution and advised recent projects to undertake collision modelling with nocturnal activity set to both 25% and 50%. Reducing the nocturnal activity factor to 25% reduced collision estimates for great black-backed gull at East Anglia TWO by around 16% (***Table 12.31***). 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.

388. A population model for great black-backed gull, at the scale of the UK North Sea BDMPS (Furness 2015), was developed to inform the East Anglia THREE assessment (EATL 2016a). The species has been subject to relatively little research and estimates of demographic rates have been categorised as low quality (Horswill and Robinson 2015). Four versions of the model were presented,

using two different sets of demographic rates (from the scientific literature) and with and without density dependent regulation of reproduction. Comparison of the historical population trend (considered to be stable) with the outputs from these models indicated that the density dependent versions generated population predictions which were much more closely comparable to the empirical 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.

389. 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 predicted populations in the absence of collision risk impact from offshore wind farms. The equivalent density independent predictions generated population reductions of 21.3% to 21.5%.

390. To provide context, JNCC population trend data for great black-backed gull indicate that the annual UK population estimate has varied by up to -35% and +25%. For all modelled scenarios the effect of cumulative collisions lies within this range and could potentially be at a scale which is undetectable, and certainly is within the range of natural variation (EATL 2016a).

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

12.7.5 Cumulative Assessment of Operational Collision Risk and Displacement

12.7.5.1 Gannet

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

393. As noted above (***section 12.7.4.1***), the estimated cumulative annual total for gannet collision mortality is 2,607. The estimated cumulative total for gannet displacement is 0-381 birds (***section 12.7.3.2***).

394. Based on the largest Annual BDMPS for the UK North Sea and Channel, of 456,298 (Furness 2015) and baseline mortality of 0.191 (***Table 12.33***), 87,153 individual gannets would be expected to die each year; the addition of 2,607-2988 individuals would represent a 3 – 3.4% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness 2015), 225,380 individuals would be expected to die; the addition of 2,607 - 2988 individuals would represent a 1.2-1.3% increase in mortality.

395. The estimated cumulative impacts of collision are an order of magnitude higher than those of displacement, and addition of the precautionary 1% estimated mortality of displaced birds to the collision mortality results in a very small change in the estimated increased in population mortality rates due to collision. As discussed in ***section 12.7.3.2*** it is considered that the mortality of displaced birds would in reality be at or very close to zero, and there would therefore be no increase in the mortality rate increases estimated for cumulative collision risk.

396. Thus the combined impact of cumulative displacement and collision risk would be of low magnitude (as for the assessment of cumulative collision risk alone, set out in ***section 12.7.4.1***), and the impact significance would be **minor adverse**.

12.8 Transboundary Impacts

397. With regard to the potential for transboundary cumulative impacts, there is clearly potential for collisions and displacement at windfarms outside UK territorial waters. However, the spatial scale and hence seabird reference populations sizes for a transboundary assessment would be much larger. Therefore, the inclusion of non-UK windfarms is highly likely to reduce the cumulative impact assessed for each species, therefore it is considered that the CIA provides a precautionary assessment of the likely impacts for each species.

Table 12.48 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 additional offshore windfarm proposals in Dutch waters. It is understood that these are developments which have been consented but not yet constructed and are due to become operational in the period 2019-2025. In response to the section 42 consultation, Rijkswaterstaat indicated that the Ecology and Cumulation Framework for offshore windfarms in the Netherlands had been updated (***Appendix 12.2***). They provided a link to

EU member state	Commentary
	Version 3.0 which includes an assessment of the accumulation for all the plans to 2030. This document has recently become available in English. As noted in ***Appendix 12.2*** the Applicant believes the report provided is too high level to allow a meaningful assessment to be conducted.

12.9 Interactions

398. 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 areas of interaction between impacts are presented in ***Table 12.49*****,** along with an indication as to whether the interaction may give rise to synergistic impacts. This provides a screening tool for which impacts have the potential to interact.

399. ***Table 12.50*** then provides an assessment for each receptor (or receptor group) related to these impacts in two ways. Firstly, the impacts are considered within a development phase (i.e. construction, operation or decommissioning) to see if, for example, multiple construction impacts could combine. Secondly, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across development phases. The significance of each individual impact is determined by the sensitivity of the receptor and the magnitude of effect; the sensitivity is constant whereas the magnitude may differ. Therefore, when considering the potential for impacts to be additive it is the magnitude of effect which is important – the magnitudes of the different effects are combined upon the same sensitivity receptor. If minor impact and minor impact were added this would effectively double count the sensitivity.

Table 12.49 Potential for Interactions Between 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	**Potential interaction between impacts**		
	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	
Decommissioning			
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.			

Table 12.50 Potential Interactions Between Impacts on Offshore Ornithology

	Highest level significance				
Receptor	**Construction**	**Operational**	**Decommissioning**	**Phase Assessment**	**Lifetime Assessment**
Red-throated diver, razorbill and guillemot (displacement) All species (prey species displacement)	Minor adverse	Minor adverse	Minor adverse	**No greater than individually assessed impact** ***Construction*** *Impact 1 Disturbance and displacement from increased vessel activity* and *Impact 2 Indirect effects as a result of displacement of prey species due to increased noise and disturbance to sea bed* were assessed separately as having negligible magnitudes of impact. They have the theoretical potential to interact however any birds displaced from the offshore development area would not be impacted by impacts upon prey species (either the birds are displaced from the area or are affected by changes to prey within the area, but not both).	**No greater than individually assessed impact** There is potential for disturbance and displacement due to construction activities, including the construction of wind turbines and other infrastructure (offshore electrical platforms, construction operation and maintenance platforms and meteorological mast) and associated vessel traffic. However, construction will not occur across the whole of the proposed wind turbine array area simultaneously or every day but will be phased, with activity focused on particular wind turbine, offshore platform or cable locations at any time. At such time as wind turbines (and other infrastructure) are installed onto foundations the impact of displacement would increase incrementally to the same levels as operational impacts. Effectively therefore the construction impacts simply extend the duration of the operational impacts. It is therefore considered that over the project lifetime these impacts would not combine and represent an increase in the significance level.

12.10 Inter-relationships

400. The construction, operation and decommissioning phases of the proposed East Anglia TWO 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).

401. 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.

402. Inter-relationships are summarised in ***Table 12.51***, which indicates where assessments carried out in other ES chapters have been used to inform the offshore ornithology assessment.

Table 12.51 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 Shellfish Ecology***	***Section 12.6.2.2***	Potential impacts on benthic ecology and fish and shellfish during operation could affect the prey resource for birds.
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

403. 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.

404. 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 TWO, which involved Natural England and the RSPB.

405. A standard survey area for offshore ornithology, covering the East Anglia TWO 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.

406. The impacts that could potentially arise for offshore ornithology during the construction, operation and decommissioning of the proposed East Anglia TWO 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

407. 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.

408. 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 TWO 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.

409. Two potential effects of the proposed East Anglia TWO 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.

410. 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 12.37***.

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

412. The potential for collisions and displacement from windfarms outside UK territorial waters (transboundary) to contribute to cumulative impacts was considered. The spatial scale and hence seabird population sizes for a transboundary assessment would be much larger and the available information is too high level to allow meaningful assessment. Therefore, the inclusion of non-UK windfarms is considered very unlikely to alter the conclusions of the existing cumulative assessment and may reduce the cumulative impact assessed on the larger population present over a larger spatial scale.

413. The identified impacts for the project alone are summarised in ***Table 12.52*** and cumulative impacts in ***Table 12.53***.

Table 12.52 Potential Impacts Identified for Offshore Ornithology

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Direct disturbance and	Red-throated diver	High	Negligible	Minor adverse	N/A	Minor adverse

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
displacement during construction of the export cable and windfarm						
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
	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
	Kittiwake	Low to medium	Negligible	Negligible	N/A	Negligible
	Lesser black-backed gull	Low to medium	Negligible	Negligible	N/A	Negligible
	Herring gull	Low to medium	Negligible	Negligible	N/A	Negligible

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	Great black-backed gull	Low to medium	Negligible	Negligible	N/A	Negligible
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 12.53 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
	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
	Herring gull	Low to medium	Negligible	Negligible	N/A	Negligible
	Great black-backed gull	Low to medium	Low	Minor adverse	N/A	Minor adverse

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