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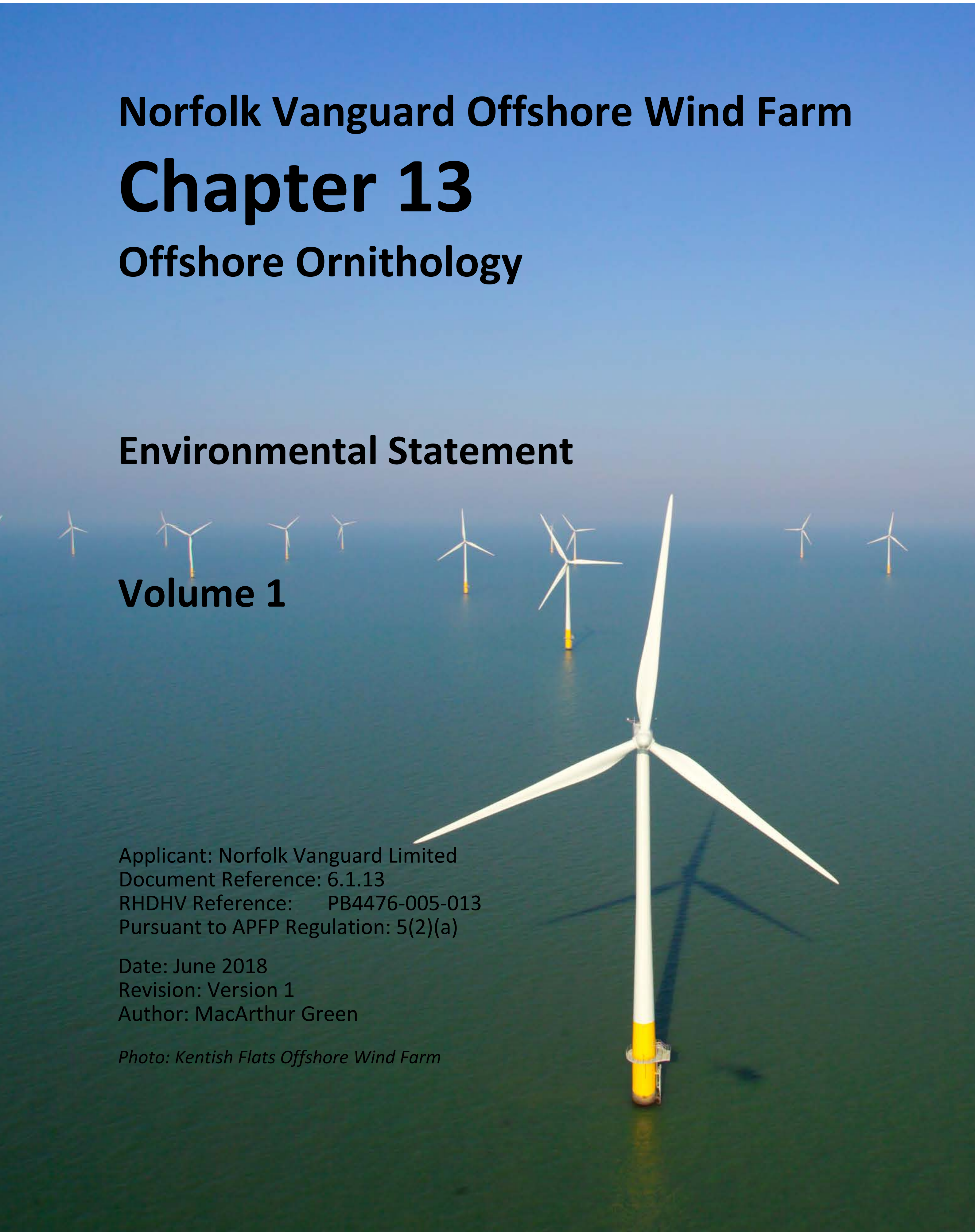

Norfolk Vanguard Offshore Wind Farm

Chapter 13

Offshore Ornithology

Environmental Statement

Volume 1

Applicant: Norfolk Vanguard Limited
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Environmental Impact Assessment

Environmental Statement

Document Reference: PB4476-005-013

June 2018

For and on behalf of Norfolk Vanguard Limited
Approved by: Rebecca Sherwood and Ruari Lean
Signed:
Date: 8th June 2018

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Glossary

AR	Avoidance Rates
BDMPS	Biologically Defined Minimum Population Scale
BoCC	Birds of Conservation Concern
BTO	British Trust for Ornithology
CIA	Cumulative Impact Assessment
CRM	Collision Risk Modelling
EATL	East Anglia THREE Limited
EIA	Environmental Impact Assessment
EMF	Electro-magnetic Field
EPP	Evidence Plan Process
ES	Environmental Statement
FAME	Future of the Atlantic Marine Environment
GGOWL	Greater Gabbard Offshore Wind Farm Limited
HRA	Habitats Regulations Assessment
IEEM	Institute of Ecology and Environmental Management
JNCC	Joint Nature Conservation Committee
KDE	Kernel Density Estimate
MAGIC	Multi-Agency Geographic Information for the Countryside
MLWS	Mean Low Water Springs
MW	Megawatt
NE	Natural England
NGO	Non-Governmental Organisation
NPPF	National Planning Policy Framework
NPS	National Policy Statement
NV East	Norfolk Vanguard East
NV West	Norfolk Vanguard West
OETG	Ornithology Expert Technical Group (part of the Evidence Plan process)
ORJIP	Offshore Renewables Joint Industry Programme
OWEZ	Offshore Wind Farm Egmond aan Zee
OWF	Offshore Wind Farm
PBR	Potential Biological Removal
PCH	Potential Collision Height
PEIR	Preliminary Environmental Information Report
PVA	Population Viability Analysis
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SNCB	Statutory Nature Conservation Body
SOSS	Strategic Ornithological Support Services
SPA	Special Protection Area (note, pSPA indicates a proposed site not yet fully designated)
SSSI	Site of Special Scientific Interest
WWT	Wildfowl and Wetlands Trust

Terminology

Array cables	Cables which link the wind turbine generators and the offshore electrical platform.
Interconnector cables	Buried offshore cables which link offshore electrical platforms.
Landfall	Where the offshore cables come ashore.
Offshore accommodation platform	A fixed structure (if required) providing accommodation for offshore personnel. An accommodation vessel may be used instead.
Offshore cable corridor	The area where the offshore export cables would be located.
Offshore electrical platform	A fixed structure located within the wind farm 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 transmit electricity from the offshore electrical platform to the landfall.
Offshore project area	The overall area of Norfolk Vanguard East, Norfolk Vanguard West and the provisional offshore cable corridor.
Safety zone	A marine zone outlined for the purposes of safety around a possibly hazardous 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.
The Applicant	Norfolk Vanguard Limited.
The OWF sites	The two distinct offshore wind farm areas, Norfolk Vanguard East and Norfolk Vanguard West.
The project	Norfolk Vanguard Offshore Wind Farm, including the onshore and offshore infrastructure.

13 OFFSHORE ORNITHOLOGY

13.1 Introduction

1. This chapter has been prepared by MacArthur Green using survey data collected by APEM Ltd. and presents the assessment of the potential impacts on ornithological receptors that might arise from construction, operation and decommissioning of the offshore components of the proposed Norfolk Vanguard project.

2. This 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. Full details of the baseline data acquired through the surveys specifically carried out within the Norfolk Vanguard offshore wind farm (OWF) sites and a 4km buffer can be found in Appendix 13.1 Norfolk Vanguard Offshore Wind Farm Ornithology Technical Appendix.

13.2 Legislation, Guidance and Policy

13.2.1 Guidance

4. The most relevant guidance on Environmental Impact Assessment (EIA) for marine ecology receptors, including birds, is the 'Guidelines for Ecological Impact Assessment in Britain and Ireland: Marine and Coastal' published by the Institute of Ecology and Environmental Management (IEEM, 2010). The EIA methodology described in section 13.4.1 and applied in this chapter is based on that IEEM guidance.

5. 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 wind farms (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 wind farms (Joint SNCB Note, 2017);
- Collision risk modelling to assess bird collision risks for offshore wind farms (Band, 2012);

- Assessing the risk of offshore wind farm development to migratory birds (Wright *et al.,* 2012);
- Vulnerability of seabirds to offshore wind farms (Furness and Wade, 2012; Furness *et al.,* 2013; Wade *et al.*, 2016);
- Mapping seabird sensitivity to Offshore Wind Farms (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).

13.2.2 Legislation

6. Table 13.1 identifies the relevant legislation and summarises the important measures derived from it.

Table 13.1 Legislation and relevant measures

Legislation	Relevant Measures	Section reference
Birds Directive - Council Directive 79/409/EEC on the Conservation of Wild Birds	This Directive provides a framework for the conservation and management of wild birds in Europe. 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 been replaced by the Article 6 provisions of the Habitats Directive.	Designated sites, including SPAs, with potential for connectivity to the wind farm are listed for consideration in section 13.6.1. Assessment of the potential impacts on the features of these SPAs, together with assessment on other Natura sites and features (e.g. special Areas of Conservation) will be provided in a Habitats Regulations Assessment.
Wildlife and Countryside Act 1981	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 birds by establishing the system of Sites of Special Scientific Interest (SSSI).	The assessment has been conducted in accordance with the protections afforded by this legislation. Features of SSSI's have also been listed in section 13.6.1.
The Conservation of Offshore Marine Habitats and Species Regulations 2017	In November 2017, the Conservation of Habitats and Species Regulations 2010 and the Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 were consolidated into the Conservation of Offshore Marine Habitats and Species Regulations 2017 ('the Habitats Regulations 2017'). The Habitats Regulations 2017 transpose the Birds Directive and the Habitats Directive into national law. The Habitats Regulations place an obligation on 'competent	As above.

Legislation	Relevant Measures	Section reference
	authorities' to carry out an appropriate assessment of any proposal likely to affect a Natura 2000 site, to seek advice from Natural England and not to approve an application that would have an adverse effect on a Natura 2000 site except under very tightly constrained conditions that involve decisions by the Secretary of State. The competent authority in the case of the proposed project is the Secretary of State for Business Energy and Industrial Strategy.	

13.2.3 Policy

7. Table 13.2 identifies policy and summarises the important measures derived from it that are relevant to offshore ornithology.

Table 13.2 Policy and relevant measures

Policy	Relevant Measures	Section reference
Overarching National Policy Statement (NPS) for Energy (NPS EN-1) (July 2011)	Paragraph 5.3.3 states that the applicant should ensure that the ES clearly sets out any effects on internationally, nationally and locally designated sites of ecological 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 interests. Paragraph 5.3.18 states that the applicant should include appropriate mitigation measures as an integral part of the proposed project.	Protected sites are listed in Table 13.9. Assessment of the potential effects of the wind farm on the features of these protected sites is provided in section 13.7. Further consideration and assessment for designated sites with potential connectivity to the wind farm will be provided in a comprehensive Habitats Regulations Assessment.
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 wind farm. 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.	Potential impacts assessed include during construction (section 13.7.4), operation (section 13.7.5) and decommissioning (section 13.7.6). The survey methods were discussed and agreed with Natural England (details are included in the Evidence Plan log).
National Planning	The National Planning Policy Framework sets out the Government's planning policies for England and how these are	The underlying principles of the NPPF

Policy	Relevant Measures	Section reference
Policy Framework	expected to be applied. The document establishes a number of core land-use planning principles that should underpin both plan-making and decision-taking, including contributing to conserving and enhancing the natural environment. Paragraph 109 states that "the planning system should contribute to and enhance the natural and local environment by minimising impacts on biodiversity and providing net gains in biodiversity where possible, contributing to the Government's commitment to halt the overall decline in biodiversity, including by establishing coherent ecological networks that are more resilient to current and future pressures".	have been adhered to throughout the assessment.
UK Post-2010 Biodiversity Framework	The 'UK Post-2010 Biodiversity Framework' succeeds the UK Biodiversity Action Plan. The Framework demonstrates how the work of the four countries and the UK contributes to achieving the Aichi Biodiversity Targets, and identifies the activities required to complement the country biodiversity strategies in achieving the targets. The following seabirds are identified as a priority for action: common scoter, black-throated diver, Balearic shearwater, Arctic skua, herring gull and roseate tern.	It should be noted that most of the named species have not been recorded on the wind farm. For those which have, potential impacts have been assessed where relevant, e.g. section 13.7.5.3.1 (herring gull and Arctic skua collision risk).

13.3 Consultation

8. To inform the offshore ornithology assessment, Norfolk Vanguard Limited has undertaken a pre-application consultation process including the following key consultation:

- Scoping Report submitted to the Planning Inspectorate (Royal HaskoningDHV, 2016);
- Scoping Opinion received from the Planning Inspectorate (the Planning Inspectorate, 2016);
- Evidence Plan - consultation with key statutory consultees has been undertaken through the Evidence Plan Process (EPP). For further detail on the EPP refer to Chapter 7 Technical Consultation; minutes from the Offshore Ornithology Expert Topic Group (OETG) meetings are included as Appendix 9.17 and Appendix 25.8 of the Consultation Report (document reference 5.1); and
- Production of a Preliminary Environmental Information Report (PEIR) which presented a full assessment using a slightly reduced dataset (as surveys were ongoing at the time). Natural England, the RSPB, Ministry of Infrastructure and Water Management Netherlands and Ministry for the Environment, France provided comments as a formal section 42 response on this document. These

comments have been used to revise and update the assessment presented below.

9. In addition to stakeholder consultation for the Norfolk Vanguard project itself, the assessment presented here has also been informed by the information gathered and assessment carried out for the nearby East Anglia ONE project and the adjacent East Anglia THREE project. Due to the close proximity of these wind farms to Norfolk Vanguard the sites share ornithological sensitivities. The East Anglia ONE project was subject to consultation prior to the submission of its application for consent in November 2012 and the East Anglia THREE project was consulted on prior to submission of its application in November 2015.

10. East Anglia ONE was consented in June 2014 and East Anglia THREE was consented in August 2017. The decisions made in relation to potential ornithological impacts for these projects have been reviewed and taken into consideration in the assessment for the proposed Norfolk Vanguard project.

11. Detailed consultation and iteration of the overall approach to the impact assessment on ornithological receptors has been discussed and agreed with stakeholders through the EPP. An Ornithology Expert Technical Group (OETG) has also been convened, which includes representatives of Natural England and the Royal Society for the Protection of Birds (RSPB). The OETG provided a forum for consultation during preparation of this Environmental Statement (ES) and this will continue during the examination phase.

12. The comments arising from the consultation process (comprising scoping, the Evidence Plan Process and PEIR responses) and the Applicant's response made to each are summarised in Table 13.3.

Table 13.3 Consultation responses

Consultee	Date / Document	Comment	Response / where addressed in the ES
Secretary of State	Scoping Opinion from the Planning Inspectorate, November 2016	Key concerns are: The potential effects of this development on birds during all phases of development encompassing displacement, indirect effects (through impacts on prey species) and collision mortality – both at a project level and cumulatively.	These aspects are considered in the relevant section of this ES. Specific points raised by the Secretary of State are considered below.
		The Scoping Report provides data sources for the proposed ornithological assessment within the offshore area; however, it does not detail the data for the offshore cable corridor. This should be detailed within the ES.	The offshore cable corridor assessment uses existing sources of data. These are detailed in the relevant section (13.5.2.1).

Consultee	Date / Document	Comment	Response / where addressed in the ES
		The potential for disturbance from the cable laying vessels and associated activities should be considered.	This aspect of construction has been assessed in section 13.7.4.1.
		The Scoping Report has referred to Furness (2015) in relation to identifying and defining the relevant biological seasons for each species. The ES should explain the relevance of this reference and whether its use has been agreed with the relevant consultees.	The source referred to (Furness, R.W. 2015. Non-breeding season populations of seabirds in UK waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Reports, Number 164.) was commissioned by Natural England. The purpose of this document was to review available data and provide a single reference source of population and season definitions for species commonly assessed and therefore this forms part of the suite of guidance recommended by Natural England.
		Paragraph 540 of the Scoping Report proposes to scope out indirect impacts on birds resulting from disturbance to prey species within the offshore cable corridor and their habitat on the basis it is likely to be indiscernible. However, Table 2.21 does not propose to scope it out. Without further justification, the Secretary of State does not consider this should be scoped out of the EIA.	This aspect has been assessed in section 13.7.4.2.
		The Secretary of State considers that, in accordance with paragraph 2.6.101 of NPS EN-3, consideration should be given to the potential effects on birds through direct habitat loss, for example from the wind turbines and offshore substation/accommodation platforms both during construction and operation.	These aspects have been assessed in sections 13.7.4.1 and 13.7.5.1.
		The methods of assessing impacts are not clearly stated within the Scoping Report and therefore it is difficult to understand how impacts would be	The impact assessment method is

Consultee	Date / Document	Comment	Response / where addressed in the ES
		assessed. The methodology should be comprehensively detailed within the ES and agreed with the relevant statutory consultees.	set out in full in section 13.4.1.
		Paragraph 543 of the Scoping Report refers to matrices in order to assess the potential effects of displacement on sensitive species. The ES should clearly set out the methodology associated with, and justification for, their use.	The displacement assessment methods are set out in section 13.7.5.1. The method follows that recommended by Natural England.
		In terms of collision risk modelling, the ES should set out which Band model, avoidance rates, flight height variations and any other relevant information has been used. The parameters used within the model should be detailed and justified (i.e. the Rochdale Envelope should be fully explained) alongside the methodology used for assessing population level impacts.	The collision risk modelling methods are clearly set out in section 13.7.5.3 and further details are provided in Technical Appendix 13.
		The Secretary of State notes that ornithological surveys are ongoing within NV West but have been completed for NV East. The Applicant is advised to agree the survey methodology with relevant consultees and to document such agreements within the ES.	Agreement on survey requirements was obtained from Natural England. This is documented in an appendix.
Secretary of State	Scoping Opinion from the Planning Inspectorate, November 2016	The Scoping Report does not provide an indication of which data will be used to characterise the offshore cable corridor area. Whilst we note that the East Anglia Zone survey data will likely cover this area, this data are now fairly old (between 5-8 years old). We note that the provisional cable corridor for Norfolk Vanguard overlaps the Greater Wash SPA. Therefore, we advise that the data used for the Greater Wash SPA could be used for characterisation assessments. We note that impacts are most likely to be displacement of red-throated diver and common scoter due to the presence of cable laying vessels during the laying of the cable.	Assessment for red-throated diver and common scoter uses the data suggested by Natural England (section 13.7.4.1).
Secretary of State	Scoping Opinion from the Planning Inspectorate, November 2016	We would advise that the laying of the offshore cable not only has the potential to disturb prey species and habitats, but the presence of cable laying vessels has the potential to disturb the birds themselves, especially more sensitive species such as red-throated diver and common scoter (which are proposed qualifying features of the Greater Wash SPA). It is not clear whether this potential impact will be considered within the disturbance and displacement potential impact	This has been assessed in section 13.7.4.1.2.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		highlighted in the Scoping Report. As the provisional cable corridor overlaps with the proposed boundary of the pSPA, we advise that this potential impact should be considered.	
Secretary of State	Scoping Opinion from the Planning Inspectorate, November 2016	Indirect impacts through effects on habitats and prey species with the offshore wind farm sites during construction focuses on disturbance from noise generated by piling. We recommend that consideration is also given here to the potential for increased sediment from construction of the turbine foundations and laying of cables within the arrays themselves. Any indirect impacts on habitat and prey for all assessment stages (construction, operation, decommissioning) should be linked to the relevant habitat and prey assessment chapters - fish and shellfish ecology, benthic ecology and water and sediment quality assessments. Regarding operational potential impacts, consideration could also be given to direct habitat loss from individual turbine location within the project footprint, although it is acknowledged that this likely to be small.	This has been assessed in section 13.7.4.1.
Secretary of State	Scoping Opinion from the Planning Inspectorate, November 2016	We agree with the potential cumulative impacts that have been identified by the Applicant, namely: collision risk and barrier effects which impact upon migration routes and prey species. However, consideration should also be given to cumulative displacement impacts. We also note that other offshore wind farms within the former East Anglia Zone could be of relevance in terms of potential for overlap in construction periods and hence advise that cumulative construction impacts are considered.	Cumulative impacts during construction have been considered and assessed where required (see section 13.8).
NE & RSPB	OETG meeting 1st February 2017	In principle agreement for PEIR: • Baseline survey data collection will provide sufficient data to inform the assessment (NB surveys are ongoing and therefore are not complete for PEIR). • Population estimates will be design based for all species and supplemented with model-based estimates where data permit. • PEIR cumulative project cut-off date is May 2017. • Collision modelling will use Band options 1 and 2. • Impacts to be assessed against biogeographic and BDMPS population scales. • If necessary, PVA to be used instead of PBR.	Discussed and agreed as part of Evidence Plan process and methodology given in section 13.5.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		Topics for which further discussion is required prior to final submission but which are not included in PEIR: • Annual displacement assessment methodology. • Inclusion of uncertainty in collision risk modelling. • Determination of seasons for months which overlap migration and breeding. • Population modelling methods (e.g. inclusion of density dependence)	Methods used in this ES reflect OETG discussions and consultation conducted following stakeholder review of the PEIR.
NE & RSPB	OETG meeting 6th October 2017	Discussions regarding content of draft PEIR Ornithology Chapter. Various technical aspects of the analysis and assessment were discussed.	The comments have been taken into account in this assessment.
NE	PEIR 11th December 2017	We note that the 2017 interim advice on assessing displacement of birds from offshore windfarms is not produced by just Natural England and JNCC, but is a joint SNCB note by NRW, DAERA/NIEA, NE, SNH and JNCC. We also suggest that reference is made to Bradbury *et al*. (2014) with regard to the vulnerability of seabirds to offshore windfarms, as this expands the species covered by Furness *et al*. (2013) to cover those additional species found in English waters, particularly as the Norfolk Vanguard site is in English waters. We also recommended that consideration is given to the updated sensitivities in Wade *et al*. (2016).	Additional information sources noted and the lists updated (section 13.2.1).
		Table 13.3 highlights four topics for which further discussion is required prior to final submission, which are not included in PEIR: Annual displacement assessment methodology – see summary comment II above regarding displacement assessments and NE's recommendations for this. These recommendations are in line with the 2017 updated joint SNCB interim displacement advice note, a link to which was sent to Vanguard's consultants on 22/02/17. Inclusion of uncertainty in collision risk modelling – we note that Masden (2015) is still undergoing testing and we would currently advise that the Band (2012) model is used and that the Applicant presents outputs from the Band model that account for variability in the input parameters – especially densities of birds in flight, flight heights and avoidance rates. We note that Vanguard have presented CRM outputs for the 'basic' Band	Displacement assessment has been updated in this assessment and NE's comments on annual displacement taken into account (section 13.7.5.1). Collision modelling has been conducted with the inclusion of the additional aspects of uncertainty detailed by NE (section 13.7.5.3 and Technical Appendix 13.1). Assignment of months to biologically relevant seasons has been conducted on a

Consultee	Date / Document	Comment	Response / where addressed in the ES
		model (Options 1 and 2) for a range of avoidance rates (covering those recommended by the SNCBs ±2SD for the species covered by Cook *et al*. 2014) and for Option 2 for a range of flight heights (including the upper and lower confidence limits of the generic flight height data in Johnston *et al*. 2014). However, the impact assessments have been based on just a single figure from one model option for the recommended avoidance rate and the site-specific (for Option 1) or median flight height (for Option 2) data. Natural England advises that the assessments of collision mortality should use the information on uncertainty and variability in the input parameters (e.g. bird densities, flight heights, avoidance rates) to allow consideration of the range of values predicted impacts may fall within, and to allow an assessment of confidence in the conclusions made regarding adverse effects on site integrity and significance of impacts for populations. Determination of seasons for months which overlap migration and breeding – we would suggest using migration free seasons for all species, as the highest numbers of birds appear to be present in the non-breeding periods and the sites are located outside of foraging range of most colonies. The exception to this is possibly lesser black-backed gull – this still needs further consideration once the full 24 months of data are available for Vanguard West, as there is a need to see if the peak figures in the breeding season are a one off or are repeated in the second year of data covering these months. Population modelling methods (e.g. inclusion of density dependence) – we suggest that Vanguard follow the approach Natural England outlined in the document we produced for Vanguard following the first Offshore Ornithology Expert Topic Group Meeting. Although discussions are ongoing within Natural England regarding this, our position has not changed since we produced the suggested approach for Vanguard. The approach suggested: For EIA scale assessments: there are many uncertainties, particularly in terms of the most suitable population to use, e.g. biogeographic or Biologically Defined Minimum Population Scale (BDMPS). Discussions are still ongoing over the most appropriate population to use, and therefore, we would suggest that the following	species-specific basis taking into account the advice of NE (sections 13.7.5.1 and section 13.7.5.3). The assessment has been conducted taking into account NE's advice on suitable reference populations and consequences (e.g. population modelling). Horswill *et al*. (2016) present evidence that density dependent population regulation is widespread among seabird populations, with many cases of compensatory density-dependence. Depensatory effects occur less often, and mostly involving increased predation when colony size drops to very low levels. These considerations are included in the population modelling assessments referred to in this ES.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		information analysis is undertaken in the first instance: • Calculate the total predicted impact (e.g. summed total cumulative collisions) within the defined spatial scale; • Estimate of the total number of birds expected to be in the area at the time • Calculate what proportion of this total number of birds come from different colonies and countries using information in Furness (2015) • Then apportion the total impact that would be on birds from the different countries/colonies. • Evaluate the predicted impact against the context of the population the assessment is dealing with. Following this, if it is felt that there is a requirement for further population modelling, we would suggest consideration is initially given to existing population models unless there is any additional evidence to suggest the modelling should be undertaken in a different way. If there is not an existing model for a species and population where a requirement for further assessment through population modelling is identified, then we would recommend following the approach outlined for HRA. For HRA: If there is clear evidence of the form and strength of density dependence operating on the focal population (colony) then we would (depending on the evidence provided) consider the outputs from density dependent models. However, it will also be important to consider whether there is any actual evidence that density dependence is acting on the focal population at the present time. We advise trialling a range of forms of density dependence, alongside density independent models and examining the potential range of outcomes using a sensitivity analysis. We advise using a density independent model where there is no information on population regulation for the focal population, but careful consideration should be given to the potential for depensatory population regulation. Consideration could also be given to the evidence for compensatory and depensatory regulation presented in Horswill *et al*. (2016).	

Consultee	Date / Document	Comment	Response / where addressed in the ES
		Paragraph 32 notes that the offshore cable corridor is included within the study area. We assume that the offshore cable corridor area goes to Mean Low Water Springs (MLWS) at the landfall location and that the assessment of impacts above MLWS is included in the onshore ornithology chapter.	This is correct.
		We note that the PEIR is based on 32 months of survey data for NV East and 18 months for NV West. We note from this paragraph that 24 months of survey data from NV West will be available for the Environmental Statement (ES) and we advise that this is included in the ES.	The assessment presented in the PEIR has been updated to include the extra survey data for Norfolk Vanguard West (for which the assessment is now based on 24 months).
		Paragraph 36 notes that no surveys have been conducted along the offshore cable corridor and therefore the data sources listed in paragraph 35 have been used to inform the baseline characterisation and impact assessment for cable installation. We note that from paragraph 35 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 have been examined. However, the offshore cable corridor passes through the Greater Wash SPA, so we would suggest that data used in the Departmental Brief for the Greater Wash SPA are also considered as a data source for characterising the offshore cable corridor.	The additional data sources have been consulted for the current assessment (section 13.5.2.1).
		We note that Figure 13.2 of SPAs assessed in relation to Norfolk Vanguard does not include the Greater Wash SPA – this is relevant to the assessment as the offshore cable corridor passes through this site.	Consideration has been given to this SPA in the current assessment (section 13.7.4.1
		Paragraph 46 states that: 'Those sites that have been identified are listed in Table 13.9 and detailed in Appendix 10.4 HRA Screening, of Chapter 10 Benthic and Intertidal Ecology.' We are uncertain why the overall HRA Screening is included as an appendix to the Benthic and Intertidal Ecology chapter, as it covers more aspects than just benthic ecology (e.g. offshore ornithology, marine mammals).	This reference was included in error and has been corrected in the current assessment.
		Table 13.9 of designated sites and their ornithological features:	The headings and information provided in this table have been

Consultee	Date / Document	Comment	Response / where addressed in the ES
		Column listing the distance of the sites to the project (km) – is this minimum distance to the offshore wind farm footprint? If so, consideration should be given to also including the distance of the sites to the offshore export cable – will be most relevant for the Greater Wash SPA as the offshore cable corridor passes through this site. We assume this table only lists ornithological features of the sites that may have connectivity with the Vanguard site, as the breeding tern qualifying features of several of the SPAs (e.g. Hamford Water, Chichester & Langstone Harbours and Solent & Southampton Water SPAs) aren't mentioned – only the passage/wintering waterbird features are. If this is the case, the table heading needs to be amended to make this clear. The Outer Thames Estuary is listed in this table, but we note consideration should also be given to the Outer Thames Estuary pSPA, where the proposal is for the extension of the boundary for foraging areas of breeding terns and for the addition of breeding common and little tern as qualifying features.	updated to reflect these comments (section 13.6.1).
		The BoCC listings included in this table appear to be out of date for some species – kittiwake and puffin are now red listed and red-throated diver is now green listed on BoCC 4 (2015)	The status of all species in this table have been reviewed against the latest BoCC report and amended accordingly (section 13.6.2.1).
		'*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 all species during the breeding season, with many species absent in one or more of the summer months. This indicated that very few breeding birds utilise the Norfolk Vanguard OWF sites. 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, sometimes also referred to as the core breeding period.*'	We have reviewed the assignment of months to biological seasons and this is reflected in section 13.6.2.1.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		This generally seems ok for Norfolk Vanguard based on the data presented in the PEIR given the low numbers of birds in the breeding season and that the Vanguard site is located outside of foraging range for all species, with the exception of lesser black-backed gull (LBBG) and gannet. We suggest this may need to be revisited (particularly with regard to LBBG) once the remaining 6 months of data from Vanguard West are included, so that there is a second breeding season of data included and we can see whether the LBBG numbers in particular are a one off or may occur more regularly.	
		Paragraph 52 notes that the abundances presented in Table 13.13 do not include birds observed in the 4km buffer around the site boundaries. We would suggest that an additional column is included in Table 13.3 to also present estimates for the site + buffer (either just the site + 4km buffer or the site + 2km buffer as well).	This would require an additional 12 columns (to cover the seasonal and site breakdown provided in this table). Data for the buffer zones are already presented in the technical appendices. Therefore, in order to minimise the complexity of the assessment and repetition of data these have not been reproduced here.
		Paragraph 57 states: 'Aerial surveys of the pSPA have recorded moderate numbers of red-throated divers in the vicinity of the cable corridor with densities of around one or two birds per km2.' As no site-specific data were collected for the offshore cable corridor, the evidence source of this figure should be included.	The source for this has been added.
		Skuas - 13.6.2.1.6 & 13.6.2.1.7; Terns - Section 13.6.2.1.11; Little gull - Section 13.6.2.1.13: These sections only consider the numbers recorded in the aerial surveys. Given these species are passing through the site on migration, turnover/flux of these species needs to be taken into account due to the snapshot nature of the aerial surveys. We would suggest that some information is included here on the work done for the CRM assessments for skuas and terns to account for this following the method in WWT & MacArthur Green (2014). We would also suggest that a similar approach is undertaken for little gull	These sections provide a summary of the survey observations. The suggested amendments are relevant to the collision assessment (section 13.7.5.3) and have been taken into account in other sections as appropriate.

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		and information from this included in the little gull baseline characterisation section.	
		13.6.2.1.1.4 It may be worth noting the higher numbers recorded in the Vanguard West 4km buffer in June and July in this section and whether there are any reasons for why higher numbers should be present in the buffer than the site. Although, we also note that a further 6 months of data (March – August 17) are yet to be included in the analysis, so it is possible that these higher numbers were a one off in June and July 2016.	We are not aware of any reason for these observations in 2016 but note that much lower numbers were recorded in the same months in 2017 and hence the average estimates are reduced.
		13.6.2.2 This section notes that migration modelling was conducted at EA3 for 23 non-seabird migrant species using the approach described in the SOSS 05 Project and that collisions were estimated using the Band collision risk model Option 1. It concludes that as the results from the EA3 modelling indicated that none of the species was at risk of significant collisions whilst on migration and non-seabird migrants were screened out of further assessment for EA3, the same conclusions apply to Norfolk Vanguard and no further assessment of potential impacts on non-seabird migrants has been undertaken. We do not consider that it is appropriate to just say that it wasn't an issue at EA3, so it won't be here. Consideration should be given to whether there are any relevant SPAs that may be in the shadow of the Vanguard sites (e.g. at EA One there were concerns over dark-bellied brent geese migrating through the site to the Deben Estuary) – there may be a need to consider sites such as the North Norfolk Coast/Breydon Water.	Further discussion on this aspect has been provided in section 13.7.5.3.
		Table 13.14 states: 'The Norfolk Vanguard site was identified through the Zonal Appraisal and Planning process and avoids European protected sites for birds (e.g. Flamborough and Filey Coast pSPA is more than 210km from the OWF sites and Alde-Ore Estuary SPA is over 100km from the OWF sites). This means the site is beyond the foraging range of almost all seabird species, the exception being gannet for which a mean maximum range of up to 229km has been estimated (Thaxter *et al.*, 2012).' We note that the mean-maximum foraging range of lesser black-backed gull (a qualifying feature of the Alde-Ore Estuary SPA) in Thaxter *et al.* (2012) is 141km and as Table 13.9 lists the Vanguard site as	The assessment has been updated to reflect these considerations.

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		being a minimum distance of 92km from the Alde-Ore, the site is within foraging range of this species as well as for gannet.	
		Paragraph 96 states: 'The maximum area of each site (NV East and NV West) in which turbines would be located relates to the total capacity of 1800MW. Thus, the only scenario for which 100% of either site would be completely developed is scenario 1 in which all of NV West would be treated as developed (e.g. in terms of its potential for causing displacement). This means, for example, that under scenario 1 there could be complete displacement from NV West and none from NV East. Under scenario 2 there would be potential for a maximum of 75% displacement from NV West (1200/1800) and 25% from NV East (600/1800). It should be noted that the maximum build out of NV east would therefore only cover 75% of the wind farm site.' We note our summary point III above regarding concerns over the appropriateness of the assumption that there would only be a proportion of displacement based on the proportion of capacity built in each site. However, we note that it is useful to see the worst case scenario in terms of capacity layout for each species, but it would also be useful to see what the worst case layout is in terms of impact on total number of birds – as it would then be possible to see which layout scenario would impact the greatest overall number of birds, but which option is having the greatest impact on an individual species. We also note that the proportions of capacity quoted in paragraph 59 for scenario 2 (75% of capacity in Vanguard West and 25% in Vanguard East is different to that presented in the operational displacement impact assessment section (see Section 13.7.4.11, paragraph 187 and Table 13.22), which lists scenario 2 as being 67% of capacity in Vanguard West and 33% in Vanguard East. We assume the figures in the operational displacement impact assessment are the correct ones, as paragraph 59 states 1200/1800MW in Vanguard West, which is 67% of the total 1800MW capacity and not 75%.	This section of the assessment (13.7.5.1) has been updated to reflect revisions to the design options for NV West and NV East and also to ensure that the worst case scenario is assessed.
		Paragraph 106 notes that black-throated diver and great northern diver were screened out of assessment (as black-throated divers were recorded on only one survey and great northern	The relevant sections have been corrected.

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		diver were recorded in only two surveys). We would suggest that this is checked as the data presented in the tables in Annex 1 of Appendix 13.1 suggest that black-throated divers were recorded in March and April (i.e. two surveys) and that great northern divers were recorded in March, April and December (i.e. three surveys).	
		We would suggest that common scoter should also be considered in the screening for construction disturbance and displacement as it is a qualifying feature of the Greater Wash SPA and is a species that is sensitive to disturbance/displacement from vessel activity etc. and the cable corridor passes through the Greater Wash SPA. Although we note that this species wasn't recorded in the offshore wind farm sites, but it was (albeit low numbers) within the 4km buffer. Additionally, no site-specific survey data have been collected for the offshore cable corridor and therefore, we would suggest that the data used in the Departmental Brief for the Greater Wash site are used to help inform the baseline characterisation for the offshore cable corridor. It may be that the cable corridor doesn't pass through the main areas of the Greater Wash SPA used by common scoter, but this should be looked at and discussed. We would suggest that this also applies for the tern qualifying features of the Greater Wash SPA as well – as Natural England does consider tern species to be sensitive to visual disturbance from cable laying in our conservation advice on operations (e.g. see for North Norfolk Coast for Sandwich and little terns) We would suggest that the distributions of the relevant species shown in the Departmental Brief are examined to see if there is any possible overlap with the foraging areas with the cable corridor. We query why red-throated diver have been screened in for the offshore cable corridor only and would suggest that they should also be screened in for the wind farm site(s) as well. As guillemot and razorbill both score a 3 for both disturbance susceptibility and habitat specialisation in Bradbury *et al*. (2014), we recommend that these species should be classed as medium sensitivity to disturbance and displacement rather than low to medium.	Further consideration to the potential for all qualifying features of the Greater Wash SPA to be affected by construction disturbance has been provided in section 13.7.4.1. Further consideration of the potential for red-throated diver to be affected by construction of the wind farm has been provided in section 13.7.4.1. Species sensitivity scores have been reviewed and amended as considered appropriate, with further justification as necessary (sections 13.7.4.1, 13.7.5.1).
		We note our summary point II above regarding the need to sum impacts across individual	Impacts have been reviewed and

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		seasons to give an overall annual impact for each species for all build out scenarios. This will be particularly important for the assessment of Vanguard East and Vanguard West impacts combined. As we recommend that guillemot and razorbill are classed as medium sensitivity to disturbance and displacement rather than low to medium, we therefore advise that the impact significance for the assessment for these species is considered to be minor adverse.	amended as appropriate (section 13.7.5.1).
		Paragraph 167 states: '…the worst case option during the non-breeding season (scenario 3) would result in 221 individual guillemots being at risk of displacement.' However, paragraph 168 states: '…Displacement of up to 110 birds will have a negligible influence on the population density across the BDMPS region…' We suggest that the discrepancy between the figures quoted in these paragraphs is checked.	The displacement assessment has been reviewed and amended as necessary.
		Table 13.20 – Operational disturbance and displacement screening: For lesser black-backed gull the biological season/s with peak numbers is listed as n/a – clarification of what this means is required – does it mean that no season had a clear peak? As noted previously, we would suggest that guillemot and razorbill are considered to have a medium sensitivity to disturbance and displacement rather than a low to medium sensitivity, given their scores for both disturbance susceptibility and habitat specialisation in Bradbury *et al*. (2014) and the 68% displacement rate for OWEZ shown in this table.	This was intended to indicate that the species abundance does not indicate a seasonal peak. This has been clarified. Species sensitivity scores have been reviewed and amended as considered appropriate, with further justification as necessary (section 13.7.5.1).
		Project scenarios (Section 13.7.4.1.1) We note our summary point III above regarding concerns over the appropriateness of the assumption that there would only be a proportion of displacement based on the proportion of capacity built in each site.	The worst case scenarios have been reviewed and updated with regard to these comments and to ensure the assessment is robust (section 13.7.5.1).
		Displacement matrix tables have been presented for each relevant season individually and displacement is presented from 0 – 100% at 10% increments and mortality is presented from 0 – 100% at 1% increments up to 10% and larger gaps thereafter. However, the range of scenarios	The displacement assessment has been reviewed and updated where necessary (section 13.7.5.1).

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		considered in the assessment are 60-80% displacement and 5-10% mortality. Natural England recommend that a worst case scenario of 100% displacement and 10% mortality is considered for red-throated divers – the 2017 SNCB joint interim displacement note suggests that for species such as divers a displacement level of 90-100% is likely to be recommended. We note our summary point IV above regarding the need to present data and predicted impacts in a way that allows the full range of uncertainty (e.g. around input data, analysis, methodology) to be understood and evaluated. We note our summary point II above regarding the need to sum impacts across individual seasons to give an overall annual impact for each species for all build out scenarios. We note our summary point III above regarding concerns over the appropriateness of the assumption that there would only be a proportion of displacement based on the proportion of capacity built in each site.	
		Displacement matrix tables 13.26-13.28 for Vanguard West – we suggest that the figures that have gone into these tables for 100% displacement and 100% mortality and hence the overall matrix figures are checked. As from the data presented in Table 26.1 of Annex 1 of Appendix 13.1 these figures appear to be too low: - In Table 13.26 (autumn) the figure given for 100% displacement and 100% mortality is 17, but Table 26.1 of Annex 1 of Appendix 13.1 suggests this figure should be 30 (29.76) for Vanguard West + 4km buffer (100% capacity). - In Table 13.27 (winter) the figure given for 100% displacement and 100% mortality is 24, but Table 26.1 of Annex 1 of Appendix 13.1 suggests this figure should be 354 (353.92) for Vanguard West + 4km buffer (100% capacity). - In Table 13.28 (spring) the figure given for 100% displacement and 100% mortality is 5, but Table 26.1 of Annex 1 of Appendix 13.1 suggests this figure should be 302 (302.22) for Vanguard West + 4km buffer (100% capacity). If this is the case then the whole matrix tables and impact assessment need to be updated. We also note that these figures may change once the remaining 6 months of data (March-August 2017) have been included for the Vanguard West site.	The assessment has been reviewed and updated and also now incorporates additional survey data for NV West which was not available for the PEIR.

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		Table 13.29 presents the red-throated diver combined Vanguard East and Vanguard West operational disturbance and displacement impacts for the various build out scenarios for each relevant season and highlights the worst case for each season. It would also be useful if matrices can be provided (in an annex) for each scenario.	The worst case scenarios have been revised and hence the assessments have also been revised (section 13.7.5.1).
		Paragraph 213 states: 'The displacement matrices have been populated with data for gannets during the autumn and spring migration periods within the site and those calculated within a 2km buffer, in line with guidance (Joint SNCB Note 2017).' The breeding season has not been included in the assessment, which should be done, as even though peak numbers of gannets occur in the Vanguard site outside of the breeding season, the data presented in Annex 1 of Appendix 13.1 show that gannets were recorded in lower numbers in all months in the breeding season. Inclusion of the breeding season will allow a complete annual prediction to be made. We note our summary point III above regarding concerns over the appropriateness of the assumption that there would only be a proportion of displacement based on the proportion of capacity built in each site.	The assessment has been revised to accommodate consideration of impacts throughout the year (section 13.7.5.1).
		We welcome that the spring and autumn migration period (i.e. non-breeding season) displacement assessments have been summed (paragraphs 219-220; 224-225; 230-231). However, breeding season impacts should also be added to this to give an annual predicted impact, which is then assessed against the baseline mortality of the largest BDMPS and biogeographic population.	The assessment has been revised to accommodate consideration of impacts throughout the year (section 13.7.5.1).
		Table 13.34 presents the gannet combined Vanguard East and Vanguard West operational disturbance and displacement impacts for the various build out scenarios for each relevant season and the non-breeding season combined and highlights the worst case for each season. It would also be useful if matrices can be provided (in an annex) for each scenario.	The worst case scenarios have been revised and hence the assessments have also been revised (section 13.7.5.1).
		Auks – Puffin, Razorbill, Guillemot We welcome that the assessments include figures for predicted displacement across a range of displacement and mortality scenarios, and that the predictions for each relevant season,	The worst case scenarios have been revised and hence the assessments have also

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		including the breeding season, are then summed to give an annual predicted total that have been assessed against the baseline mortality for the largest BDMPS and the biogeographic population. However, we note: The concerns we have raised in our summary point III above regarding concerns over the appropriateness of the assumption that there would only be a proportion of displacement based on the proportion of capacity built in each site. Our summary point IV above regarding the need to present data and predicted impacts in a way that allows the full range of uncertainty (e.g. around input data, analysis, methodology) to be understood and evaluated. The recommendation that the sensitivity of guillemot and razorbill to displacement should be considered to be medium rather than low to medium. Tables 13.48 and 13.55 present the razorbill and guillemot combined Vanguard East and Vanguard West operational disturbance and displacement impacts for the various build out scenarios for each relevant season and the annual impacts combined and highlights the worst case for each season. It would be useful if matrices can be provided (in an annex) for each scenario.	been revised (section 13.7.5.1).
		We welcome that collision risk modelling (CRM) outputs have been presented for Band (2012) Options 1 and 2. Paragraph 311 notes that Option 2 uses the percentage of birds flying at PCH derived from data presented in Johnston *et al*. (2014). As noted at EA3, Natural England considers it inappropriate to use the Johnston *et al*. (2014) generic flight height curves for boat-based data with site-specific densities from aerial surveys in CRM assessments using the Band model. We therefore advise that the focus, wherever possible should be on the CRM Band Option 1 outputs.	We note this comment. However, following subsequent advice provided by the aerial survey contractor (see section 13.7.5.3 and Technical Appendix 13.1) we are unable to base the collision assessment on option 1 (site-based flight heights) and hence the assessment uses the results of option 2 modelling. Both sets of results (options 1 and 2) are presented in the technical appendix.

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		Paragraph 313 notes the work undertaken by APEM Ltd. looking at gannet avoidance rates at Greater Gabbard. We acknowledge the findings in APEM (2014) that use of the 98.9% avoidance rate for the basic Band model may overestimate collision predictions. At present our advice regarding gannet avoidance is as per the joint Statutory Nature Conservation Bodies response to the Marine Scotland review of avoidance rates report by Cook *et al*. (2014), i.e. 98.9% avoidance rate for gannet with the basic Band model. As this study is based on just 8 gannets entering the offshore wind farm, there is not enough evidence to robustly determine the avoidance rate. However, we welcome future monitoring along the lines of the APEM (2014) study to determine an appropriate avoidance rate for gannet.	No update required.
		Paragraph 316 notes the work previously undertaken for EA3 on nocturnal flight activities. We note that the work previously undertaken for EA3 (EATL 2015) presented a reasonable amount of evidence of nocturnal flight activity of gannet and kittiwake, but much less was presented for lesser black-backed gulls and none for herring gulls or great black-backed gulls. Therefore, Natural England does not consider there to be sufficient evidence to accept changing the nocturnal factor used for large gulls. However, there may be sufficient evidence for stating that the nocturnal activity assumed for gannet and kittiwake in the CRM can be considered a precautionary approach. But we do note that following the second Offshore Ornithology Expert Topic Group meeting, MacArthur Green are going away to consider this further.	We understand that Natural England have provided advice to Norfolk Boreas OWF to present collision modelling with existing nocturnal activity levels and reduced ones (by 25%) for all the species named here. A review of tag-based studies has identified revised nocturnal flight activity estimates for gannet (Furness subm.). Collision modelling for this species has used these revised figures. Although a similar review will shortly be available for kittiwake, no work has been conducted to date for the larger gull species. Thus, these gull species have been modelled in line with the Natural England advice noted above (existing nocturnal

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			level and reduced level).
		Paragraph 318 identifies great skua, Arctic skua, Arctic tern and common tern as potential migrants through the Vanguard site where collision risks have been estimated using Options 1 and 2 and also following the methods described in WWT & MacArthur Green (2014). We welcome that this approach has been undertaken for these species and suggest that little gull is also a species assessed using this approach.	No action required.
		Paragraph 322 states: 'The default avoidance rate was 99%, the exceptions to which were for gannet and kittiwake (98.9%) and large gulls (99.5%)': We note that the default avoidance rate for species not covered by Cook *et al*. (2014) and the joint SNCB response to this work should be 98% and not 99%. The joint SNCB response to Cook *et al*. (2014) states that for other seabirds (e.g. skuas) and waterbirds (e.g. divers, seaducks, etc.) Cook *et al*. (2014) does not conduct an analysis or provide recommended avoidance rates for any version of the Band model. In light of this, the SNCBs continue to recommend the basic Band model, in conjunction with a default 98% avoidance rate, for predicting collisions of species other than those detailed here, until such time as further species-specific work has been undertaken.	The default avoidance rate for species not specifically identified in Cook *et al*. (2014) has been revised to 98%.
		Paragraph 323 states: 'Only gannet and kittiwake had sufficient flight height observations (i.e. >100) to permit robust site-based height estimates across the three survey datasets (for the former East Anglia FOUR, NV East and NV West). For these two species collision estimates assessed use Band option 1. For all other species Band Option 2 is used': We assume that this is considering just the data from the Vanguard East and West sites and does not include the 4km buffers – as the data presented in Table 10 of Annex 3 of Appendix 13.1 shows that the old EA4 dataset had over 100 records of fulmar and great black-backed gull as well as gannet and kittiwake for the site + 4km buffer. We would suggest that the data from the Vanguard East and West sites + 4km buffers are used for establishing sufficient flight height observations in order to maximise the data set, unless there is reason to believe that flight	We note this comment however, as noted above, we are unable to base the collision assessment on option 1 (site-based flight heights) and hence the assessment uses the results of option 2 modelling. Both sets of results (options 1 and 2) are presented in the technical appendix.

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		heights in the buffers are significantly different to the sites. This should be revisited once all the data from Vanguard West are available.	
		Tables 13.56 and 13.57 – seasonal and annual collision estimates for each project scenario for 7MW and 15MW turbines. It is unclear for which avoidance rate the collision figures presented in these tables refer to – we assume they are for the recommended avoidance rates for the Basic Band model, i.e. 98.9% for gannet and kittiwake, 99.5% for lesser black-backed gull, herring gull, great black-backed gull and 98% for fulmar, skuas, little gull, common gull. This needs to be made clear.	Clarification has been provided.
		Seabird collision mortality estimates. We welcome that collision mortality predictions have been presented for gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull for Band Options 1 and 2 for a range of avoidance rates, which include the SNCB recommended rates for these species for the 'basic' Band model as well as the recommended +/- 2SD of these rates. We also welcome that for Option 2 outputs have also been provided for the %PCH for the maximum likelihood and upper and lower 95% confidence limits of the generic flight height data. This takes account of the uncertainty in avoidance rates and flight heights. We also note that uncertainty in the bird densities could also be incorporated by providing collision predictions using the upper and lower confidence limits of the density data.	Additional collision modelling, taking into account uncertainty in a range of parameters has been conducted and is presented in full in the technical appendix and is summarised in section 13.7.5.3).
		Paragraph 330 suggests that the Vanguard site is within mean maximum foraging range of lesser black-backed gull only. We note that Table 13.9 suggests that the Vanguard site is a minimum of 205km from the Flamborough and Filey Coast pSPA and hence the site is within the mean-maximum foraging range of 229.4km of gannet in Thaxter *et al*. (2012).	The text has been updated to acknowledge this fact.
		Paragraph 331 notes that the BTO have undertaken several years of GPS tracking of breeding lesser black-backed gull from the Alde-Ore Estuary SPA colony (Thaxter *et al*. 2015) and that the results of this show there was virtually no overlap between the foraging areas and the wind farms. We suggest that a figure(s) is included to illustrate the evidence to support this statement. Paragraph 331 also notes that based on the tracking work it is therefore likely that very few of the lesser black-backed gulls recorded during the	A figure has been copied from the source publication as suggested and included in Technical Appendix 13.1. The survey data have been analysed in relation to Natural England's suggestion of looking at age

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		breeding season on the Norfolk Vanguard sites are breeding adults from this colony: If these birds are not from the Alde-Ore, then which colonies are these birds coming from? We note that even though the tracking studies of birds from the Alde-Ore found that few tracks approached the Vanguard OWF area, these studies only track a small proportion of the birds from the site, so it cannot be ruled out that they are linked to the Alde-Ore. If the birds recorded on the site are non-breeders and/or immatures, then we would assume that a proportion of these are linked to the Alde-Ore SPA. Are there any age data available from the aerial surveys for the lesser black-backed gulls identified on the Vanguard sites during the breeding season?	distributions of lesser black-backed gulls. Details of this analysis are presented in Technical Appendix 13,1 Annex 8, and this has been used to inform the relevant sections of the assessment.
		Paragraph 332 uses the non-breeding season Biologically Defined Minimum Population Scales (BDMPS) proportion of immature birds to calculate breeding season populations, for all species assessed for CRM. We note the comments we have raised in our summary point V above regarding this. This is particularly relevant for lesser black-backed gull and we would suggest that the breeding season BDMPS used here is calculated based on all colonies within foraging range of the Vanguard site.	The assessment has been revised to address these points.
		Table 13.60 - Percentage increase in the background mortality of seasonal and annual populations due to predicted collisions due to the worst case 7MW turbine and species specific worst case development scenario: - It needs to be clear from this table which Band model option (1 or 2) outputs have been used to calculate these figures. We assume it is Option 1 for gannet and kittiwake and Option 2 for the large gulls. We also assume that the CRM outputs presented are for the recommended avoidance rates (i.e. 98.9% for gannet and kittiwake and 99.5% for the large gulls) and the median generic flight heights (where Option 2 is presented). We would suggest that figures are presented for the range of avoidance rates and generic flight height data, so that the conclusions can be based on a range of figures. - The reference populations used here are the biogeographic populations. We would suggest that the assessment is done against the baseline mortalities of both the largest BDMPS and the biogeographic population, as has been done for	The assessment has been revised to address these points and also to accommodate other revisions since the PEIR analysis was conducted (section 13.7.5.3).

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		the operational displacement for auks as this will give a range for the impact.	
		Paragraph 203 makes conclusions on the magnitude and significance of impact from collision risk, but no reference is made to the sensitivity of each species to collision risk – this should be included somewhere in the assessment.	The assessment has been updated to address this point (section 13.7.5.3).
		Additive impacts: Natural England considers the two impacts of collision and displacement as additive and advises that they should be summed – this is of particular relevance for gannet. We acknowledge that in summing the predicted mortalities that may arise via these two mechanisms, there is a risk of double counting. Thus, it is acknowledged that this simplistic approach will therefore incorporate a degree of precaution. However, the extent of that is hard to gauge given that the predictions of the number of fatalities due to collisions depends critically upon application of an assumed overall avoidance rate (i.e. an assumed percentage of individuals which alter their flight behaviour to avoid collisions) which in some cases can be considered to incorporate some degree of macro-avoidance of entire wind farms and might otherwise be classed as barrier impacts. The SNCBs are seeking further evidence from ongoing and proposed studies into avoidance rates that will help clarify the relationship between collision risk, displacement and so called 'macro' avoidance.	We do not consider it appropriate to combine these mutually exclusive sources of potential impact for gannet at this location. This is due to the fact that almost all records of this species occur outside the breeding season when the consequences of displacement from the wind farm for this species, which undertakes migration to west African waters, will be negligible, since the scale of movements makes it clear the species is not reliant for resources on any given location in the southern North Sea.
		Table 13.61 – Key parameters for predicting collision risk for migrant seabirds: - The figures for the percentage of birds at rotor height presented in the table are referenced as being from Johnston *et al*. (2014) – however, these figures look to be the ones in Cook *et al*. (2012) and not Johnston *et al*. (2014) – the figures from the corrigendum to Johnston *et al*. (2014) are: Arctic skua – 2.6%, great skua – 5.9%, Arctic tern – 4%, common tern 7.4%, so we would suggest that these are updated. We note that the figures presented in Johnston *et al*. (2014) are for a 20-120m turbine, therefore, we suggest that the flight height data from Johnston *et al*. (2014) are used to calculate the %PCH for each species for	The Johnston *et al*. (2014) data have been used for the options 2 collision assessment. Migration corridors have been reviewed and amended as necessary (Section 13.7.5.3).

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		the Vanguard worst case scenario turbine specifications. It also appears that currently the %PCH figures presented in Table 13.61 for Arctic and great skuas are the wrong way round. - We suggest that the migration corridor of 0-10km presented for Arctic tern is checked, as WWT & MacArthur Green (2014) lists this as 0-20km.	
		Paragraph 341 states: 'NV West and NV East are located 47km and 70km from the coast at their nearest points. These are farther offshore than any of the corridor widths for the migrant seabird species in Table 13.61. While a few individuals may travel beyond the outer edges of these corridors, given the low percentages at collision height the overall collision risk will be very small. Consequently, any effects from Norfolk Vanguard will be negligible and cause no material difference to current baseline mortality rates. The magnitude of effects is considered to be negligible for all species. Therefore, no impacts would be expected to result from collisions for any of these migrant seabird species': With regard to the migrant seabirds considered so far, while we cannot say with certainty that there will be no impact, we do agree that given the distance Norfolk Vanguard is offshore, any impacts will be negligible. We advise that little gull is also considered here, although note that given that WWT & MacArthur Green (2013) gives a likely migration corridor of 0-20km for this species that it is likely that the same conclusion will apply as for skuas and terns already considered. Migrant non-seabirds: As noted above, we do not consider that it is appropriate to just say that it wasn't an issue at EA3, so it won't be here. Consideration should be given to whether there are any relevant SPAs that may be in the shadow of the Vanguard offshore wind farm (e.g. at EA One there were concerns over dark-bellied brent geese migrating through the site to the Deben Estuary). There may be need to consider sites such as the North Norfolk Coast/Breydon Water. As a minimum we would suggest that the CRM is re-done using the densities produced at EA3 (if they are appropriate after consideration of any SPAs that may be in the shadow of the site) and the Vanguard turbine specifications, site details etc.	The migrant seabird assessment has been updated as suggested (section 13.7.5.3). The migrant non-seabird assessment has been considered in further detail and additional assessment included as necessary (section 13.7.5.3).

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		We agree that any effects of decommissioning are likely to be similar to those generated during the construction phase. However, we note that further consultation regarding decommissioning activities will be required with SNCBs to allow any best practice to be incorporated to minimise potential impacts.	Noted.
		Table 13.62 – Potential cumulative impacts: Both points on construction impacts should make reference to any potential overlap, particularly temporally, with construction of EA3, unless there is absolutely no chance of construction timings of these two sites overlapping. Consideration should perhaps also be given to any potential for cumulative operation of EA3 overlapping with construction of Norfolk Vanguard.	Consideration of these points has been made in the revised assessment (section 13.8.2).
		Cumulative effects are considered for kittiwake, common gull, lesser black-backed gull, herring gull, great black-backed gull and red-throated diver. We suggest that effects on little gull, common scoter and terns are also considered.	Consideration has been given to the inclusion of these species in the cumulative assessment.
		Table 13.63 – Summary of projects considered for CIA: It would be useful if the tier each windfarm is considered to be in was included in this table. We note that EA3 has now been consented. We note that the PEIR for Hornsea 3 has been completed and is available at: http://www.dongenergy.co.uk/en/Pages/PEIR-Documents.aspx However, we note that this document is based on only 11 months of baseline data and so the figures presented are likely to change. However, they could be used here to give an indication of likely impacts from this project.	The cumulative assessment has been updated to reflect the currently available data (section 13.8.2.3).
		Paragraph 370 suggests that the species assessed for project alone operational displacement impacts (and the relevant seasons) included black-throated diver and great northern diver. We suggest that this is checked as these species were screened out of the operational displacement for the site alone based on the very few surveys on which these species were recorded. Paragraph 371 talks about the windfarms included within the BDMPS for the cumulative impact assessment	These sections (13.8.2.4) have been revised accordingly.

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		for red-throated, black-throated and great northern divers, which suggest that all three diver species have been included in the cumulative assessment. However, we note that Section 13.8.2.5 (cumulative assessment of operation displacement risk) does not include any assessments for black-throated and great northern divers.	
		Paragraph 372 states: 'The species assessed for project alone collision impacts (and the relevant seasons) were those for which collision mortality greater than 30 individuals was estimated.' We note that this list of species will need to be revisited once the remaining 6 months of data are included for Vanguard West and the CRM has been revised. We also note that a figure of predicted mortality of greater than 10 individuals was used as the cut off figure at EA3 for including species in CRM impact assessments for the project alone – we would recommend that this is again used here rather than the higher figure of 30.	We have updated the collision modelling with additional data and for the use of option 2 throughout. Following this any further revision in light of this comment has also been included (section 13.8.2.5).
		Paragraph 373 states: 'BDMPS populations have not been defined for common gull and little gull, therefore these species have been assessed in relation to their biogeographic populations with connectivity to the North Sea.' This suggests that common and little gull have been included in the cumulative CRM assessments, but these species have not been included in the assessments in Section 13.8.2.6 (cumulative assessment of collision risk).	These sections (13.8.2.5) have been amended.
		Cumulative Assessment of Operation Displacement Risk For all species assessments we note our summary comment I above regarding there being a remaining 6 months of data to be included for the ES for Vanguard West. We also note the concerns we have raised in our summary point III above regarding the appropriateness of the assumption that there would only be a proportion of displacement based on the proportion of capacity built in each of Vanguard East and West. The assessments for all species are based on taking the cumulative figures presented for EA3 and adding the Norfolk Vanguard predictions to these totals. Therefore, the cumulative figures presented do not include figures for Hornsea 3 – whilst figures may not have been available at the time of drafting this PEIR, the Hornsea 3 PEIR has	The cumulative assessment has been updated to reflect the currently available data (section 13.8.2.6).

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		been submitted at Section 42 and is available at: http://www.dongenergy.co.uk/en/Pages/PEIR-Documents.aspx We note that this document is based on only 11 months of baseline data and so the figures presented are likely to change. However, these figures could be used here to give an indication of likely impacts from this project. For all species assessed, we suggest that a matrix table is included for summed annual cumulative impact assessment (to include all seasons, including the breeding season for all except red-throated diver) and that assessments are then made of the annual predicted mortalities against the baseline mortality of the largest BDMPS and the biogeographic population.	
		Red throated diver In addition to the general recommendations made for all species assessments, we also note the queries we have raised regarding the need to check the figures used in the displacement matrices for Vanguard West. Therefore, at present we cannot make comment/agree to the conclusions made in paragraph 376 regarding the level of impact from cumulative operational displacement to red-throated diver.	This section has been updated (13.8.2.6.1).
		Gannet In addition to the general recommendations made for all species assessments, paragraph 377 states: 'Norfolk Vanguard East and Norfolk Vanguard West are located beyond the mean maximum foraging range of gannets from breeding colonies in the North Sea. Therefore, displacement risk is only of concern outside the breeding season.' We note that Table 13.9 of the PEIR chapter lists the Flamborough & Filey Coast pSPA as being a minimum of 205km from Vanguard. Therefore, Vanguard is within the 229.4km mean-maximum foraging range of gannet from the Flamborough pSPA colony. As noted in our summary comment II above, breeding season impacts should also be considered and these should be summed together with the impacts from the non-breeding period (i.e. autumn and spring migration). The annual predicted mortality should then be assessed against the baseline mortality of the largest BDMPS and the biogeographic population.	This section has been updated (13.8.2.6.2).

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		Auks In addition to the general recommendations made for all species assessments, we note that the assessments for all auk species have considered that an increase in mortality due to displacement from windfarm sites seems likely to be at the low end of the proposed 1 - 10% range, and a value of 1% when combined with the precautionary 70% displacement rate is considered appropriate for wintering auks. Whilst Natural England agrees that the mortality for auks is likely to be at the low end of the range, we do not agree that using 1% mortality for the cumulative assessment (with 70% displacement) can be considered the worst case scenario. Our recommendation is a range from 30% displacement and 1% mortality up to 70% displacement and 10% mortality, with 70% displacement and 10% mortality as the worst case. Which is the same worst case scenario as used in the assessment of the project alone. Whilst the mortality across the different seasons that make up the non-breeding season have been summed for the assessment of Vanguard West and East combined, there does not appear to be any displacement impacts in the breeding season from other North Sea projects added to the overall cumulative assessment of displacement impacts. As advised at EA3, we advise that a further assessment is undertaken that incorporates the cumulative impact across the whole annual cycle (including the breeding season), where seasonal impacts are summed. The cumulative total should then be assessed against the appropriate scale (which was agreed at the first Offshore Ornithology Expert Topic group meeting would be both the BDMPS and the biogeographic population). The assessments should then look at what point 1% of baseline mortality (of BDMPS and biogeographic population) is exceeded, in order to make a judgement on whether the cumulative displacement impacts are significant at an EIA level for each auk species. We again note the recommendation that the sensitivity of guillemot and razorbill to displacement should be considered to be medium rather than low to medium.	This section has been updated (13.8.2.6.3).

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		Cumulative Assessment of Collision Risk Assessment As with cumulative displacement, for all species assessments we note that the figures for Vanguard may potentially change once the remaining 6 months of data have been included for Vanguard West (March-August 2017). The assessments for all species are based on taking the cumulative figures presented for EA3 and adding the Norfolk Vanguard predictions to these totals. Therefore, the cumulative figures presented do not include figures for Hornsea 3 – whilst figures may not have been available at the time of drafting this PEIR, the Hornsea 3 PEIR has been submitted at Section 42 and is available at: http://www.dongenergy.co.uk/en/Pages/PEIR-Documents.aspx We note that this document is based on only 11 months of baseline data and so the figures presented are likely to change. However, they could be used here to give an indication of likely impacts from this project. The figures presented in the cumulative collision tables for lesser black-backed gull, herring gull and great black-backed gull for the various Vanguard scenarios are for Option 2 (Tables 13.77-13.79). This is due to the number of records of these species in flight from the current data set used being less than 100 records. This should be revisited once the remaining 6 months of data for Vanguard West are included. We also note our suggestion made above that all the data from the Vanguard East and West sites + 4 km buffers are used for calculating %PCHs and informing which 'basic' Band option is most appropriate in order to maximise the data set. The assessments for all species (except gannet) states '…The only projects consented after November 2014 are Hornsea Project 1, Dogger Bank Creyke Beck A&B and Dogger Bank Teesside A&B. Therefore, the previous cumulative annual collision total excluding these three projects would have been…' We note that both Hornsea 2 and EA3 have also been consented after November 2014, so we suggest that this is updated to reflect that.	This section has been updated (13.8.2.7).
		Gannet Paragraph 442 notes the work undertaken by APEM at Greater Gabbard that suggest gannet avoidance rate should be even higher than 98.9%.	Noted.

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		Natural England acknowledges the findings in APEM (2014) that use of the 98.9% avoidance rate for the basic Band model may overestimate collision predictions. At present our advice regarding gannet avoidance is as per the joint Statutory Nature Conservation Bodies response to the Marine Scotland review of avoidance rates report by Cook *et al*. (2014), i.e. 98.9% avoidance rate for gannet with the basic Band model. As this study is based on just 8 gannets entering the offshore wind farm, there is not enough evidence to robustly determine the avoidance rate. However, we welcome future monitoring along the lines of the APEM (2014) study to determine an appropriate avoidance rate for gannet. The cumulative CRM annual total for gannet based on the data that has been included in the PEIR is between 2,967 and 3,168, which equates to 3.40-3.63% of baseline mortality for the largest BDMPS (autumn migration in Furness 2015) and 1.32-1.41% of baseline mortality for the biogeographic population, which is a significant impact and therefore requires further consideration. We note and welcome the use of the SOSS gannet PVA model outputs (WWT 2012) and that even when the west coast offshore wind farms are included (giving a cumulative total of between 3,000-3,200 collisions) the cumulative total is below the figure predicted by the WWT (2012) density independent model of 10,000 individuals per year before the population growth would not remain positive, and just above the 95% confidence interval on population growth, which remained positive until additional mortality exceeded 3,500 individuals. However, we note that the national population has increased since the WWT model, so thresholds would also have gone up.	
		Paragraph 448 notes that the relative contribution of the proposed Norfolk Vanguard project to this cumulative total is small. We note that based on the data that has been included in the PEIR, the Vanguard contribution of 93-293 gannet collisions to a cumulative total of 2,967-3,167 collisions is 3.13-9.25%, which does not seem that small.	Noted.
		Paragraph 453 notes the review of nocturnal flight activity undertaken for EA3 and that this suggests that nocturnal activity for kittiwake is too high and reducing this could reduce the overall cumulative collision estimate by 7-25%, so	As noted above, work is ongoing in relation to this aspect for kittiwake. The collision assessment has been

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		again the cumulative figures are likely to be an overestimate. Natural England notes that a review of nocturnal activity has indicated that the value of 50% used in CRM is likely to be an over estimate. However, we note that there has been no proposal/evidence collected validating assumptions about nocturnal activity. This could be something that the regulators and industry consider as part of any monitoring conditions within marine licences.	revised to reflect the current thinking on this parameter.
		Paragraph 454 refers to the PVA model that was developed at EA3 to assess the potential effects of cumulative mortality on the kittiwake BDMPS populations (EATL 2015). It notes that using the density dependent model, cumulative annual mortality of 4,250 individuals (assessed against the larger autumn BDMPS population) was predicted to result in the population after 25 years being 3.6% to 4.7% smaller than that predicted in the absence of additional mortality. We advise that the density independent model outputs are also presented/considered here.	This section has been updated (13.8.2.7.2).
		Paragraph 455 states: '…the worst case cumulative collision mortality is considered to be of low to medium magnitude, resulting in impacts of minor to moderate adverse significance. However, when the various sources of precaution are taken in to account (precautionary avoidance rate estimates, reduction in wind farm size, over-estimated nocturnal activity) the cumulative collision risk impact magnitude is reduced to low, and the impact to minor adverse significance.' Given that the British kittiwake population is declining and based on the figures currently presented, we do not agree with the reduction of the significance from minor to moderate adverse significance to minor adverse significance. This is because the figures currently presented for cumulative kittiwake collision mortality for the various Vanguard scenarios equate to 2.86-3.24% of baseline mortality for the largest BDMPS population and 0.47-0.53% of baseline mortality for the biogeographic population, which is not insignificant and requires further consideration. Based on the current figures, Vanguard contributes 6.9-17.7% of the total kittiwake cumulative CRM collision figure, which appears to be a fairly sizeable contribution to the overall total.	This section has been updated (13.8.2.7.2).

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		We would welcome any proposals of best practice mitigations that seeks to reduce the in-combination collision total, for example by raising the height of the lower rotor tip of the turbines (which would also be relevant for other species in seeking to reduce the in-combination collision total). Also, it would appear that based on the current build out scenarios considered that Option 4 (67% of capacity in Vanguard East and 33% in West) represents the worst case option in terms of kittiwake collisions from the Vanguard project (this is also the case for all other species considered for CRM except LBBG based on the data currently available). Therefore, we would also suggest that further information is given on the likelihood of each build out scenario occurring.	
		Lesser black-backed gull (LBBG) Based on the data currently presented the total cumulative LBBG CRM total is between 524 and 562 collisions per annum, which equates to between 1.99-2.14% of baseline mortality for the largest BDMPS (autumn migration in Furness 2015), which is not insignificant. However, the cumulative CRM total equates to 0.48-0.52% of baseline mortality for the biogeographic population. The impact likely lies somewhere between the ranges of these figures. We suggest that the assessment of the predicted impact also considers the population trend of the population the assessment is dealing with. Based on the current figures, Vanguard contributes 9.5-15.6% of the total LBBG cumulative CRM collision figure, which appears to be a fairly sizeable contribution to the overall total.	This section has been updated (13.8.2.7.3).
		Herring gull Based on the figures presented in the PEIR, the total predicted cumulative herring gull CRM total is 705-732 collisions per annum, which equates to 0.88-0.91% of baseline mortality for the largest BDMPS (non-breeding in Furness 2015) and 0.37-0.39% of baseline mortality for the biogeographic population. Therefore, at this level of increase to baseline mortality we would agree with the conclusion of a minor adverse impact significance. We would also suggest that the assessment of the predicted impact also considers the population trend of the population the assessment is dealing with.	This section has been updated (13.8.2.7).

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		Great black-backed gull (GBBG) Based on the figures presented in the PEIR, the total predicted cumulative GBBG CRM total is 881-939 collisions per annum, which equates to 5.21-5.26% of baseline mortality of the largest BDMPS (non-breeding in Furness 2015) and 2.03-2.16% of the baseline mortality of the biogeographic population, which is not insignificant and requires further consideration. We suggest that this could be done by considering the approach we outlined to Norfolk Vanguard in our response following the first Offshore Ornithology Expert Topic Group meeting (outlined in our comments on the Consultation section above). We note that reference has been made to the decision at Rampion (in paragraphs 476-477), but no reference is made to the PVA constructed for GBBG for EIA scale at EA3. We would suggest that reference is made to the outputs of this here, including reference to the density independent model outputs. We suggest that the assessment of the predicted impact also considers the population trend of the population the assessment is dealing with. Based on the above, we currently do not agree with the conclusion of a minor adverse impact significance. The figures presented in the PEIR suggest that Vanguard contributes 4.64-10.53% of the total GBBG cumulative CRM collision figure, which appears to be a fairly sizeable contribution to the overall total.	This section has been updated (13.8.2.7.4).
		Transboundary Impacts: We note that no transboundary impacts have been considered in the PEIR – is this because these have been screened out? If this is the case, then justification should be provided on the reasons for this.	Transboundary impacts have been considered in relation to designated sites in the Habitats Regulations Assessment.
		13.10 - We suggest that this section is updated in light of the comments made above and once all the data are incorporated into the assessments.	This section has been updated (13.12).
NE	PEIR Appendix 13.1 11th December 2017	Are any data available on bird flight directions and age class proportions from the aerial survey data? – as this may be useful to inform whether lesser black-backed gulls (LBBG) recorded in June and July in Vanguard West may be immatures rather than breeding adults (will also potentially be useful for other species and the conclusions	A further review of the survey data was conducted to investigate these suggestions. The results of this analysis are provided in

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		currently made that birds present at the Vanguard sites in the breeding season are immatures). Flight direction data may provide information to suggest that birds recorded at the site are heading in the general direction towards or away from breeding colonies (e.g. for LBBGs heading either to or from the Alde-Ore Estuary).	Technical Appendix 13.1 Annex 8 and have been used to inform the relevant sections of the assessment.
		Table 14 – Species biometrics used in CRM: Clarification is needed on the sources of information for each of the biometrics presented in this table.	These are standard metrics as used in recent assessments.
		Clarification is required in the headings for all results tables presented on which avoidance rate has been used – we assume it is the one recommended in the SNCB response to Cook *et al*. (2014), i.e. 98.9% for gannet and kittiwake; 99.5% for lesser black-backed gull, herring gull, great black-backed gull; and 98% for all other species not covered by Cook *et al*. (2014) and the joint SNCB response. Clarification is also required in the headings for all results tables regarding which generic flight height data set (e.g. median, upper or lower confidence level) have been used for the Option 2 outputs presented – we assume it is the median data set.	Additional clarity on this matter has been provided.
		Helicopters represent a very loud and disturbing form of transport and are known to disturb birds. Any use of helicopters will have to be assessed, with various conditions likely required, such as: certain flight heights and flight paths and the speed at which altitude is gained. This is particularly important when transiting over protected sites.	This aspect has been considered in section 13.7.4.
RSPB	PEIR 11th December 2017	The RSPB is unable to agree at this stage that no impacts greater than minor significance will occur to ornithological interests as a result of offshore elements of the project. Our concerns relate principally to collision risk to gannet and kittiwake, particularly in relation to the Flamborough and Filey Coast pSPA, lesser black-backed gull of the Alde-Ore Estuary SPA and great black-backed gull. Whilst at this stage our concerns relate primarily to cumulative impacts, given the level of collision risk predicted at this stage for this project and more generally in the southern North Sea, we consider it likely that the Habitats Regulations Assessment is required due to further concerns relating to the project in-	The relevant sections of this assessment provide full details of the predicted impact magnitudes and significance, with justification for the conclusions reached.

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		combination with others, and possibly the project alone.	
		The choice of construction scenario (the balance of development between Norfolk Vanguard East and West, along with choice of turbine size) will be an important factor in determining significance of impacts and we advocate the use of a scenario maximising development within Norfolk Vanguard West (although note that whilst this is the best case scenario for most species, it is the worst case scenario for lesser black-backed gull) along with the use of the largest turbines possible. Given the level of collision risk predicted, we also consider that mitigation should be proposed at an early stage to reduce impacts as far as possible.	These aspects have been taken into account in the assessment. However, it should be noted that there is also a need for the project to balance these concerns against those from other disciplines and to give consideration to other project constraints.
		The PEIR throughout makes the assertion that birds present in the breeding season are unlikely to be breeding birds, and makes erroneous statements regarding foraging ranges, such as in para. 377 which states that Norfolk Vanguard is outside the mean-max foraging range of gannet from North Sea colonies. At 205km from the Flamborough and Filey Coast (FFC) pSPA, Norfolk Vanguard is within the mean-max foraging range of gannet (229km). It is also within the meanmax foraging range of lesser black-backed gull (141km), being sited 92km from the Alde-Ore Estuary SPA. Non-breeding adults and juveniles which are part of SPA populations may also be present and should be considered as they could breed in future.	These aspects have been reviewed and updated in the relevant sections of this ES.
		The RSPB considers that any decision to screen species out from further assessment should be properly justified. Para. 326 explains that collision risk to little and common gulls is screened out from further assessment as annual collisions are less than 30. We consider that this is an arbitrary threshold and that further justification for this should be given.	The collision assessment has been further refined for this ES and screening decisions have been supported with evidence as appropriate.
		We note that apportioning of offshore impacts (collision risk and displacement) to SPAs both alone and in-combination with other projects has not yet been carried out and that this will need to be addressed to ensure compliance with the Habitat Regulations requirements.	This aspect has been addressed in the Information to support the Habitats Regulations Report.
		We note that the migration-free breeding season has been used rather than the standard breeding season as it is assumed that there is a very low presence of breeding birds within the project	We note the RSPB's position on the assignment of months to appropriate

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		area. We disagree with this assumption, as explained in point 1. For example for gannet, the migration-free breeding season excludes March and September, which reduces the number of predicted collisions. But gannets start arriving in January and establishing their nest sites in March. Whilst peak fledging is in August, some birds are still fledging in September, hence there is a strong argument for considering these months to be part of the breeding season. For kittiwake, the migration-free breeding season excludes March-April and August, which again significantly reduces the number of collisions. The first kittiwakes arrive at the colony in February, with most birds back by March and remaining until August, hence there is a strong argument for considering March, April and August to be part of the breeding season. If figures for the migration-free breeding season are to be presented, we consider that it would be necessary to attribute birds in the crossover months to breeding and dispersal in order to ensure collision risk to breeding birds is not underestimated. We would therefore like to see cumulative mortality figures presented for the standard breeding season (alongside the migration-free breeding season, if required), as well as the autumn period, so that the contribution of the different seasons to total annual mortality can be determined and, for the purposes of HRA, impacts on the FFC pSPA understood more clearly.	biological seasons. This is complicated by the fact that there may be both migrating and breeding individuals of the same species present in any given area at the same time, albeit from different colonies. The determination of how to accommodate this has been based on the best available evidence and is defined in section 13.6.2.
		For collision risk modelling of breeding season gannet, kittiwake and lesser black-backed gull, a biologically defined minimum population size (BDMPS) for 'breeding season populations of nonbreeding individuals' is calculated based on the percentage of the spring BDMPS which are subadults (Para. 332). This equates to 40% of the spring BDMPS for UK North Sea and Channel for gannets, 47.3% of the spring BDMPS for kittiwake and 42.8% of the spring BDMPS for lesserblack-backed gull. We do not agree, as stated in point 1 above, that there is sufficient evidence that all birds present in the breeding season are likely to be non-breeders. We also would not agree that these assumptions could be used to avoid apportioning any impacts to the SPAs in the HRA. We note the proposal to try to use aerial images to provide ageing data and inform proportion of	This aspect of the assessment has been reviewed and updated where considered necessary.

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		adults/immatures in breeding season and look forward to seeing further information about this in due course.	
		Para. 313 notes that an avoidance rate (AR) for gannet of 98.9% is used for all seasons. This is also presented as likely to overestimate gannet mortality due to work by APEM (2014) which proposed a rate of 99.5% during autumn migration. Whilst the RSPB accept the SNCB's recommended amendment to the gannet AR (from 98% to 98.9%) for non-breeding birds, we do not agree that this figure should be applied to the breeding season due to the lack of available evidence relating to breeding birds. The reason for the difference between Natural England and the RSPB in their preferred avoidance rates for gannet is that the avoidance rate review carried out by the BTO for gannet was almost entirely based on birds outside the breeding season. It would be expected that breeding gannets would behave differently from non-breeding birds, and recent work by Cleasby *et al*. (2015), demonstrated that foraging birds flew higher, and were therefore at greater risk of collision, than commuting birds. In light of this recent evidence, and given that the BTO review was so heavily biased to non-breeding birds, while we accept the rate for non-breeding season, we prefer a lower, more precautionary rate for the breeding season. We therefore consider that an AR of 98% should be presented for the breeding season. The current SNCB advice also highlights that due consideration should be given to uncertainty in collision risk estimates, including the use of confidence intervals around the avoidance rates and flight height estimates.	The collision modelling assessment has been revised since the PEIR and updated where it was considered appropriate. Uncertainty has been included in the collision risk assessment as advised by Natural England.
		Para. 314 - 316 states that nocturnal activity rates are 'almost certainly overestimates'. Nocturnal activity is one of a number of variables included in the Band model process, and recent work by Masden (2015) has indicated how important consideration of these variables is. As such we welcome this review of nocturnal activity. However, we would caution against the use of such a review to make overarching comments on the over-estimation of collision risk at all sites at all times of year. For example, the studies reviewed for non-breeding gannets are robust, and therefore the conclusions are useful. However, for breeding gannets, the authors cite work by Warwick-Evans *et al*. (2015). Again, this is	Further work on this aspect has been undertaken and is in the process of being published in the scientific literature. The RSPB, among others, has had the opportunity to review and provide comments on these studies.

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		a robust study, but we would point out that this reported the highest levels of gannet activity between the hours of 0400 and 0600 in the morning, with a slightly lower peak between 0300 and 0400. Activity associated with foraging by plunge diving, when collision risk is greatest, was highest between 0500 and 0600 and between 1900 and 2000. The purpose of differentiating between night-time and daytime flight activity, as detailed in the Band model guidance, is simply to separate between times when surveys take place (daytime) and where they do not (night-time) and the flight activity factor applied is a correction for this. While timings for when the aerial surveys were carried out are not presented, it is unlikely that surveys were carried out so far from shore between 0300 and 0600, and between 1900 and 2000, and as such the results for gannet could omit a large part of flight activity and therefore produce a potentially serious underestimation of collision risk. This would also be relevant should it be intended to apply the proposed reductions in CR to other windfarms as part of the cumulative/in-combination assessment, as it is unlikely that the timings of surveys undertaken will be known. As such, while a review of the input variables to the Band modelling process is welcome, it is not possible to draw the overly simplistic conclusion that modelled rates of collision mortality are over-estimates.	The collision modelling has been revised since the PEIR and this includes consideration of nocturnal activity levels. Further details are provided in section 13.7.5.3 and n Technical Appendix 13.1.
		The assessment of CR to migrant non-seabirds is taken from work carried out for East Anglia THREE. Para. 319 notes that the population and flight activity data used in that assessment have not been updated. As discussed at a recent Topic Group meeting, we recommend that this assessment is updated to include more locally relevant species, such as those from the Breydon Water, Broadland and North Norfolk Coast SPAs. These may also require consideration in the HRA.	The species named as features at these SPAs were included in the previous work which has been cited for this assessment and there is no evidence to suggest that the results are not valid for this adjacent project.
		As noted above, we do not agree that cumulative collision risk to gannet, kittiwake and great black-backed gull can be considered to be of minor negative significance. These impacts should be regarded as of moderate significance.	Impacts have been reviewed since the PEIR and revised as necessary.
		We note that other Tier 4 windfarms are included in the cumulative collision risk modelling on a qualitative basis only, and therefore that figures from Hornsea 3, which may be significant, are not	The best available data for sites currently in planning have been included in the

Consultee	Date / Document	Comment	Response / where addressed in the ES
		included. These figures should be obtained and presented.	assessment where possible.
		Para. 440 states that many of the collision estimates for other windfarms are based on higher numbers of turbines than were actually installed – based on a method of updating collision estimates presented by EATL (2016) this is stated to overestimate mortality by 13% for gannets, 15% for kittiwakes, 35% for lesser black-backed gull, 30% for herring gull and 30% for great black-backed gull. This is an acceptable point for windfarms where the DCO has been amended and therefore there is legal certainty regarding the reduction, but where windfarms still have their original DCOs, it is not appropriate to do anything less than assess the full extent of those DCOs when considering in-combination/cumulative effects.	The legal argument is acknowledged and the tables of cumulative collisions provide consented collision estimates. However, it remains informative to consider the extent to which these are over-estimates for the reasons stated.
		Para. 454 notes that the EATL density dependent population viability analysis (PVA) outputs for kittiwake indicate an up to 4.7% reduction in population size after 25 years. This is compared to British kittiwake population change over 15 year intervals between censuses (+24%, -25% and -61%) to conclude that change due to windfarms will be undetectable. However, we consider that only the density independent model is robust because results from versions that include density dependence are sensitive to the assumptions made about its strength. The true strength of density dependence is unknown for these seabird populations, therefore density independence is the precautionary approach and so should be considered. Note that density independence may not generate the worst case scenario, as should density dependence be depensatory, impacts could be greater.	Further consideration of density dependence in population modelling is provided in relevant sections.
		Species from the Greater Wash SPA require consideration of displacement impacts during construction (particularly tern species)	The scope of the construction impact assessment has been increased to consider other potentially sensitive species.
		As noted above the RSPB considers that any decision to screen species out from further assessment should be properly justified. Cumulative gannet displacement in the breeding season is screened out on the basis that Norfolk Vanguard is outside the mean max foraging range of North Sea gannet colonies. Table 13.9 shows	Screening justifications have been revised and updated as necessary.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		Norfolk Vanguard to be 205km from FFC pSPA (minimum distance) and so within the 229.4km mean max foraging range of gannets from this colony. Breeding season displacement for gannet is not presented due to 'low' numbers of birds at this season. The Norfolk Vanguard contribution appears likely to be small based on comparison of annual figures with other seasons in Table 13.34 so screening out may be acceptable, but justification for this on the basis of foraging range is not.	
		Cumulative displacement for guillemots is presented for the 'midwinter' period only, despite significant numbers present in Norfolk Vanguard during the breeding period (1501 during standard breeding season). We recommend that figures for the breeding season are also presented.	The displacement assessment has been updated and revised with consideration for all seasons included as necessary.
Ministry of Infrastructure and Water Management Netherlands	PEIR 11th December 2017	Chapter 13 on offshore ornithology has a clear structure, with a good description on used methodology. Some remarks though: • Conclusions on cumulative impacts are less clear and structured: worst case estimates of collisions/displacement are given followed by a (qualitative) reasoning that actual impacts will be lower. • Attention could also be paid to possible mitigating measures to reduce the impacts, disregard if this is a significant effect or not. We also note that the impact of wind parks in the Netherlands, Belgium and Germany are not taken into consideration. For bird populations which have the Southern North Sea as habitat, an international cumulative approach would be required. Within the international cooperation of North Sea countries as a follow-up of the Political declaration on Energy Cooperation (also signed by the UK) such an approach is looked into and developed further.	The cumulative impact assessment sections have been revised and updated as necessary. Mitigation has been considered where appropriate. Transboundary impacts have been considered in section 13.9.
Ministry for the Environment, France	PEIR 11th December 2017	Some of the wind turbines part of the project will exceed 325 meters above sea level. The rotor and the tower of a wind turbine could increase exposure to the hazards of bird strike. It means that a wind farm project could be a threat for the movement of birds. The Norfolk Vanguard wind farm project, near the East Anglia THREE wind farm project, is located in two main migration corridors.	These aspects (barrier effects and collision risk) have been considered and assessed in full in this ES.

Consultee	Date / Document	Comment	Response / where addressed in the ES
		The barrier effect of a wind turbine is also a reality for the marine wildlife.	

13.4 Assessment Methodology

13.4.1 Impact Assessment Methodology

13. The impact assessment methodology applied in this Chapter is based on that described in Chapter 6 EIA Methodology, adapted to make it applicable to ornithology receptors and aligned with the key guidance document produced on impact assessment on ecological receptors (IEEM, 2010). The impact assessment methodology applied in this chapter has also been consulted on with Natural England and RSPB through the EPP and builds on the approaches adopted for other recent wind farm applications.

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

- Source – the origin of a potential impact (noting that one source may have several pathways and receptors) e.g. an activity such as cable installation and a resultant effect such as re-suspension of sediments.
- Pathway – the means by which the effect of the activity could impact a receptor e.g. for the example above, re-suspended sediment could settle and smother the seabed.
- Receptor – the element of the receiving environment that is impacted e.g. for the above example, bird prey species living on or in the seabed are unavailable to foraging individuals.

13.4.1.1 Sensitivity

15. Table 13.4 provides example definitions of the different sensitivity levels for ornithology receptors using as its example the potential impact of disturbance through construction activity.

Table 13.4 Definitions of sensitivity levels for ornithological receptors

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

16. It should be noted that although sensitivity is a core component of the assessment, conservation value (defined below) is also taken into account in determining each potential impact's significance. Furthermore, high conservation value (defined below) and high sensitivity are not necessarily linked within a particular impact. A receptor could be categorised as being 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. Determination of potential impact significance takes both of these into consideration. 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.

13.4.1.2 Conservation value

17. 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 species, with site-based protection (e.g. Special Protection Areas, SPA) generally limited to specific periods of the year (e.g. the breeding season). Therefore, conservation value 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 wind farm 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 (Table 13.5).

Table 13.5 Definitions of conservation value levels for ornithological receptors

Value	Definition
High	A species for which individuals at risk can be clearly connected to a particular SPA.
Medium	A species for which individuals at risk are probably drawn from particular SPA populations, although other colonies (both SPA and non-SPA) may also contribute to individuals observed on the wind farm.
Low	A species for which it is not possible to identify the SPAs from which individuals on the wind farm have been drawn, or for which no SPAs are designated.

13.4.1.3 Magnitude

18. The definitions of the magnitude levels for ornithology receptors are set out in Table 13.6. This set of definitions has been determined on the basis of changes to bird populations.

Table 13.6 Definitions of magnitude levels for ornithological receptors

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

13.4.1.4 Impact significance

19. 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

13.7. Impacts shaded red or orange represent those with the potential to be significant in EIA terms.

Table 13.7 Impact significance matrix

		Negative 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*

20. 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 and it is not a prescriptive formulaic method. Expert judgement has been applied to the assessment of likelihood and ecological significance of a predicted impact. For the purpose of this assessment the IEEM (2010) guidance is followed which states that an ecologically-significant impact is:

'*an impact that has a negative, or positive, effect on the integrity of a site or ecosystem and/or the conservation objectives for habitats or species populations within a given geographical area. In this way significant impacts are distinguished from other, lesser (and, in the context of EIA, unimportant) effects*'

21. The impact significance categories are divided as shown in Table 13.8.

Table 13.8 Impact significance definitions

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

22. Note that for the purposes of this Chapter, major and moderate impacts are deemed to be significant. In addition, whilst minor impacts are not significant in their own right, it is important to distinguish these from other non-significant impacts as they may contribute to significant impacts cumulatively or through interactions.

13.4.2 Cumulative Impact Assessment

23. The cumulative impact assessment methodology applied in this Chapter is based on that described in Chapter 6 EIA Methodology, adapted to make it applicable to ornithology receptors.

24. The methodology has also been aligned with the approach to the assessment of cumulative impacts that has been applied by Ministers when consenting offshore wind farms and confirmed in recent consent decisions. It also follows the approach set out in recent guidance from the Planning Inspectorate (Planning Inspectorate, 2012) and from the renewables industry (RenewableUK, 2013).

13.4.3 Transboundary Impact Assessment

25. The transboundary impact assessment methodology applied in this Chapter is based on that described in Chapter 6 EIA Methodology, adapted to make it applicable to ornithology receptors.

26. 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).

13.5 Scope

27. This chapter describes the ornithological interests of the OWF sites and the offshore cable corridor to landfall and evaluates the potential impacts of the proposed project on these ornithological interests.

28. The baseline section describes the distribution and abundance of bird species recorded during surveys of the site and draws on additional data as outlined in section 13.5.2.1. This includes flight characteristics (e.g. height and direction), ecology, seasonality and behaviour.

29. The predicted magnitude of impacts and significance of effects arising due to construction, operation and decommissioning of the wind farm on the ornithological interests of the site are assessed on the basis of the worst case project 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.

13.5.1 Study Area

30. 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 discussed and agreed with Natural England and the RSPB during the EPP.

31. This study area includes the OWF sites and 4km buffers around them, plus the offshore cable corridor (Figure 13.1). Monthly aerial surveys have been undertaken across the offshore wind farm sites as follows and as agreed with Natural England:

- March 2012 to February 2014 (former East Anglia FOUR site which corresponds to Norfolk Vanguard East);
- September 2015 to April 2016 (Norfolk Vanguard East); and,
- September 2015 to August 2017 (Norfolk Vanguard West).

32. Thus, for the ornithology assessment presented in this assessment, there are 32 months of survey data for NV East and 24 months for NV West.

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

13.5.2 Data Sources

13.5.2.1 Desk based assessment

34. 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 wind farm project submissions and reports. It includes the published literature on seabird ecology and distribution and on the potential impacts of wind farms (both derived from expert judgement and post-construction monitoring studies). The key topics for which the literature has been examined include:

- Potential impacts of wind farms (Garthe and Hüppop, 2004; Drewitt and Langston, 2006; Stienen *et al.,* 2007; Speakman *et al.,* 2009; Langston, 2010; Band, 2012; Cook *et al.,* 2012; Furness and Wade, 2012; Wright *et al.,* 2012; Furness *et al.,* 2013; Johnston *et al.,* 2014a,b);
- 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);
- Bird migration and foraging movements (Wernham *et al.,* 2002; Thaxter *et al.,* 2012); and

- Red-throated diver densities in the Outer Thames Estuary SPA (JNCC, 2013), data from an unpublished report on surveys carried out in 2013 by APEM for Natural England and Natural England and JNCC (2016).

35. Owing to the short-term nature and small spatial scale of potential impacts on offshore ornithological receptors from installation of the export cable, no surveys have been conducted along the offshore cable corridor, therefore the above data sources have also been used to inform the baseline characterisation and impact assessment for cable installation.

36. 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).

13.5.2.2 Site specific surveys

37. To assess the temporal and spatial abundance and distribution of birds, digital aerial surveys were conducted by APEM Ltd across the OWF sites and four kilometre buffers. Further details of how these surveys were carried out, how the images acquired were analysed and the results of the surveys are provided in Appendix 13.1.

13.5.3 Assumptions and Limitations

38. The marine environment is highly variable, both spatially and temporally. Thus, although the baseline site characterisation is based on more than two years of survey data (i.e. more than is typically available for an offshore wind farm assessment), there remains an underlying assumption that the survey data are representative of the site for the purpose of impact assessment. However, given the project's location (beyond the foraging range of most breeding seabirds) and the results obtained from surveys conducted for other wind farm applications in the former East Anglia Zone (e.g. East Anglia ONE, East Anglia THREE, zonal surveys, etc.), the data are considered to be consistent with previous survey results.

13.6 Existing Environment

39. This Section details the baseline ornithological information based on the desk-based assessment and the surveys listed above in paragraph 31 and detailed in Appendix 13.1.

40. A summary of the ornithological receptors potentially affected by the offshore components is provided at the end of this section in Table 13.10.

13.6.1 Statutory Designated Sites

41. Four classes of statutory designated sites that can have birds included as interest features are considered in this section: SPAs, pSPAs, Ramsar sites and SSSIs (Figures 13.2, 13.3, 13.4).

42. Statutory designated sites have been considered in this assessment on the basis of their potential connectivity to the project. These sites can be broadly separated into those designated for their breeding seabird interests and those for their terrestrial / coastal / marine bird interests (typically for overwintering aggregations).

43. Seabird breeding sites may be connected during the breeding season (e.g. the wind farm lies within foraging range of breeding birds) or during the non-breeding season (e.g. birds pass through during spring and autumn migration or are present overwinter), or during both periods.

44. Terrestrial / coastal sites designated for migrant species outside the breeding season may be connected on the grounds of passage movements through the wind farm.

45. Those sites that have been identified for potential connectivity are listed in Table 13.9 and detailed in Appendix 5.1 Information to Support the HRA. In each case their ornithological interest features are listed. The legal process of the designation of SPAs and Ramsar sites in the UK means that, other than marine sites, each SPA and Ramsar site is supported by a complementary SSSI that covers the same area (sometimes the SSSI may cover a larger area because of SSSI interest features that are not relevant to the international designation).

46. The assessment of likely significant effect on the interest features of the internationally designated sites (SPAs and Ramsar sites) is carried out through the Habitats Regulations Assessment (HRA) process and this is reported separately in the Information for the Habitats Regulations Assessment submitted with the DCO application.

Table 13.9 SPAs, Ramsar sites and SSSI with potential for connectivity to Norfolk Vanguard. Ornithological Interest Features and minimum distance to Norfolk Vanguard, listed in increasing distance

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
Greater Wash	SPA	Classified for its populations of breeding and non-breeding (wintering and migration) bird populations.	36 (although note that the export cable route will pass through this pSPA)

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
Outer Thames Estuary	SPA / pSPA	A marine SPA classified for its non-breeding populations of seabirds.	21
Winterton-Horsey Dunes	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	48
Great Yarmouth and North Denes	SPA, SSSI	Classified for its populations of breeding seabirds.	49
Breydon Water	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	53
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations of waders and wildfowl.	
Broadland	SPA	Classified for its populations of wintering and passage waterbirds.	53
Pakefield to Easton Bavents	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	63
Minsmere-Walberswick Heaths and Marshes	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations of waders and wildfowl.	75
Minsmere - Walberswick	SPA, Ramsar	Classified for its populations of breeding, wintering and passage waterbirds.	75

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
North Norfolk Coast	SPA	Classified for its populations of wintering and passage waterbirds.	80
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	
Sizewell Marshes	SSSI	Notified for its populations of breeding birds.	85
Alde-Ore Estuary	SPA, Ramsar	Classified for its populations of breeding marsh harrier and breeding and non-breeding waterbirds.	92
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations of waders and wildfowl.	
Voordelta (Netherlands)	SPA	A marine and coastal SPA classified for non-breeding seabirds and waterbirds.	106
Deben Estuary	SPA, Ramsar	Classified for its populations of non-breeding waterbirds, including population of Brent goose at levels of international importance.	107
	SSSI	Notified for its populations of breeding and overwintering waders and wildfowl.	
Waddenzee (Netherlands)	SPA	A coastal SPA classified for breeding and non-breeding seabirds,	111

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
		waterbirds and a raptor species.	
Orwell Estuary	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations of waders and wildfowl.	119
Stour & Orwell Estuaries	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	119
Stour Estuary	SSSI	Notified for its populations of non-breeding (wintering and migration) birds.	119
The Wash	SPA	Classified for its populations of wintering and passage waterbirds.	120
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	
Hunstanton Cliffs	SSSI	Notified for its populations of breeding birds.	122
Hamford Water	SPA	Classified for its populations of wintering and passage waterbirds.	127
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	
Gibraltar Point	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	133

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	
Cattawade Marshes	SSSI	Notified for its populations of breeding waders and wildfowl.	134
Holland Haven Marshes	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	136
Upper Colne Marshes	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations of waders and wildfowl.	144
Colne Estuary	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	144
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	
Saltfleetby – Theddlethorpe Dunes	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations of wildfowl and waders.	145
Humber Estuary	SPA, Ramsar, SSSI	Classified for its populations of wintering and passage waterbirds.	149

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
Abberton Reservoir	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	150
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations.	
Blackwater Estuary	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	152
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	
Dengie	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	155
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	
Foulness	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	158
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) waders and wildfowl populations.	
The Lagoons	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	164

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
Crouch & Roach Estuary	SPA	Classified for its populations of wintering and passage waterbirds.	167
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	
Thanet Coast	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations of waders and wildfowl.	171
Thanet Coast and Sandwich Bay	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	171
Benfleet & Southend Marshes	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	182
	SSSI	Notified for its populations of non-breeding (wintering and migration) populations of waders and wildfowl.	
The Swale	SPA	Classified for its populations of wintering and passage waterbirds.	187
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations of waders and wildfowl.	
Thames Estuary and Marshes	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	188
South Thames Estuary and Marshes	SSSI	Notified for its populations of breeding	189

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
		and non-breeding (wintering and migration) bird populations.	
Medway Estuary & Marshes	SPA	Classified for its populations of wintering and passage waterbirds.	190
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) populations of waders and wildfowl.	
Pitsea Marsh	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	191
Vange and Fobbing Marshes	SSSI	Notified for its population of breeding and non-breeding (wintering and migration) bird population.	192
Holehaven Creek	SSSI	Notified for its populations of non-breeding (wintering) birds.	193
Hornsea Mere	SPA	Classified for its populations of wintering and passage waterbirds.	197
	SSSI	Notified for its populations of breeding and non-breeding (wintering and migration) bird populations.	
Mucking Flats and Marshes	SSSI	Notified for its populations of non-breeding (wintering and	198

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
		migration) and passage bird populations.	
Flamborough and Filey Coast [pSPA]	SPA	Classified for its populations of breeding seabirds.	205
Flamborough Head	SSSI	Notified for its populations of breeding birds.	205
Filey Brigg	SSSI	Notified for its population of non-breeding (wintering and migration) birds	222
Borkum-Riffgrund (Germany)	SPA	A marine SPA classified for its non-breeding populations of seabirds.	234
Teesmouth and Cleveland Coast	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	289
Northumbria Coast	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	308
Sylter Auβenriff (Germany)	SPA	A marine SPA classified for its non-breeding seabirds.	311
Chichester & Langstone Harbour	SPA	Classified for its populations of migratory waterbirds.	313
Littoral Seino-Marin (France)	SPA	A marine, coastal and terrestrial SPA classified for its breeding seabirds and a raptor and non-breeding seabirds, waterbirds and a raptor.	315
Portsmouth Harbour	SPA	Classified for its populations of migratory waterbirds.	326

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
Solent & Southampton Water	SPA	Classified for its populations of migratory waterbirds.	331
Seevogelschutzgebiet Helgoland (Germany)	SPA	A marine and island SPA classified for its populations of breeding and non-breeding seabirds.	343
Östliche Deutsche Bucht (Germany)	SPA	A marine SPA classified for its populations of non-breeding seabirds.	345
Ramsar-Gebiet S-H Wattenmeer und angrenzende Küstengebiete (Germany)	SPA	A coastal SPA classified for its breeding, wintering and passage waterbirds, other migrant species and Annex 1 species (82 species listed).	365
Coquet Island	SPA	Classified for its populations of breeding seabirds.	366
Farne Islands	SPA	Classified for its populations of breeding seabirds.	393
Lindisfarne	SPA, Ramsar	Classified for its populations of wintering and passage waterbirds.	398
Chesil Beach & The Fleet SPA	SPA	Classified for its populations of migratory waterbirds.	420
Baie de Seine Occidentale (France)	SPA	A coastal SPA classified for its populations of breeding and non-breeding seabirds and waterbirds.	429
St Abbs Head to Fast Castle	SPA	Classified for its populations of breeding seabirds.	438

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
Falaise du Bessin Occidental (France)	SPA	A marine, coastal and terrestrial SPA classified for its breeding populations of seabirds and a passerine and non-breeding populations of seabirds and raptors.	445
Firth of Forth	SPA	Classified for its populations of wintering and passage waterbirds.	463
Exe Estuary	SPA	Classified for its populations of migratory waterbirds.	470
Forth Islands (Fife/East Lothian)	SPA	Classified for its populations of breeding seabirds.	471
Imperial Dock Lock, Leith	SPA	Classified for its populations of breeding seabirds.	491
Firth of Tay & Eden Estuary	SPA	Classified for its populations of wintering and passage waterbirds.	503
Montrose Basin	SPA	Classified for its populations of wintering and passage waterbirds.	520
Fowlsheugh	SPA	Classified for its populations of breeding seabirds.	525
Ythan Estuary, Sands of Forvie and Meikle Loch	SPA	Classified for its populations of wintering and passage waterbirds.	556
Buchan Ness to Colleston Coast	SPA	Classified for its populations of breeding seabirds.	556
Loch of Strathbeg	SPA	Classified for its populations of wintering and passage waterbirds.	581

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
Troup, Pennan and Lion`s Heads	SPA	Classified for its populations of breeding seabirds.	597
Moray and Nairn Coast	SPA	Classified for its populations of wintering and passage waterbirds.	624
Inner Moray Firth	SPA	Classified for its populations of wintering and passage waterbirds.	652
Cromarty Firth	SPA	Classified for its populations of wintering and passage waterbirds.	664
Dornoch Firth and Loch Fleet	SPA	Classified for its populations of wintering and passage waterbirds.	669
East Caithness Cliffs	SPA	Classified for its populations of breeding seabirds.	685
North Caithness Cliffs	SPA	Classified for its populations of breeding seabirds.	708
Pentland Firth Islands	SPA	Classified for its populations of breeding seabirds.	716
Copinsay	SPA	Classified for its populations of breeding seabirds.	725
Hoy (Orkney)	SPA	Classified for its populations of breeding seabirds.	733
Calf of Eday	SPA	Classified for its populations of breeding seabirds.	760
Fair Isle (Shetland)	SPA	Classified for its populations of breeding seabirds.	762

Site	Designation	Ornithological interest features with potential for connectivity to Norfolk Vanguard	Minimum distance to the project (km)
Rousay	SPA	Classified for its populations of breeding seabirds.	763
Marwick Head	SPA	Classified for its populations of breeding seabirds.	767
West Westray	SPA	Classified for its populations of breeding seabirds.	773
Papa Westray (North Hill and Holm)	SPA	Classified for its populations of breeding seabirds.	778
Sumburgh Head	SPA	Classified for its populations of breeding seabirds.	791
Mousa	SPA	Classified for its populations of breeding seabirds.	807
Noss (Shetland).	SPA	Classified for its populations of breeding seabirds.	816
Foula (Shetland)	SPA	Classified for its populations of breeding seabirds.	833
Papa Stour	SPA	Classified for its populations of breeding seabirds.	851
Fetlar (Shetland)	SPA	Classified for its populations of breeding seabirds.	859
Ronas Hill - North Roe and Tingon	SPA	Classified for its populations of breeding seabirds.	866
Hermaness, Sax Vord and Valla Field (Shetland)	SPA	Classified for its populations of breeding seabirds.	881

13.6.2 Baseline Environment and Assessment of Nature Conservation Value for Each Bird Species

13.6.2.1 Seabirds

47. The bird abundance estimates and how they were derived are presented in detail in Appendix 13.1. Detail from the baseline report has not been repeated within this chapter in order to present a clear and concise impact assessment. Bird abundances and assemblages have been estimated from the site-specific surveys of Norfolk Vanguard.

48. Species assessed for impacts are those which were recorded during surveys and which are considered to be at potential risk either due to their abundance, potential sensitivity to wind farm impacts or due to biological characteristics (e.g. commonly fly at rotor heights) which make them potentially susceptible. The conservation status of these species is provided in Table 13.10. The locations of all species observed are plotted on figures in Appendix 13.1.

Table 13.10 Summary of nature conservation value of species considered at risk of impacts

Species	Conservation status
Red-throated diver	BoCC Green listed, Birds Directive Migratory Species, Birds Directive Annex 1
Black-throated diver	BoCC Amber listed, Birds Directive Migratory Species, Birds Directive Annex 1
Great northern diver	BoCC Amber listed, Birds Directive Migratory Species, Birds Directive Annex 1
Fulmar	BoCC Amber listed, Birds Directive Migratory Species
Gannet	BoCC Amber listed, Birds Directive Migratory Species
Arctic skua	BoCC Red listed, Birds Directive Migratory Species
Great skua	BoCC Amber listed, Birds Directive Migratory Species
Puffin	BoCC Red listed, Birds Directive Migratory Species
Razorbill	BoCC Amber listed, Birds Directive Migratory Species
Common guillemot	BoCC Amber listed, Birds Directive Migratory Species
Common tern	BoCC Amber listed, Birds Directive Migratory Species, Birds Directive Annex 1
Arctic tern	BoCC Amber listed, Birds Directive Migratory Species, Birds Directive Annex 1
Kittiwake	BoCC Red listed, Birds Directive Migratory Species
Little gull	BoCC Green listed, Birds Directive Migratory Species
Lesser black-backed gull	BoCC Amber listed, Birds Directive Migratory Species
Herring gull	BoCC Red listed, Birds Directive Migratory Species
Great black-backed gull	BoCC Amber listed, Birds Directive Migratory Species

49. Impacts have been assessed in relation to relevant biological seasons, as defined by Furness (2015). For the non-breeding period, the seasons and relevant biologically defined minimum population scales (BDMPS) were taken from Furness (2015) Table 13.11. For the breeding period, the potential for connectivity to known breeding populations has been considered. However, it should be noted that bird abundance was low for all species during the breeding season, with many species absent in one or more of the summer months. This indicated that very few breeding birds utilise the Norfolk Vanguard OWF sites. 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 13.11), sometimes also referred to as the core breeding period. This ensured that any late or early migration movements which were observed were assessed in relation to the appropriate reference populations. One exception to this was lesser black-backed gull, for which there is potential that breeding adults from the Alde Ore Estuary SPA population may forage on the Norfolk Vanguard OWF sites. Hence for this species the full breeding season was applied in the attribution of potential impacts to relevant populations.

Table 13.11 Species specific seasonal definitions and biologically defined minimum population sizes (in brackets) have been taken from Furness (2015). Shaded cells indicate the appropriate non-breeding season periods used in the assessment for each species.

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*	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)	-

Species	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
Arctic skua	May-Jul	Jun-Jul	Aug-Oct (6,427)	-	Apr-May (1,227)	-
Great skua	May-Aug	May-Jul	Aug-Oct (19,556)	Nov-Feb (143)	Mar-Apr (8,485)	-
Puffin	Apr-Aug	May-Jun	Jul-Aug	Sep-Feb	Mar-Apr	Mid-Aug-Mar (231,957)
Razorbill	Apr-Jul	Apr-Jul	Aug-Oct (591,874)	Nov-Dec (218,622)	Jan-Mar (591,874)	-
Guillemot	Mar-Jul	Mar-Jun	Jul-Oct	Nov	Dec-Feb	Aug-Feb (1,617,306)
Commic tern**	May-Aug	Jun	Jul-Sep (308,841)	-	Apr-May (308,841)	-
Kittiwake	Mar-Aug	May-Jul	Aug-Dec (829,937)	-	Jan-Apr (627,816)	-
Little gull (Not included in Furness 2015)	Apr-Jul	May-Jul	-	-	-	Aug-Apr
Lesser black-backed gull	Apr-Aug	May-Jul	Aug-Oct (209,007)	Nov-Feb (39,314)	Mar-Apr (197,483)	-
Herring gull	Mar-Aug	May-Jul	Aug-Nov	Dec	Jan-Apr	Sep-Feb (466,511)
Great black-backed gull	Mar-Aug	May-Jul	Aug-Nov	Dec	Jan-Apr	Sep-Mar (91,399)

* Not included in Furness (2015). Natural England (2012) states: Breeding black-throated divers migrate to saltwater habitats from August, returning to their breeding sites from April. Birds are also seen in small numbers on eastward passage through the English Channel in April and May.

** Commic tern' is used to include common terns and Arctic terns, as these species are not readily identified to species from the survey data

50. In addition to BDMPS populations, the biogeographic populations have also been considered in the assessment where appropriate. These are provided in Table 13.12.

Table 13.12 Biogeographic population sizes taken from Furness (2015).

Species	Biogeographic population with connectivity to UK waters (adults and immatures)
Red-throated diver	27,000
Black-throated diver (not included in Furness 2015)	56,460*
Great northern diver	430,000
Fulmar	8,055,000
Gannet	1,180,000
Arctic skua	229,000
Great skua	73,000
Puffin	11,840,000
Razorbill	1,707,000
Guillemot	4,125,000
Commic tern**	628,000 (Arctic: 480,000; Common: 248,000)
Kittiwake	5,100,000
Great black-backed gull	235,000
Herring gull	1,098,000
Lesser black-backed gull	864,000
Little gull (not included in Furness 2015)	75,000 #

* JNCC (http://jncc.defra.gov.uk/pdf/UKSPA/UKSPA-A6-2.pdf). Note this figure has been calculated as 19,196 breeding pairs multiplied by 2 and divided by the estimated proportion of adults in the population (0.68).

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

** 'Commic tern' is used to include common terns and Arctic terns, as these species are not readily identified to species from the survey data

51. The seasonal peak abundance within species specific seasons (as defined in Table 13.11) recorded individually within the NV East and NV West sites and summed across both sites are provided in Table 13.13 (note these abundances do not include birds observed in the 4km buffer around the site boundaries).

52. The method to calculate the seasonal peaks for NV East and NV West was as follows:

- The population density and abundance for each survey was calculated using design-based estimation methods, with 95% confidence intervals calculated using non-parametric bootstrapping (see Technical Appendix 13.1 for further details).
- The abundance for each calendar month was calculated as the mean of estimates for each month (e.g. mean of two values for NV West and two to three for NV East, see section 13.5.1).
- The seasonal peak was taken as the highest from the months falling within 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 13.13.

Table 13.13 Seasonal peak population and 95% confidence intervals within the Norfolk Vanguard East and West sites. The population size in each calendar month was calculated as the mean of the individual surveys conducted in that month and the values shown in the table are the highest from all months in each season. Figures in italics identify occasions when the same peak was recorded in different seasons due to overlapping months.

Species	Site	Breeding		Migration-free breeding		Migration - autumn		Winter		Migration - spring		Non-breeding	
		Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.
Red-throated diver	East	*77*	*0 - 291*	30	0 - 115	27	0 - 101	18	0 - 71	*77*	*0 - 291*	N / A	
	West	*109*	*46 - 184*	6	0 - 27	3	0 - 24	142	37 - 282	*109*	*46 - 184*	N / A	
	Total	***186***	***46 - 475***	**36**	**0 - 142**	**30**	**0 - 125**	**160**	**37 - 353**	***186***	***46 - 475***	**N / A**	
Black-throated diver	East	12	0 - 56	0	0 - 0	N / A		N / A		N / A		18	0 - 96
	West	0	0 - 0	0	0 - 0	N / A		N / A		N / A		0	0 - 0
	Total	**12**	**0 - 56**	0	0 - 0	**N / A**		**N / A**		**N / A**		**18**	**0 - 96**
Great northern diver	East	N / A		N / A		0	0 - 0	3	0 – 31	*42*	*0 - 183*	*42*	*0 - 183*
	West	N / A		N / A		0	0 - 0	0	0 - 0	0	0 - 0	0	0 - 0
	Total	**N / A**		**N / A**		**0**	**0 - 0**	**3**	**0 - 31**	***42***	***0 - 183***	***42***	***0 - 183***
Fulmar	East	*291*	*58 - 554*	*291*	*58 - 554*	362	49 - 645	83	0 - 194	89	9 - 266	N / A	

Species	Site	Breeding		Migration-free breeding		Migration - autumn		Winter		Migration - spring		Non-breeding	
		Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.
	West	*127*	*0 - 320*	*127*	*0 - 320*	590	9 - 1319	53	8 - 118	68	0 - 192		N / A
	Total	***418***	***58 - 874***	***418***	***58 - 874***	**952**	**58 - 1964**	**136**	**8 - 312**	**157**	**9 - 458**		**N / A**
Gannet	East	125	23 - 238	77	27 - 141	1135	614 - 2131		N / A	342	0 - 638		N / A
	West	*53*	*0 - 146*	*53*	*0 - 146*	531	336 - 765		N / A	15	0 - 55		N / A
	Total	**178**	**23 - 384**	**130**	**27 - 287**	**1666**	**950 - 2896**		**N / A**	**357**	**0 - 693**		**N / A**
Arctic skua	East	0	0 - 0	0	0 - 0	15	0 - 70		N / A	0	0 - 0		N / A
	West	0	0 - 0	0	0 - 0	0	0 - 0		N / A	0	0 - 0		N / A
	Total	**0**	**0 - 0**	**0**	**0 - 0**	**15**	**0 - 70**		**N / A**	**0**	**0 - 0**		**N / A**
Great skua	East	0	0 - 0	0	0 - 0	15	0 - 57	0	0 - 0	3	0 - 18		N / A
	West	0	0 - 0	0	0 - 0	9	0 - 27	0	0 - 0	0	0 - 0		N / A
	Total	**0**	**0 - 0**	**0**	**0 - 0**	**24**	**0 - 84**	**0**	**0 - 0**	**3**	**0 - 18**		**N / A**

Species	Site	Breeding		Migration-free breeding		Migration - autumn		Winter		Migration - spring		Non-breeding	
		Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.
Puffin	East	*24*	*0 - 96*	*24*	*0 - 96*	21	0 - 81	*86*	*0 - 339*	9	0 - 52	*86*	*0 - 339*
	West	0	0 - 0	0	0 - 0	0	0 - 0	0	0 - 0	0	0 - 0	0	0 - 0
	Total	***24***	***0 - 96***	***24***	***0 - 96***	**21**	**0 - 81**	***86***	***0 - 339***	**9**	**0 - 52**	***86***	***0 - 339***
Razorbill	East	*458*	*148 - 904*	*458*	*148 - 904*	321	79 – 565	223	33 - 521	526	301 - 880	N / A	
	West	*153*	*77 – 242*	*153*	*77 – 242*	239	44 – 484	313	99 – 543	115	44 - 198	N / A	
	Total	***611***	***225 – 1146***	**611**	***225 – 1146***	**560**	**123 – 1049**	**536**	**132 – 1064**	**641**	**345 - 1078**	***N / A***	
Guillemot	East	*1649*	*155 – 3372*	*1649*	*155 – 3372*	862	159 – 2134	767	114 – 1579	*1298*	*182 – 3167*	*1298*	*182 – 3167*
	West	*652*	*234 – 1142*	271	36 - 581	*979*	*601 – 1379*	1575	613 – 2674	*1699*	*204 – 3337*	*1699*	*204 – 3337*
	Total	**2301**	**389 – 4514**	**1920**	**191 – 3953**	**1841**	**760 – 3513**	**2342**	**727 – 4253**	***2997***	***386 – 6504***	***2997***	***386 - 6504***
Commic tern	East	*122*	*40 - 250*	0	0 - 0	9	0 – 35	N / A		*122*	*40 - 250*	N / A	

Species	Site	Breeding		Migration-free breeding		Migration - autumn		Winter		Migration - spring		Non-breeding	
		Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.
	West	*88*	*16 - 183*	0	0 - 0	*88*	*16 - 183*	N / A		65	0 -188	N / A	
	Total	**210**	**56 - 433**	**0**	**0 - 0**	**97**	**16 – 118**	**N / A**		**187**	***40 - 438***	**N / A**	
Kittiwake	East	612	0 – 1841	154	38 – 346	371	123 – 842	N / A		841	169 - 1524	N / A	
	West	*248*	*37 - 521*	142	73 – 239	189	64 – 336	N / A		*248*	*37 - 521*	N / A	
	Total	**860**	**37 – 2362**	**296**	**111 – 585**	**560**	**187 – 1178**	**N / A**		**1089**	**206 - 2045**	***N / A***	
Little gull (not included in Furness 2015)	East	*56*	*0 - 212*	*56*	*0 - 212*	N / A		N / A		N / A		62	0 - 179
	West	0	0 - 0	0	0 - 0							18	*0 - 46*
	Total	***56***	***0 - 212***	***56***	***0 - 212***	**N / A**		**N / A**		**N / A**		***80***	***0 - 225***
Lesser black-backed gull	East	*53*	*0 - 141*	12	0 - 44	*53*	*0 – 141*	98	0 - 284	12	0 - 47	N / A	
	West	*74*	*9 – 164*	*74*	*9 – 164*	109	16 – 244	21	0 – 72	24	0 - 83	N / A	

Species	Site	Breeding		Migration-free breeding		Migration - autumn		Winter		Migration - spring		Non-breeding	
		Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.	Seasonal peak	95% c.i.
	Total	**127**	**9 – 305**	**86**	**9 – 308**	**162**	**16 – 385**	**119**	**0 – 356**	**36**	**0 - 130**	**N / A**	
Herring gull	East	21	0 – 94	6	0 - 30	30	0 - 110	101	0 – 304	*202*	*0 – 589*	*202*	*0 – 589*
	West	*65*	*0 – 185*	15	0 – 61	*65*	*0 – 185*	6	0 - 27	24	0 - 73	38	0 - 88
	Total	**86**	**0 – 279**	**21**	**0 – 91**	**95**	**0 – 295**	**107**	**0 – 331**	**226**	**0 – 662**	**240**	**0 - 677**
Great black-backed gull	East	51	0 – 160	15	0 - 58	169	16 - 476	244	9 - 472	*437*	*19 – 1224*	*437*	*19 - 1224*
	West	27	0 - 83	9	0 – 46	*192*	*80 - 328*	0	0 - 0	94	9 - 219	*192*	*80 - 328*
	Total	**78**	**0 – 243**	**24**	**0 – 104**	**361**	**96 - 804**	**244**	**9 - 472**	**531**	**28 – 1443**	**629**	**99 - 1552**

* Combined population presented due to difficulty of separating common and Arctic tern species in survey data.

53. The following sections provide a summary of the observations for each species with reference to the offshore wind farm sites, and offshore cable corridor (where relevant).

54. Note that some species, such as skuas, terns and little gull are likely to be poorly represented in the survey data (e.g. due to infrequent passage movements) and therefore the impact assessments for these species draw on additional sources of information with regards their anticipated movements and utilise methods developed for migratory species (e.g. WWT & MacArthur Green 2013).

13.6.2.1.1 Red-throated diver

Norfolk Vanguard East

55. Red-throated divers were recorded on NV East between November and May. The seasonal peak abundance was estimated in March (77 individuals including a proportion of unidentified divers), coinciding with the period of migration to breeding sites. The species was absent between June and October.

Norfolk Vanguard West

56. Red-throated divers were recorded on NV West between November and May. The seasonal peak abundance was estimated in January (142 individuals including a proportion of unidentified divers), and remained around this level until March, coinciding with the period of migration to breeding sites. The species was absent between June and October.

Offshore Cable Corridor

57. The offshore cable corridor will pass through the proposed Greater Wash SPA. This marine SPA includes nonbreeding red-throated diver as a feature. Aerial surveys of the SPA have recorded moderate numbers of red-throated divers in the vicinity of the offshore cable corridor with densities of around one to two birds per km^2 (Natural England and JNCC 2016)

13.6.2.1.2 Black-throated diver

Norfolk Vanguard East

58. Black-throated divers were recorded on the NV East site in March and April, with a seasonal peak estimated population on the wind farm in March of 18 individuals (including a proportion of unidentified divers). This timing indicates passage movements through the region on spring migration.

Norfolk Vanguard West

59. No black-throated divers were recorded on the NV West site or 4km buffer.

13.6.2.1.3 Great northern Diver

Norfolk Vanguard East

60. Great northern divers were recorded on the NV East site in only three out of 32 surveys, with very small numbers seen in December, March and April, and not at all in surveys since 2013. The seasonal peak estimated population on the wind farm was 42 individuals in March. The estimated numbers are strongly influenced by apportioning of unidentified divers to species, which is based on the assumption that the ratio identified to species is an accurate reflection of proportions. In this case that may be incorrect, as it is likely that most divers not identified to species will be red-throated divers where it is difficult to rule out black-throated diver. Since great northern divers are very likely to be correctly identified to species, apportioning unidentified divers to great northern is likely to overestimate their numbers. The timing primarily indicates sporadic passage movements through the region on spring migration.

Norfolk Vanguard West

61. No great northern divers were recorded on the NV West site or 4km buffer.

13.6.2.1.4 Fulmar

Norfolk Vanguard East

62. Fulmars were recorded in all months on the NV East site. Numbers were lowest in mid-winter and mid-summer, with a seasonal peak estimated population of 362 in September. Peaks on the site may be related to migration movements, particularly in September. However, given the wide-ranging nature of this species and its tendency to associate with fishing vessels it is problematic to assign seasonal patterns to these observations.

Norfolk Vanguard West

63. Fulmars were recorded in all months on the NV West site. Numbers were generally low in most months, with a seasonal peak estimated population of 590 individuals in October. This may be related to post-breeding migration movements. However, given the wide-ranging nature of this species and its tendency to associate with fishing vessels it is problematic to assign seasonal patterns to these observations.

13.6.2.1.5 Gannet

Norfolk Vanguard East

64. Gannets were recorded in all months on NV East, mostly in small numbers. However, there was a clear peak during autumn migration, with numbers increasing in October

and peaking in November (estimated seasonal peak abundance 1,135 individuals) which dropped off again in December.

Norfolk Vanguard West

65. Gannets were recorded in most months on NV West, mostly in small numbers (none were recorded in April and December). As for NV East, there was a clear peak during autumn migration, with numbers increasing in October and peaking in November (estimated mean abundance 531 individuals).

13.6.2.1.6 Arctic skua

Norfolk Vanguard East

66. Arctic skuas were recorded on the NV East site in August and September, with a seasonal peak estimated population of 15 individuals in September. This pattern is consistent with post-breeding migration through the region.

Norfolk Vanguard West

67. No Arctic skuas were recorded on the NV West site, however a small number were recorded in the 4km buffer in September.

13.6.2.1.7 Great skua

Norfolk Vanguard East

68. Great skuas were recorded on the NV East site in March, September and October, with a seasonal peak estimated population of 15 individuals in September. This pattern is consistent with occasional migrants passing through the region.

Norfolk Vanguard West

69. Great skuas were recorded on the NV West site in September and February (in the buffer), with a seasonal peak estimated population of nine individuals in September. This pattern is consistent with occasional migrants passing through the region.

13.6.2.1.8 Puffin

Norfolk Vanguard East

70. Puffins were recorded in all months on the NV East site except February and June, generally in low numbers. The estimated seasonal peak population was 86 in November. With the exception of this peak, there was no clear seasonal pattern to these observations.

Norfolk Vanguard West

71. No puffins were recorded on NV West.

13.6.2.1.9 Razorbill

Norfolk Vanguard East

72. Razorbills were recorded in all months on the NV East site, with numbers lowest in June and July and an estimated seasonal peak population of 526 in March (including a proportion of unidentified auks and accounting for availability bias). The seasonal pattern indicates presence in the area is focussed primarily on the nonbreeding season.

Norfolk Vanguard West

73. Razorbills were recorded in all months on the NV West site, with numbers lowest in May and June and an estimated seasonal peak population of 239 in September (including a proportion of unidentified auks and accounting for availability bias). The seasonal pattern indicates presence in the area is focussed primarily on the nonbreeding season.

13.6.2.1.10 Guillemot

Norfolk Vanguard East

74. Guillemots were recorded in all months on the NV East site, with numbers lowest in June and July and an estimated seasonal peak population of 1,649 in March (including a proportion of unidentified auks and accounting for availability bias). The seasonal pattern indicates presence in the area is focussed primarily on the nonbreeding season.

Norfolk Vanguard West

75. Guillemots were recorded in all months on the NV West site, with numbers lowest in May and June and an estimated peak population of 1,699 in January (including a proportion of unidentified auks and accounting for availability bias). The seasonal pattern indicates presence in the area is focussed primarily on the nonbreeding season.

13.6.2.1.11 Sandwich tern

Norfolk Vanguard East

76. Sandwich terns were recorded on the NV East site in September, with an estimated seasonal peak population of 3 individuals.

Norfolk Vanguard West

77. Sandwich terns were recorded on the NV West site in April and June, with an estimated seasonal peak population (when the 2km buffer was included) of 14.

13.6.2.1.12 Commic tern

Norfolk Vanguard East

78. Common and/or Arctic terns were recorded on the NV East site in May and September, with an estimated seasonal peak population in May of 122 individuals. The timing of these records coincides with migration through the site to and from breeding colonies to the north.

Norfolk Vanguard West

79. Common and/or Arctic terns were recorded on the NV West site in April, May and August, with an estimated seasonal peak population in August of 88 individuals. The timing of these records coincides with migration through the site to and from breeding colonies to the north.

13.6.2.1.13 Kittiwake

Norfolk Vanguard East

80. Kittiwakes were recorded on NV East in all months, with higher numbers between November and April. The estimated seasonal peak population was 841 individuals in January (including a proportion of unidentified small gulls). The pattern of observations indicates the main periods of presence are during mid-winter and spring migration.

Norfolk Vanguard West

81. Kittiwakes were recorded on NV West in all months, with higher numbers in October, November and March. The estimated seasonal peak population was 248 individuals in March (including a proportion of unidentified small gulls). The pattern of observations indicates the main periods of presence are during the nonbreeding period.

13.6.2.1.14 Black-headed gull

Norfolk Vanguard East

82. Black-headed gulls were recorded sporadically on the NV East site, with records in January, March, May, July, October and November. The estimated seasonal peak population was 15 individuals in July (including a proportion of unidentified small gulls).

Norfolk Vanguard West

83. Black-headed gulls were recorded sporadically on the NV West site, with records in January, February, March, April, July and October. The estimated seasonal peak

population was 15 individuals in October (including a proportion of unidentified small gulls).

13.6.2.1.15 Little gull

Norfolk Vanguard East

84. Little gulls were recorded sporadically on the NV East site, with records in January, February, May, August, September and November. The estimated seasonal peak population was 62 individuals in August (including a proportion of unidentified small gulls). These peaks are likely to correspond to passage movements through the region.

Norfolk Vanguard West

85. Little gulls were only recorded on the NV West site in September and November. The estimated seasonal peak population was 18 individuals in November (including a proportion of unidentified small gulls).

13.6.2.1.16 Common gull

Norfolk Vanguard East

86. Common gulls were recorded on the NV East site in January, February, March, August, October, November and December. The estimated seasonal peak population was 15 individuals in January (including a proportion of unidentified small gulls).

Norfolk Vanguard West

87. Common gulls were recorded on the NV West site in most months. The estimated seasonal peak population was 50 individuals in November (including a proportion of unidentified small gulls).

13.6.2.1.17 Lesser black-backed gull

Norfolk Vanguard East

88. Lesser black-backed gulls were recorded on the NV East site in all months except June. The estimated population was variable across months with no discernible patterns. The seasonal peak estimated population was 98 individuals in November (including a proportion of unidentified black-backed and large gulls).

Norfolk Vanguard West

89. Lesser black-backed gulls were recorded on the NV West site in all months except December. The estimated population was variable across months with a slight hint at higher numbers between June and September. The seasonal peak estimated

population was 109 individuals in September (including a proportion of unidentified black-backed and large gulls).

13.6.2.1.18 Herring gull

Norfolk Vanguard East

90. Herring gulls were recorded on the NV East site in all months except June and August. The estimated population was low in most all months, with a clear peak over mid-winter. The seasonal peak estimated population was 202 individuals in January (including a proportion of unidentified large gulls).

Norfolk Vanguard West

91. Herring gulls were recorded on the NV West site primarily outside the breeding season months. The seasonal peak estimated population was 65 individuals in August (including a proportion of unidentified large gulls).

13.6.2.1.19 Great black-backed gull

Norfolk Vanguard East

92. Great black-backed gulls were recorded on the NV East site in all months except June and July. The population was low during the breeding season months, but higher in winter with an estimated seasonal peak population in January of 437 individuals (including a proportion of unidentified black-backed and large gulls).

Norfolk Vanguard West

93. Great black-backed gulls were recorded on the NV West site primarily outside the breeding season. The estimated seasonal peak population was 192 individuals in November (including a proportion of unidentified black-backed and large gulls).

13.6.2.2 Non-seabird migrants

94. Migrant terrestrial bird species are typically not well recorded by offshore surveys as they rapidly traverse marine areas, often at altitudes which make them difficult to see or identify and during the night. Consequently, in recognition of this, previous wind farm assessments have been conducted to estimate the potential risk of collisions on the basis of knowledge of migration flight paths and migratory population sizes (e.g. for East Anglia THREE, EATL 2015).

95. The EATL (2015) assessment comprised a screening exercise which identified 23 species as at potential collision risk at the East Anglia THREE site on migration. The proportion of each flyway population predicted to pass through the East Anglia THREE site was estimated using the approach described in the Strategic Ornithological Support Services (SOSS) 05 Project (Wright *et al.,* 2012). Collisions

were estimated using the Band collision risk model Option 1 using the Migrant sheet to calculate the number of potential collisions in each migration season (with a 98% avoidance rate).

96. The results from this modelling indicated that none of the species were at risk of significant collisions whilst on migration. Indeed, the impacts were of such small magnitude (for most species between zero and one collision was predicted per year) that the potential for the proposed East Anglia THREE project to contribute to cumulative impacts was ruled out and no cumulative assessment was therefore necessary (there were only five species with annual collisions greater than one: dark-bellied Brent goose (six), wigeon (two), oystercatcher (two), lapwing (three) and dunlin (ten)).

97. East Anglia THREE wind farm is of a similar size to Norfolk Vanguard and is located immediately to the south of Norfolk Vanguard East, therefore the results from this assessment will be valid for the current wind farms. The same conclusions for collisions therefore apply to Norfolk Vanguard and therefore no further assessment of potential impacts on non-seabird migrants has been undertaken. Therefore, non-seabird migrants were screened out of further assessment.

98. The approach taken used generic data (e.g. Wright *et al.,* 2012) and the basis for the assessment (i.e. methods and population data) have not been updated since. The approach considers broad migration fronts and the degree to which these overlap with offshore wind farms. Although NV West is located closer to the coast than East Anglia THREE (minimum 47km compared to minimum 67km), this is not considered likely to alter the comparability of the two sites in terms of their potential collision risks for migrating birds. Therefore, since the EATL (2015) assessment was conducted for a nearly identical location and development, the conclusions of negligible collision risks and no significant impacts provide a reliable guide to the potential risks for the Norfolk Vanguard project. Indeed, this seems overwhelmingly more likely to be the case than the alternative situation that Norfolk Vanguard, located adjacent to East Anglia THREE, will generate significant collision risks while virtually none were predicted a few kilometres to the south.

13.6.3 Anticipated Trends in Baseline Conditions

99. 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).

100. 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.

101. 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 seem likely to continue in the short to medium term future.

102. Climate change is likely to be the strongest influence on seabird populations in coming years, with anticipated deterioration in conditions for breeding and survival for most species of seabirds (Burthe *et al*. 2014, Macdonald *et al*. 2015, Capuzzo *et al*. 2018) and therefore further declines in numbers of most of our seabird populations are anticipated. It is therefore highly likely that breeding numbers of most of our seabird species will continue to decline under a scenario with continuing climate change due to increasing levels of greenhouse gases. Fisheries management is also likely to influence future numbers in seabird populations. The Common Fisheries Policy (CFP) Landings Obligation ('discard ban') will further reduce food supply for scavenging seabirds such as great black-backed gulls, lesser black-backed gulls, herring gulls, fulmars, kittiwakes and gannets (Votier *et al*. 2004, Bicknell *et al*. 2013, Votier *et al*. 2013, Foster *et al*. 2017). Recent changes in fisheries management that aid recovery of predatory fish stock biomass are likely to further reduce food supply for seabirds that feed primarily on small fish such as sandeels, as those small fish are major prey of large predatory fish. Therefore, anticipated future increases in predatory fish abundance resulting from improved management to constrain fishing mortality on those commercially important species at more sustainable levels than in the past are likely to cause further declines in stocks of small pelagic seabird 'food-fish' such as sandeels (Frederiksen *et al*. 2007, Macdonald *et al*. 2015).

103. 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, 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).

104. 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.

105. 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.

13.7 Potential Impacts

106. The impacts that could potentially arise during the construction, operation and decommissioning of the proposed project have been discussed with Natural England and the RSPB as part of the EPP. As a result of those discussions it has been agreed that the potential impacts that require assessment are:

- 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 / displacement;
  - Impact 4: Indirect impacts through effects on habitats and prey species;
  - Impact 5: Collision risk; and
  - Impact 6: Barrier effect.
- In the decommissioning phase:
  - Impact 7: Disturbance / displacement; and
  - Impact 8: Indirect impacts through effects on habitats and prey species.

13.7.1 Embedded Mitigation

107. Norfolk Vanguard Limited has committed to a number of techniques and engineering designs/modifications inherent as part of the project, during the pre-application phase, in order to avoid a number of impacts or reduce impacts as far as possible. Embedding mitigation into the project design is a type of primary mitigation and is an inherent aspect of the EIA process.

108. A range of different information sources has been considered as part of embedding mitigation into the design of the project (for further details see Chapter 5 Project Description, Chapter 4 Site Selection and Assessment of Alternatives) including engineering requirements, ongoing discussions with stakeholders and regulators, commercial considerations and environmental best practice.

109. Mitigation measures which are embedded into the proposed project design and are relevant to offshore ornithology receptors are listed in Table 13.14.

Table 13.14 Embedded mitigation relating to offshore ornithology

Parameter	Mitigation measures embedded in the proposed project design
Site Selection	The Norfolk Vanguard site was identified through the Zonal Appraisal and Planning process and avoids European protected sites for birds (e.g. Flamborough and Filey Coast pSPA is more than 210km from the OWF sites and Alde-Ore Estuary SPA is over 100km from the OWF sites). This means the site is beyond the foraging range of almost all seabird species, the exceptions being gannet and lesser black-backed gull for which mean maximum ranges of up to 229km and 141km have been estimated respectively (Thaxter *et al.,* 2012). However, tracking of individuals from the colonies within potential foraging range (Flamborough Head and Alde Ore) have revealed a very low degree of connectivity.
Turbine model	Norfolk Vanguard Limited has reduced the maximum number of turbines from 257 to 200, while maintaining the maximum generating capacity of up to 1800MW by committing to using 9MW to 20MW turbines. This reduces collision risks and is also likely to reduce displacement effects.

13.7.2 Monitoring

110. An In-Principle Monitoring Plan (document 8.12) is submitted with the DCO application. An ornithological monitoring plan (as required under condition [14.(1)(l)] of the Deemed Marine Licences (DMLs) (Schedules 9 and 10 of the DCO)] will be developed in accordance with the In-Principle Monitoring Plan.

111. Vattenfall have a proven commitment to ornithological monitoring for offshore wind farms and improving understanding of potential impacts (e.g. Vattenfall 2017) and will maintain this in relation to Norfolk Vanguard. The aims of monitoring should be to reduce uncertainty for future impact assessment and address knowledge gaps. To this end Vattenfall Wind Power Ltd will engage with stakeholders to agree appropriate monitoring studies, ideally ones which are both relevant to Norfolk Vanguard and the wider offshore wind power industry. Aspects for consideration will include collision risks (e.g. improvements to modelling, options for mitigation and reduction), displacement (e.g. understanding the consequences of displacement) and improving reference population estimates and colony connectivity.

13.7.3 Worst Case

112. The detailed design of Norfolk Vanguard (including numbers of wind turbines, layout configuration etc.) will not be determined until after the DCO has been determined. Therefore, realistic worst case scenarios in relation to impacts/effects on ornithology are adopted.

113. The worst case scenarios with regard to potential impacts of the proposed project on offshore ornithology receptors from the construction, operation and decommissioning phases are dependent on the survey results for each species, as some species were more abundant in NV West and some were more abundant in NV East.

13.7.3.1 Layout

114. The layout of the wind turbines will be defined post consent but will be based on the following maxima (Table 13.15):

- Up to 1800MW in NV East, 0MW in NV West; or
- 0MW in NV East, up to 1800MW in NV West.

115. Hereafter these are referred to as scenarios 1 and 2. All potential impacts are assessed in accordance with the Chapter 6 EIA Methodology and the topic specific methods detailed in section 13.4.1.

Table 13.15 Alternative wind farm generating options between NV East and NV west assessed for ornithological impacts.

Scenario	NV West (MW capacity)	NV East (MW capacity)
1	1800	0
2	0	1800

116. Any other potential layouts that are considered up to a maximum of 1800MW (e.g. 1,200MW in NV West and 600MW in NV East, 600MW in NV West and 1,200MW in NV East or 900MW in NV West and 900MW in NV East) lie within the envelope of these scenarios. Therefore, the maximum parameters outlined in Table 13.15, could all be located in NV East; all in NV West; or split between in each site.

117. To ensure this assumption is robust and following a request from Natural England (2017), for certain aspects of the assessment (e.g. operational displacement) an absolute worst case has been assumed which considers complete displacement from both NV East and NV West. This is highly precautionary, since any division of turbines between NV East and NV West will mean that the total number of turbines (e.g. the maximum of 200 x 9MW) will be split between the sites. Therefore, either less than 100% of each site will be developed, or the turbines will be separated by up to twice the minimum inter-turbine distance (680m; Table 13.16). In either situation the

magnitude of displacement from each site would be expected to be considerably lower than that predicted for a development with all turbines located in a single site. For other aspects, such as collision risk, which scale in proportion with the number of turbines, the 'either/or' scenarios listed in Table 13.15 include the worst case for each species.

13.7.3.2 Phasing

118. To maximise the clarity of this assessment the worst case scenario is identified for each impact-species combination. Norfolk Vanguard Limited is currently considering constructing the proposed project in the following phase options.

- A single phase of up to 1800MW; or
- Two phases (with a total combined capacity of up to 1800MW).

119. The total programme for construction of 1800MW would be two to four years depending on the time between commencement of phases. Indicative programmes for these phased approaches are provided in Chapter 5 Project Description. In summary, construction in one phase is anticipated to take approximately 23 months of activity over the construction window. For the two phase scenarios the indicative programme would be 12 months of activity per phase.

Table 13.16 Worst case assumptions

Impact	Parameter	Notes
Construction		
Impact 1: Disturbance and displacement from increased vessel activity	Up to 113 vessels across both sites at any one time. Total estimated movements; up to 1,130 for single or two phase construction.	Maximum estimated number of vessel movements would cause greatest displacement to birds on site. This assumes a maximum construction schedule of 24 hours a day, 7 days a week for a maximum construction period of 24 months within an overall period of up 4 years. Note, however, that there will be periods of downtime.
Impact 2: Indirect effects as a result of displacement of prey species due to increased noise and disturbance to seabed	Spatial worst case impact (maximum area of impact at one time and maximum anticipated pile energy) Monopiles: 2 concurrent piling events, 90 x 15m diameter wind turbine foundations, 2 offshore electrical platforms, 2 accommodation platforms and 2 met masts. 5,000kJ hammer. Temporal worst case impact (greatest duration of pile driving based on the greatest number of piles)	See Chapter 11 Fish and Shellfish Ecology

Impact	Parameter	Notes
	Jackets: 2 concurrent piling, 200 wind turbine foundations (with 4 piles each), 2 offshore electrical platforms, 2 accommodation platforms and 2 met masts. 2,700kJ hammer.	
	Disturbance/displacement from increased suspended sediment concentration.	Total sediment release over the maximum 4 year build period is listed in Chapter 10 Benthic Ecology, Table 10.9. However, the release on a daily basis would be temporary and localised with sediment settling out quickly.
	The maximum area of disturbance to benthic habitats during construction would be approximately 32km^2 across the Norfolk Vanguard offshore project area.	Breakdown is given in Chapter 10 Benthic Ecology, Table 10.9. Note that the total area developed remains around 32km^2 irrespective of the division of turbines between NV East and NV West.
Operation		
Impact 3: Disturbance and displacement from offshore infrastructure and due to increased vessel and helicopter activity	An area of 592km^2 (East 297km^2, West 295km^2) plus individual 4km buffers with a maximum of 200 wind turbines, with a minimum spacing of 680 x 680m between turbines. Maximum 2 offshore electrical platforms, 2 accommodation platforms, 2 met masts, 2 LiDAR platforms and 2 wave buoys. Support vessels making approximately 440 two-way vessel movements per annum for supporting wind farm operations (average of 1-2 per day). Maximum of 14 two-way helicopter movements per week for scheduled and unscheduled maintenance (728 per year).	Maximum density of turbines and structures across the offshore project area, which maximises the potential for avoidance and displacement. Other options represent a smaller total area occupied and reduced density of turbines. Assessment assumes varying displacement from site and a buffer, where appropriate. See Chapter 5 Project Description.
Impact 4: Indirect effects due to habitat loss / change for key prey species	The maximum possible above seabed footprint of the project including scour protection plus any cable protection. The overall total footprint is 14km^2.	Breakdown is given in Chapter 10 Benthic ecology, Table 10.9.
Impact 5: Collision risk	Maximum of 200 x 9MW turbines.	Collision risk modelling shows that 200 x 9MW turbines have largest collision impact risk. Other options (e.g. 15 MW turbines) have a reduced number of turbines (e.g.

Impact	Parameter	Notes
		120) and lower collision risks (Appendix 13.1).
Impact 6: Barrier effects	Maximum offshore project area 592km^2 (East 297km^2, West 295km^2) with a maximum of 200 wind turbines, with a minimum spacing of 680 x 680m between turbines. Maximum 2 offshore electrical platforms, 2 accommodation platforms, 2 met masts, 2 LiDAR platforms and 2 wave buoys.	Maximum density of turbines and structures across the offshore project area, which maximises the potential barrier to foraging grounds and migration routes for bird species. Other options result in reduced number and density of turbines.
Decommissioning		
Impact 7: Disturbance and displacement from decommissioning activities	Disturbance is anticipated to be similar in nature but of lower magnitude than during construction, but specific details are not currently known.	Maximum estimated number of vessel movements would cause greatest displacement to birds on site.
Impact 8: Indirect effects due to habitat loss / change for key prey species	As above for construction, there would be habitat disturbance effects around sites of activity across the site and offshore cable corridor. There would be limited noise disturbance to prey (as no piling and no use of explosives).	Breakdown is given in Chapter 10 Benthic Ecology, Table 10.2.
Cumulative		
Cumulative impacts are assessed as for the above project alone impacts. The worst case cumulative impacts are defined in the relevant sections and reflect the current knowledge of other projects which could contribute to cumulative effects.		

13.7.4 Potential Impacts during Construction

13.7.4.1 Impact 1: Disturbance and displacement from increased vessel activity

120. The construction phase of the proposed project has the potential to affect bird populations in the marine environment through disturbance due to construction activity leading to displacement of birds from construction sites. This would effectively result in temporary habitat loss through reduction in the area available for feeding, loafing and moulting. The worst case scenario, outlined in Table 13.16, describes the elements of the proposed project considered within this assessment.

121. The maximum duration of offshore construction for the proposed project would be 24 months which would overlap with a maximum of two breeding seasons, two winter periods and up to four migration periods.

122. The construction phase would require the mobilisation of vessels, helicopters and equipment and the installation of foundations, export cables and other

infrastructure. These activities have the potential to disturb and displace birds from within and around the offshore elements of the proposed project, including the wind farm and the subsea cables. 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 worst case 24 month construction period.

123. Any impacts resulting from disturbance and displacement from construction activities are considered likely to 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.

124. Some species are more susceptible to disturbance than others. 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 wind farm (GGOWL 2011) and close to active foundation piling activity at the Egmond aan Zee (OWEZ) wind farm, where they showed no noticeable reactions to the works (Leopold and Camphuysen, 2007). However, species such as divers and scoters have been noted to avoid shipping by several kilometres (Mitschke *et al.,* 2001 from Exo *et al.,* 2003; Garthe and Hüppop, 2004; Schwemmer *et al.* 2011).

125. 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 wind farm. Garthe and Hüppop (2004) developed a scoring system for such disturbance factors, which is used widely in offshore wind farm EIAs. Furness and Wade (2012) developed disturbance ratings for particular 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. Although, all else being equal, a helicopter may constitute a more pronounced source of disturbance than a vessel, the combination of higher speed (and hence briefer presence) and greater distance to the sea surface means that helicopter disturbance is considered to be the same or lower than that resulting from vessel movements. Thus, the following assessment is based on disturbance due to vessels and it has been assumed that this also encompasses disturbance due to helicopters.

126. 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 only and the potential zone of construction displacement will be small (that located around up to three

construction vessels) it is likely that the assessment presented below for the migration periods will over-estimate population impacts.

127. 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 13.17). Any species with a low sensitivity to displacement or recorded only in very small numbers within the Study Area (including the offshore cable corridor) was screened out of further assessment.

Table 13.17 Disturbance and displacement screening

Receptor	Sensitivity to disturbance and displacement	Screening result (IN/OUT)
Common scoter	High	**Screened IN** for export cable installation only.
Red-throated diver	High	**Screened IN** for the OWF sites and export cable installation.
Black-throated diver	High	**Screened OUT** as species only present during spring migration and therefore additional displacement would be negligible.
Great northern diver	High	**Screened OUT** as species only present during spring migration and therefore additional displacement would be negligible.
Fulmar	Very Low	**Screened OUT** as the species has a Very Low sensitivity and is not known to avoid vessels.
Gannet	Low	**Screened OUT** as has a Low sensitivity to disturbance and displacement.
Puffin	Low to Medium	**Screened IN** for OWF sites only as classified of Low to Medium sensitivity to disturbance and displacement, and following advice from NE.
Razorbill	Medium	**Screened IN** for OWF sites only due to numbers recorded and classified as Medium sensitivity to disturbance and displacement.
Guillemot	Medium	**Screened IN** for OWF sites only due to numbers recorded and classified as Medium sensitivity to disturbance and displacement.
Little tern	Low to Medium	**Screened OUT** for OWF sites as classified of Low to Medium sensitivity to disturbance and displacement, and very low numbers recorded on wind farm sites. **Screened OUT** for export cable installation as route does not overlap areas identified in Natural England and JNCC (2016).
Sandwich tern	Low to Medium	**Screened OUT** for OWF sites as classified of Low to Medium sensitivity to disturbance and displacement, and very low numbers recorded on wind farm sites. **Screened OUT** for export cable installation as route does not overlap areas identified in Natural England and JNCC (2016).
Commic tern	Low to Medium	**Screened OUT** for OWF sites as classified of Low to Medium sensitivity to disturbance and displacement, and low numbers recorded on wind farm sites.

Receptor	Sensitivity to disturbance and displacement	Screening result (IN/OUT)
		Screened OUT for export cable installation as route does not overlap areas identified in Natural England and JNCC (2016).
Kittiwake	Low	**Screened OUT** as has a Low sensitivity to disturbance and displacement.
Great black-backed gull	Low	**Screened OUT** as has a Low sensitivity to disturbance and displacement.
Herring gull	Low	**Screened OUT** as has a Low sensitivity to disturbance and displacement.
Lesser black-backed gull	Low	**Screened OUT** as has a Low sensitivity to disturbance and displacement.
Little gull	Low	**Screened OUT** as has a Low sensitivity to disturbance and displacement.

13.7.4.1.1 Common scoter

Export cable installation

128. Common scoter over-winter on inshore waters around the British coast with notable concentrations in the Greater Wash area, Carmarthen Bay and the Irish Sea. This species has been identified as being particularly sensitive to human activities in marine areas including through the disturbance effects of ship and helicopter traffic (Garthe and Hüppop, 2004; Schwemmer *et al.,* 2011; Furness and Wade, 2012; Bradbury *et al.,* 2014).

129. Common scoter is not considered at risk of construction impacts on the wind farm sites since it was only recorded on one survey with 2 individuals identified in the 4km buffer for NV West. This is to be expected given their habitat preferences (less than 20m sea depth). However, there is potential for disturbance and displacement of non-breeding common scoters resulting from the presence of construction vessels installing the offshore cables through the Greater Wash SPA, for which this species is a proposed nonbreeding feature.

130. Cable laying vessels are static for large periods of time and move only short distances as cable installation takes place, and offshore cable installation activity is a relatively low noise emitting operation. Therefore, the potential magnitude of disturbance is very small. Furthermore, Natural England and JNCC (2016) indicate that no birds were recorded within 10km of the export cable route, and the main concentrations of this species were located along the north Norfolk coast, towards the Wash.

131. On this basis, the potential risks to common scoter resulting from disturbance due to offshore cable laying are considered to be temporary and localised in nature and the

magnitude of effect has been determined as negligible or no change. As the species is of high sensitivity to disturbance, the impact significance is at worst **minor adverse**.

13.7.4.1.2 Red-throated diver

Export cable installation

132. Red-throated diver has been identified as being particularly sensitive to human activities in marine areas (Dierschke *et al.*, 2016), including through the disturbance effects of ship and helicopter traffic (Garthe and Hüppop, 2004; Schwemmer *et al.,* 2011; Furness and Wade, 2012; Bradbury *et al.,* 2014; Dierschke *et al.,* 2017).

133. There is potential for disturbance and displacement of non-breeding red-throated divers resulting from the presence of construction vessels installing the offshore cables, including when they are laid through the Greater Wash SPA. However, cable laying vessels are static for large periods of time and move only short distances as cable installation takes place. Offshore cable installation activity is also a relatively low noise emitting operation.

134. The magnitude of disturbance to red-throated diver from construction vessels has been estimated on a worst case basis. This assumes that there would be 100% displacement of birds within a 2km buffer surrounding the source, in this case around a maximum of two cable laying vessels. This 100% displacement from vessels is consistent with Garthe and Hüppop (2004) and Schwemmer *et al.,* (2011) since they suggested that all red-throated divers present fly away from approaching vessels at a distance of often more than 1km.

135. In order to calculate the number of red-throated divers that would potentially be at risk of displacement from the offshore cable corridor during the cable laying process, the density of red-throated divers in the SPA along the section crossed by the offshore cable corridor was estimated. This was derived from a review of the Greater Wash SPA proposal details (Natural England and JNCC, 2016). This indicated that the peak density of birds in the SPA crossed by the cable route was between 1.36 and 3.38 per km^2.

136. 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 $25.2km^2$ ($2 \times 12.6km^2$). If 100% displacement is assumed to occur within this area, then a peak of between 34 and 85 divers could be displaced at any given time. This would lead to a 1 to 1.5% increase in diver density in the remaining areas of the SPA assuming that displaced birds all remain within the SPA. As the vessels move it is assumed that displaced birds return and therefore any individual will be subjected to a brief period of impact. It is considered reasonable to assume that birds will return following

passage of the vessel since the cable laying vessels will move at a maximum speed of 400m per hour if surface laying, 300m per hour for ploughing and 80m per hour if trenching (Chapter 5 Project Description). This represents a maximum speed of 7m per minute. For context, a modest tidal flow rate for the region would be in the region of 1m per second (60m per minute). The tide would therefore be flowing about nine times faster than the cable laying vessel. Consequently, for the purposes of this assessment it can be assumed that the estimated number displaced represents the total number displaced over the course of a single winter.

137. Definitive mortality rates associated with displacement for red-throated divers, or for any other seabird species, are not known and precautionary estimates have to be used. There is no evidence that birds displaced from wind farms suffer any mortality as a consequence of displacement; 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 (Dierschke *et al.,* 2017). Such impacts are most likely to be negligible, and below levels that could be quantified, as the available evidence suggests that red-throated divers are unlikely to be affected by density-dependent competition for resources during the non-breeding period (Dierschke *et al.,* 2017). 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), displacement of sandeel-dependent seabirds from optimal habitat may increase mortality. In years when food supply is good, displacement is unlikely to have any negative effect on seabird populations. Red-throated divers may feed on sandeels, but take a wide diversity of small fish prey, so would be buffered to an extent from fluctuations in abundance of individual fish species. It is not possible for the proposed project to predict future fishing effort. However, this assessment has assumed a precautionary maximum mortality rate associated with the displacement of red-throated diver in the wintering period of 5% (i.e. 5% of displaced individuals suffer mortality as a direct consequence, a level in keeping with the annual natural mortality rate of around 10% (Dierschke *et al.,* 2017), so making the precautionary assumption that a single instance of displacement is equivalent to half the annual mortality rate of affected individuals). At this level of additional mortality, only a maximum of between two and four 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, which would be restricted to a single season, and only if cable laying takes place during these months. Even when compared to the smaller winter BDMPS for this species (10,177; Furness, 2015) it is clear that this highly precautionary assessment will generate an effect of negligible magnitude.

138. The construction works, specifically offshore cable laying, 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**.

Norfolk Vanguard East

139. Red-throated divers were recorded in NV East in low numbers between November and May, with numbers peaking in March (mean density 0.26/km^2) with none present between June and October. Although March, April and May were identified as breeding months in Furness (2015) this species does not breed in the southern North Sea and individuals recorded at this time are considered to be part of the spring migration population (February – April; Furness 2015).

140. There is potential for disturbance and displacement of red-throated divers due to construction activity, including wind turbine construction 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 a maximum of two foundations expected to be installed simultaneously. Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire NV East site.

141. For this precautionary assessment it has been assumed that 5% of displaced individuals could die as a result of displacement by construction vessels.

142. During autumn migration, with a seasonal peak density of 0.09/km^2 and a precautionary 2km radius of disturbance around each construction vessel, 2 individuals (0.09 x 12.56 x 2) could be at risk of displacement and up to 0.1 at risk of mortality in a maximum of two autumn periods.

143. At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die in the autumn BDMPS is 3,027 (13,277 x 0.228). The addition of a maximum of 0.1 to this increases the mortality rate by 0.003%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the autumn migration period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

144. During winter, with a seasonal peak density of 0.06/km^2 and a precautionary 2km radius of disturbance around each construction vessel, 2 individuals (0.06 x 12.56 x 2) could be at risk of displacement and up to 0.1 at risk of mortality during a maximum of two winter periods.

145. At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die in the winter BDMPS is 2,320 (10,177 x 0.228). The addition of a maximum of 0.1 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 winter period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

146. During spring, with a seasonal peak density of 0.26/km^2 and a precautionary 2km radius of disturbance around each construction vessel, 7 individuals (0.26 x 12.56 x 2) could be at risk of displacement and up to 0.3 at risk of mortality during a maximum of two spring periods.

147. At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) 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 0.3 to this increases the mortality rate by 0.01%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the spring period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

148. The combined nonbreeding impact of construction, with approximately 0.5 individuals at risk of construction displacement mortality, will be similarly undetectable against background levels (this would increase the background mortality of the smallest BDMPS population by 0.02%). Therefore, during the combined nonbreeding period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

Norfolk Vanguard West

149. Red-throated divers were recorded in NV West in low numbers between November and May, with numbers peaking in January (mean density 0.48/km^2) with none present between June and October. Although March, April and May were identified as breeding months in Furness (2015) this species does not breed in the southern North and these records are considered to be part of the spring migration population (February – April; Furness 2015). Red-throated divers are considered to have a high sensitivity to disturbance and displacement. Thus, assessment has been conducted in relation to the nonbreeding populations.

150. There is potential for disturbance and displacement of red-throated divers due to construction activity, including wind turbine construction 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 a maximum of two foundations expected to be installed simultaneously. Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire NV West site.

151. For this precautionary assessment it has been assumed that 5% of displaced individuals could die as a result of displacement by construction vessels.

152. During autumn migration, with a seasonal peak density of 0.01/km^2 and a precautionary 2km radius of disturbance around each construction vessel, less than 1 individual (0.01 x 12.56 x 2 = 0.25) could be at risk of displacement and up to 0.01 at risk of mortality during a maximum of two autumn periods.

153. At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die in the autumn BDMPS is 3,027 (13,277 x 0.228). The addition of a maximum of 0.01 to this increases the mortality rate by 0.003%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the autumn migration period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

154. During winter, with a seasonal peak density of 0.48/km^2 and a precautionary 2km radius of disturbance around each construction vessel, 12 individuals (0.48 x 12.56 x 2) could be at risk of displacement and up to 0.6 at risk of mortality during a maximum of two winter periods.

155. At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die in the winter BDMPS is 2,320 (10,177 x 0.228). The addition of a maximum of 0.6 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 even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

156. During spring, with a seasonal peak density of 0.37/km^2 and a precautionary 2km radius of disturbance around each construction vessel, 9 individuals (0.37 x 12.56 x 2) could be at risk of displacement and up to 0.5 at risk of mortality during a maximum of two spring periods.

157. At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) 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 0.5 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 period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

158. The combined nonbreeding impact of construction, with approximately 1.1 individuals at risk of construction displacement mortality, will be similarly undetectable against background levels (this would increase the background mortality of the smallest BDMPS population by 0.05%). Therefore, during the combined nonbreeding period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

Norfolk Vanguard East and Norfolk Vanguard West

159. The NV East and NV West construction disturbance and displacement assessment is summarised in Table 13.18. Although construction may occur on both NV East and NV West at the same time, the maximum number of simultaneous piling events would remain two. Therefore, any construction split across the sites would be of smaller magnitude than either of those assessed for each site individually and no further assessment is required.

Table 13.18 Red-throated diver construction disturbance and displacement mortality impacts assessed for the worst case of two simultaneous piling operations on either NV East or NV West during each season and summed across seasons.

Season	Site	Peak density (birds/km^2)	Max. no individuals subject to displacement mortality	Increase in background mortality (%)
Autumn migration	NV East	0.09	0.1	0.003
	NV West	0.01	0.01	0.003
Winter	NV East	0.06	0.1	0.004
	NV West	0.48	0.6	0.03
Spring migration	NV East	0.26	0.3	0.01
	NV West	0.37	0.5	0.02
Total	NV East	-	0.5	≤0.02
	NV West	-	1.1	≤0.05

13.7.4.1.3 Puffin

Norfolk Vanguard East

160. Puffins have been recorded in NV East in low numbers in most months, with numbers peaking in November (mean peak density 0.29/km^2) and with none present in June. Puffins are considered to have a low to medium general sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004) and Furness and Wade (2012).

161. There is potential for disturbance and displacement of puffins due to construction activity, including wind turbine construction 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 a maximum of two foundations expected to be installed simultaneously. Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire NV East site.

162. For this precautionary assessment it has been assumed that a maximum of 10% of displaced individuals could die as a result of displacement by construction vessels. During the nonbreeding season, at a seasonal peak density of 0.29/km^2 and with a highly precautionary 2km radius of disturbance around each construction vessel, 7 individuals (0.29 x 12.56 x 2) could be at risk of displacement and approximately 1 at risk of mortality. The nonbreeding season BDMPS for puffin is 231,957 (Furness, 2015). At the average baseline mortality rate for puffin of 0.167 (Table 13.23) the number of individuals expected to die in the nonbreeding BDMPS is 38,737 (231,957 x 0.167). The addition of 1 individual to this increases the mortality rate by 0.002%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the nonbreeding period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible to minor adverse**.

163. During the breeding season the seasonal peak density on the site was 0.08/km^2 (May) which suggests that 2 individuals (0.08 x 12.56 x 2) could be at risk of displacement and 0.2 at risk of mortality. There are no breeding colonies for puffin within foraging range of the NV East site, therefore it is reasonable to assume that individuals seen during the breeding season are nonbreeding (e.g. immature birds). Since immature seabirds are known to remain in wintering areas, the number of immature birds in the relevant population during the breeding season may be estimated as 45% of the total wintering BDMPS population (Furness, 2015). This gives a breeding season population of 104,381 immatures (BDMPS for the UK North Sea and Channel, 231,957 x 45%). At the average baseline mortality rate for puffin

of 0.167 (Table 13.23) the number of individuals expected to die in the breeding season is 17,432 (104,381 x 0.167). The addition of 0.2 individuals to this increases 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. Therefore, during the breeding season, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible to minor adverse**.

164. The construction works are temporary and localised in nature and the magnitude of effect has been determined as negligible. As the species is of low to medium sensitivity to disturbance, even when the individual season impacts are combined (up to 1.2 additional mortalities in total) the increase in mortality would be no more than 0.003% therefore the impact significance is **negligible to minor adverse**.

Norfolk Vanguard West

165. No puffins were recorded in NV West; therefore, no impact assessment has been conducted for construction effects on this species.

Norfolk Vanguard East and Norfolk Vanguard West

166. No puffins were recorded in NV West, therefore no combined impact assessment across the two sites is required and that for NV East is applicable for both sites. The puffin construction disturbance and displacement assessment is summarised in Table 13.19.

Table 13.19 Puffin construction disturbance and displacement mortality impacts assessed for the worst case of two simultaneous piling operations on either NV East or NV West during each season and summed across seasons.

Season	Site	Peak density (birds/km^2)	Max. no individuals subject to displacement mortality	Increase in background mortality (%)
Nonbreeding	NV East	0.29	1	0.002
	NV West	0	0	0
Breeding	NV East	0.08	0.2	0.001
	NV West	0	0	0
Total	NV East	-	1.2	0.003
	NV West	-	0	0

13.7.4.1.4 Razorbill

Norfolk Vanguard East

167. Razorbills have been recorded in NV East year round, with numbers peaking in March (mean density 1.77/km^2) and at their lowest in July (mean density 0.06/km^2). Razorbills are considered to have a medium general sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004) and Furness and Wade (2012). Dierschke *et al.* (2016) categorized razorbill as 'weakly avoiding offshore wind farms' based on a review of numbers inside and outside of operational offshore wind farms; their behavioural response to construction is likely to be similar and probably slightly stronger than during operation.

168. There is potential for disturbance and displacement of razorbills due to construction activity, including wind turbine construction 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 a maximum of two foundations expected to be installed simultaneously. Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire NV East site.

169. For this precautionary assessment it has been assumed that 10% of displaced individuals could die as a result of displacement by construction vessels.

170. During the autumn migration season, at a seasonal peak density of 1.08/km^2 and with a highly precautionary 2km radius of disturbance around each construction vessel, 27 individuals (1.08 x 12.56 x 2) could be at risk of displacement and 3 at risk of mortality. The autumn migration BDMPS for razorbill is 591,874 (Furness, 2015). At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the autumn migration BDMPS is 102,986 (591,874 x 0.174). The addition of 3 individuals to this would increase the mortality rate by 0.003% which would be undetectable. Therefore, during the autumn period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. The construction works are temporary and localised in nature and the magnitude of effect has been determined as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

171. During the winter, at a seasonal peak density of 0.75/km^2 and with a highly precautionary 2km radius of disturbance around each construction vessel, 19 individuals (0.75 x 12.56 x 2) could be at risk of displacement and up to 2 at risk of mortality. The winter (nonbreeding season) BDMPS for razorbill is 218,622 (Furness, 2015). At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the

number of individuals expected to die in the winter BDMPS is 38,040 (218,622 x 0.174). The addition of 2 individuals to this would increase the mortality rate by 0.005% which would be undetectable. Therefore, during the winter period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach.

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

173. During the spring migration season, at a peak mean density of 1.77/km^2 and with a highly precautionary 2km radius of disturbance around each construction vessel, 44 individuals (1.77 x 12.56 x 2) could be at risk of displacement and up to 4 at risk of mortality. The spring migration BDMPS for razorbill is 591,874 (Furness, 2015). At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the spring migration BDMPS is 102,986 (591,874 x 0.174). The addition of 4 individuals to this would increase the mortality rate by 0.004% which would be undetectable. Therefore, during the spring migration period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach.

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

175. During the breeding season the seasonal peak density of razorbills on the site was 1.54/km^2 (May) which suggests that 39 individuals (1.54 x 12.56 x 2) could be at risk of displacement and up to 4 at risk of mortality.

176. The mean maximum foraging range for breeding razorbill is 48.5km (Thaxter *et al.,* 2012) which places NV East considerably beyond the range of any razorbill breeding colonies. It should be noted that some recent tagging studies have recorded larger apparent foraging ranges (one razorbill was recorded travelling 312km from Fair Isle) which would 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, 1997) so would take almost 11 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 three 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, 1986), so there are simply not enough hours in the day to allow successfully breeding razorbills to make such long trips to provision a chick. At 16m per second NV East is 4.1 hours direct flight

time away from the nearest razorbill breeding colony (Flamborough Head). A return trip would take 8.2 hours, not allowing for foraging. As for the Fair Isle example, travelling such distances is incompatible with successful breeding. On the basis of three 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.

177. On the basis of the above evidence, it can be stated with confidence that there are no breeding colonies for razorbill within foraging range of NV East, therefore it is reasonable to assume that individuals seen during the breeding season are nonbreeding (e.g. immature birds). Since immature seabirds are known often 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%). At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the breeding season is 16,357 (94,007 x 0.174). The addition of up to 4 individuals to this would increase the mortality rate by less than 0.02% which would be undetectable. Therefore, during the breeding season, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

178. 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, even when the individual season impacts are combined (up to 13 additional mortalities in total) the increase in mortality would be no more than 0.03% (using the smaller BDMPS) therefore the impact significance is **minor adverse**.

Norfolk Vanguard West

179. Razorbills have been recorded in NV West year round, with numbers peaking in November (mean density 1.06/km^2) and at their lowest in May (mean density 0.04/km^2). Razorbills are considered to have a medium general sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004) and Furness and Wade (2012). Dierschke *et al.* (2016) categorized razorbill as ‘weakly avoiding offshore wind farms’ based on a review of numbers inside and outside of operational offshore wind farms; their behavioural response to construction is likely to be similar and probably slightly stronger than during operation.

180. There is potential for disturbance and displacement of razorbills due to construction activity, including wind turbine construction 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 a maximum of two foundations expected to be installed simultaneously. Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire NV West site.

181. For this precautionary assessment it has been assumed that 10% of displaced individuals could die as a result of displacement by construction vessels.

182. During the autumn migration season, at a seasonal peak density of 0.81/km^2 and with a highly precautionary 2km radius of disturbance around each construction vessel, 20 individuals (0.81 x 12.56 x 2) could be at risk of displacement and up to 2 at risk of mortality. The autumn migration BDMPS for razorbill is 591,874 (Furness, 2015). At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the autumn migration BDMPS is 102,986 (591,874 x 0.174). The addition of 2 individuals to this would increase the mortality rate by 0.002% which would be undetectable. Therefore, during the autumn period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach.

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

184. During the winter, at a seasonal peak density of 1.06/km^2 and with a highly precautionary 2km radius of disturbance around each construction vessel, 27 individuals (1.06 x 12.56 x 2) could be at risk of displacement and up to 3 at risk of mortality. The winter (nonbreeding season) BDMPS for razorbill is 218,622 (Furness, 2015). At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the winter BDMPS is 38,040 (218,622 x 0.174). The addition of 3 individuals to this would increase the mortality rate by 0.008% which would be undetectable. Therefore, during the winter period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach.

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

186. During the spring migration season, at a seasonal peak density of 0.39/km^2 and with a highly precautionary 2km radius of disturbance around each construction vessel, 10 individuals (0.39 x 12.56 x 2) could be at risk of displacement and up to 1 at risk of

mortality. The spring migration BDMPS for razorbill is 591,874 (Furness, 2015). At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the spring migration BDMPS is 102,986 (591,874 x 0.174). The addition of 1 individual to this would increase the mortality rate by 0.001% which would be undetectable. Therefore, during the spring migration period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach.

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

188. During the breeding season the seasonal peak density on the site was 0.52/km^2 (July) which suggests that 13 individuals (0.52 x 12.56 x 2) could be at risk of displacement and up to 1 at risk of mortality.

189. As described for NV East (above), NV West is beyond the foraging range of razorbill from the nearest breeding colony (204km). Therefore, it is reasonable to assume that individuals seen during the breeding season are nonbreeding (e.g. immature birds). Since immature seabirds are known to remain in wintering areas, the number of immature birds in the relevant population during the breeding season may be estimated as 43% of the total wintering BDMPS population (Furness, 2015). This gives a breeding season population of 94,007 (BDMPS for the UK North Sea and Channel, 218,622 x 43%). At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the breeding season is 16,357 (94,007 x 0.174). The addition of 1 individual to this would increase the mortality rate by 0.01% which would be undetectable. Therefore, an impact on 1 (likely immature) individual during the breeding season will be negligible at the population level. The construction works are temporary and localised in nature and the magnitude of effect has been determined as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

190. As the species is of low to medium sensitivity to disturbance, even when the individual season impacts are combined (up to 7 additional mortalities in total) the increase in mortality would be no more than 0.02% (using the smaller BDMPS) therefore the impact significance is **minor adverse**.

Norfolk Vanguard East and Norfolk Vanguard West

191. The NV East and NV West construction disturbance and displacement assessment is summarised in Table 13.20. Although construction may occur on both NV East and NV West at the same time, the maximum number of simultaneous piling events would remain three. Therefore, any construction split across the sites would be of

smaller magnitude than either of those assessed for each site individually and no further assessment is required.

Table 13.20 Razorbill construction disturbance and displacement mortality impacts assessed for the worst case of two simultaneous piling operations on either NV East or NV West during each season and summed across seasons.

Season	Site	Peak density (birds/km²)	Max. no individuals subject to displacement mortality	Increase in background mortality (%)
Breeding	NV East	1.54	4	0.02
	NV West	0.52	1	0.01
Autumn migration	NV East	1.08	3	0.003
	NV West	0.81	2	0.002
Winter	NV East	0.75	2	0.005
	NV West	1.06	3	0.008
Spring migration	NV East	1.77	4	0.004
	NV West	0.39	1	0.001
Total	NV East	-	13	≤0.03
	NV West	-	7	≤0.02

13.7.4.1.5 Guillemot

Norfolk Vanguard East

192. Guillemots have been recorded in NV East year round, with numbers peaking in March (mean density 5.5/km^2) and at their lowest in June (mean density 0.16/km^2). Guillemots are considered to have a medium general sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004), Furness and Wade (2012), Furness *et al.* (2013) and Bradbury *et al.* (2014). Dierschke *et al*. (2016) categorized guillemot as 'weakly avoiding offshore wind farms' based on a review of numbers inside and outside of operational offshore wind farms; their behavioural response to construction is likely to be similar and probably slightly stronger than during operation.

193. There is potential for disturbance and displacement of guillemots due to construction activity, including wind turbine construction and associated vessel traffic. However, construction will not occur across the whole of the proposed wind turbine array area simultaneously or every day but will be phased, with no more than two foundations expected to be installed at any time within NV East.

Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire NV East site.

194. For this precautionary assessment it has been assumed that 10% of displaced individuals could die as a result of displacement by construction vessels.

195. During the nonbreeding season, at a seasonal peak density of 4.4/km^2 and with a highly precautionary 2km radius of disturbance around each construction vessel, a maximum of 110 individuals (4.4 x 12.56 x 2) could be at risk of displacement and up to 11 at risk of mortality. The nonbreeding season BDMPS for common guillemot is 1.6 million birds (Furness, 2015). At the average baseline mortality rate for guillemot of 0.14 (Table 13.23) the number of individuals expected to die in the nonbreeding BDMPS is 226,423 (1,617,306 x 0.14). The addition of 11 individuals to this would increase the mortality rate by 0.005% which would be undetectable. Therefore, during the nonbreeding period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach.

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

197. During the breeding season the seasonal peak density on the NV East site was 5.55/km^2 (March) which suggests that 139 individuals (5.55 x 12.56 x 2) could be at risk of displacement and up to 14 at risk of mortality.

198. The mean maximum foraging range for breeding guillemot is 84.2km (Thaxter *et al.,* 2012) which places NV East considerably beyond the range of any guillemot breeding colonies. It should be noted that some recent tagging studies have recorded larger apparent distances than this (one guillemot was recorded travelling 340km from Fair Isle) which would indicate connectivity to breeding colonies. However, further consideration of this apparent potential for connectivity 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, 1997) so would take almost ten 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 five 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 NV East is 3.4 hours direct flight time away from the nearest guillemot breeding colony (Flamborough Head, 236km from NV East). A return trip would take

6.8 hours, not allowing for foraging. As is the case for the Fair Isle example, travelling such distances is incompatible with successful breeding. On the basis of five 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.

199. On the basis of the above evidence, it can be stated with confidence that there are no breeding colonies for guillemot within foraging range of NV East, therefore it is reasonable to assume that individuals seen during the breeding season are nonbreeding (e.g. immature birds). Since immature seabirds are known often to remain in wintering areas, the number of immature birds in the relevant population during the breeding season may be estimated as 43% (the proportion of the population that is of immature status) of the total wintering BDMPS population (Furness, 2015). This gives a breeding season population of nonbreeding immature birds of 695,441 (BDMPS for the UK North Sea and Channel, 1,617,306 x 43%). At the average baseline mortality rate for guillemot of 0.14 (Table 13.23) the number of individuals expected to die in the breeding season is 97,362 (695,441 x 0.14). The addition of 14 individuals to this would increase the mortality rate by 0.01% which would be undetectable. Therefore, during the breeding season, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. Therefore, an impact on 14 (likely immature) individuals during the breeding season will be negligible.

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

201. Guillemot are of medium sensitivity to disturbance, thus even when the individual season impacts are combined (up to 25 additional mortalities in total) the increase in mortality would be no more than 0.01% therefore the impact significance is **minor adverse**.

Norfolk Vanguard West

202. Guillemots have been recorded in NV West year round, with numbers peaking in January (mean density 5.8/km^2) and at their lowest in May (mean density 0.28/km^2). Guillemots are considered to have a medium general sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004), Furness and Wade (2012), Furness *et al.* (2013) and Bradbury *et al.* (2014). Dierschke *et al*. (2016) categorized guillemot as 'weakly avoiding offshore wind farms' based on a review of numbers inside and outside of operational offshore

wind farms; their behavioural response to construction is likely to be similar and probably slightly stronger than during operation.

203. There is potential for disturbance and displacement of guillemots due to construction activity, including wind turbine construction and associated vessel traffic. However, construction will not occur across the whole of the proposed wind turbine array area simultaneously or every day but will be phased, with no more than two foundations expected to be installed at any time within the NV West site. Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire NV West site.

204. During the nonbreeding season, at a seasonal peak density of 5.76/km^2 and with a highly precautionary 2km radius of disturbance around each construction vessel, a maximum of 145 individuals (5.76 x 12.56 x 2) could be at risk of displacement and up to 15 at risk of mortality. The nonbreeding season BDMPS for common guillemot is 1.6 million birds (Furness 2015). At the average baseline mortality rate for guillemot of 0.14 (Table 13.23) the number of individuals expected to die in the nonbreeding BDMPS is 226,423 (1,617,306 x 0.14). The addition of 15 individuals to this would increase the mortality rate by 0.006% which would be undetectable. Therefore, during the nonbreeding period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach.

205. The construction works are temporary and localised in nature and the magnitude of effect has been determined as negligible, even making precautionary assumptions about numbers present and distance over which displacement may act. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

206. During the breeding season the seasonal peak density on NV West was 2.21/km^2 (July) which suggests that 55 individuals (2.21 x 12.56 x 2) could be at risk of displacement and 6 at risk of mortality.

207. As described for NV East (above), NV West is beyond the foraging range of guillemot from the nearest breeding colony (204km). Therefore, it is reasonable to assume that individuals seen during the breeding season are nonbreeding (e.g. immature birds). Since some 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% (the proportion of the population that is of immature status) of the total wintering BDMPS population (Furness, 2015). This gives a breeding season population of 695,441 nonbreeding immatures (BDMPS for the UK North Sea and Channel, 1,617,306 x 43%). At the average baseline mortality rate for guillemot of 0.14 (Table 13.23) the number of individuals expected to die in the breeding season is 97,362 (695,441 x 0.14). The addition of 6 individuals to this

would increase the mortality rate by 0.006% which would be undetectable. Therefore, during the breeding season, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach.

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

209. Guillemot are of medium sensitivity to disturbance, thus even when the individual season impacts are combined (up to 21 additional mortalities in total) the increase in mortality would be no more than 0.01% therefore the impact significance is **minor adverse**.

Norfolk Vanguard East and Norfolk Vanguard West

210. The NV East and NV West construction disturbance and displacement assessment is summarised in Table 13.21. Although construction may occur on both NV East and NV West at the same time, the maximum number of simultaneous piling events would remain three. Therefore, any construction split across the sites would be of smaller magnitude than either of those assessed for each site individually and no further assessment is required.

Table 13.21 Guillemot construction disturbance and displacement mortality impacts assessed for the worst case of two simultaneous piling operations on either NV East or NV West during each season and summed across seasons.

Season	Site	Peak density (birds/km^2)	Max. no individuals subject to displacement mortality	Increase in background mortality (%)
Breeding	NV East	5.55	14	0.01
	NV West	2.21	6	0.006
Nonbreeding	NV East	4.37	11	0.005
	NV West	5.76	15	0.006
Total	NV East	-	25	0.01
	NV West	-	21	0.01

13.7.4.2 Impact 2: Indirect effects as a result of displacement of prey species due to increased noise and disturbance to seabed

211. 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 seabed 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 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 10 Benthic Ecology and Chapter 11 Fish and Shellfish Ecology and the conclusions of those assessments inform this assessment of indirect effects on ornithological receptors.

212. With regard to noise impacts on fish, Chapter 11 Fish and Shellfish Ecology discusses the potential impacts upon fish as prey species relevant to birds. With regard to physical injury or behavioural changes, underwater noise impacts on fish during construction of the proposed project are considered to be minor or negligible (see Chapter 11 Fish and Shellfish Ecology) for species such as herring, sprat and sandeel which are main prey items of seabirds such as gannet and auks. Given that Norfolk Vanguard is situated in a region of lower importance for foraging seabirds (i.e. beyond foraging range of breeding colonies), a minor or negligible adverse impact on fish that are bird prey species will give rise to impacts on seabirds occurring in or around the proposed project during the construction phase of a **negligible to minor adverse** significance.

213. With regard to changes to the seabed and to suspended sediment levels, Chapter 10 Benthic Ecology discusses the nature of any change and impact. Such changes are considered to be temporary, small scale and highly localised. The consequent indirect impact on fish through habitat loss is considered to be minor or negligible (see Chapter 11 Fish and Shellfish Ecology) for species such as herring, sprat and sandeel which are 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 project during the construction phase is similarly **negligible to minor adverse**.

13.7.5 Potential Impacts during Operation

13.7.5.1 Impact 3: Disturbance and displacement from offshore infrastructure

214. The presence of wind turbines has the potential to directly disturb and displace birds from within and around the OWF sites. 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. Vessel activity and the lighting of wind turbines and associated ancillary structures could also attract (or repel) certain species of birds and affect migratory behaviour on a local scale.

215. Seabird species vary in their reactions to the presence of operational infrastructure (e.g. wind turbines, offshore project substations and met masts) and to the maintenance activities that are associated with them (particularly ship and helicopter traffic), with Garthe and Hüppop (2004) presenting a scoring system for such disturbance factors, which is used widely in offshore wind farm EIAs. As offshore wind farms are a new feature in the marine environment, there is limited evidence as to the disturbance and displacement effects of the operational infrastructure in the long term. However, Dierschke *et al*. (2016) reviewed all available evidence from operational offshore wind farms on the extent of displacement or attraction of seabirds in relation to these structures. They found strong avoidance of operational offshore wind farms by great crested grebe, red-throated diver, black-throated diver and gannet. They found weak avoidance by long-tailed duck, common scoter, fulmar, Manx shearwater, razorbill, guillemot, little gull and Sandwich tern. They found no evidence of any consistent response by eider, kittiwake, common tern and Arctic tern, and evidence of weak attraction to operating offshore wind farms 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. Dierschke *et al*. (2016) suggested that strong avoidance would lead to some habitat loss for those species, while attracted birds appear to benefit from increases in food abundance within operational offshore wind farms.

216. The Statutory Nature Conservation Bodies (SNCBs) issued a joint Interim Displacement Guidance Note (JNCC, 2017), which provides recommendations for presenting information to enable the assessment of displacement effects in relation to offshore wind farm developments. This guidance note has been used in the assessment provided below.

217. There are a number of different measures used to determine bird displacement from areas of sea in response to activities associated with an offshore wind farm. Furness *et al.* (2013), for example, use disturbance ratings for particular species, alongside scores for habitat flexibility and conservation importance to define an index value that highlights the sensitivity to disturbance and displacement. These authors also recognise that displacement may contribute to individual birds experiencing fitness consequences, which at an extreme level could lead to the mortality of individuals.

218. Both the presence of the infrastructure and the operational activities associated with the proposed project have the potential to directly disturb birds. These activities could potentially displace birds from important areas for feeding, moulting and loafing. Reduced access to some areas could result, at the extreme, in changes to feeding and other behavioural activities resulting in a loss of fitness and a reduction in survival chances. 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 *et al.,* 2013; Bradbury *et al.,* 2014).

219. The methodology presented in JNCC (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, BDMPS or biogeographic) to determine the magnitude of effect.

220. The population estimate used for each species to assess the displacement effects was the relevant seasonal peak (i.e. the highest 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 JNCC (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.

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

222. 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 OWF sites. However, disturbance from operational cable activities (e.g. maintenance) 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. 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.

223. 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 13.22), focussing on the main species described in the Ornithology Technical Report (Appendix 13.1). The species identified as at risk were then assessed within the biological seasons within which effects were potentially likely to occur. Any species

with a low sensitivity to displacement or recorded only in very small numbers within the OWF sites during the breeding and wintering seasons, were screened out of further assessment.

224. This process screened out black-throated diver and great northern diver as these species were only recorded in two and four surveys respectively and in very low numbers.

225. Operational disturbance and displacement screening (Table 13.22) 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 wind farm rather than the wind turbine) are derived from a review of monitoring reports at constructed wind farms (Krijgsveld *et al.*, 2011, Leopold *et al.*, 2011, Mendel *et al.,* 2014, Vanermen *et al.,* 2013, Braasch *et al.,* 2015, Walls *et al.*, 2013), and from a published review of offshore wind farm displacement studies (Dierschke *et al.,* 2016).

Table 13.22 Operational disturbance and displacement screening

Receptor	Sensitivity to Disturbance and Displacement (Garthe and Hüppop, 2004; Furness and Wade, 2012, Wade *et al.*, 2016, Dierschke *et al.*, 2016)	Displacement Rate based on OWEZ (Krijgsveld *et al.*, 2011, Leopold *et al.*, 2011)	Displacement Rate based on Robin Rigg (Walls *et al.*, 2013)	Biological Season(s) with peak numbers	Screening Result (IN or OUT)
Red-throated diver	Very High	68%	n/a (sample size small)	Spring migration	**Screened IN** for potential effects during autumn migration, midwinter and spring migration.
Fulmar	Considered Low in some studies, but possibly high according to Dierschke *et al.* (2016)	28%	n/a	Breeding & migration periods	**Screened OUT** as the species has a maximum habitat flexibility score of 1 in Furness & Wade (2012), suggesting species 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)	64%	50%	Autumn migration	**Screened IN** for autumn and spring migration seasons, as has a high macro avoidance rate.
Guillemot	Medium	68%	30% (Some evidence of displacement)	Migration periods	**Screened IN** as present in moderate numbers in nonbreeding season and due to medium sensitivity to disturbance and displacement.
Razorbill	Medium	68%	30% (Some evidence of displacement for all auks)	Nonbreeding season	**Screened IN** as present in moderate numbers in nonbreeding season and due to medium sensitivity to disturbance and displacement.
Puffin	Low	68%	30% (Some evidence of displacement for all auks)	Nonbreeding season	**Screened IN** as present in moderate numbers in nonbreeding season and due to medium sensitivity to disturbance and displacement.

Receptor	Sensitivity to Disturbance and Displacement (Garthe and Hüppop, 2004; Furness and Wade, 2012, Wade *et al.*, 2016, Dierschke *et al.*, 2016)	Displacement Rate based on OWEZ (Krijgsveld *et al.*, 2011, Leopold *et al.*, 2011)	Displacement Rate based on Robin Rigg (Walls *et al.*, 2013)	Biological Season(s) with peak numbers	Screening Result (IN or OUT)
Kittiwake	Low	18%	0% (No clear evidence of Displacement)	Migration periods	**Screened OUT** as migration numbers low relative to BDMPS and not known to avoid wind turbines (low macro avoidance rate)
Lesser black-backed gull	Low	18%	0% (No difference in gull presence)	No clear seasonal peak	**Screened OUT** as present in low numbers in all seasons and not known to avoid wind turbines (low macro avoidance rate)
Herring gull	Low	18%	0% (No difference in gull presence)	Breeding	**Screened OUT** as present in low numbers in all seasons and not known to avoid wind turbines (low macro avoidance rate)
Great black-backed gull	Low	18%	0% (No difference in gull presence)	Breeding & Wintering	**Screened OUT** as present in low numbers in all season and not known to avoid wind turbines (low macro avoidance rate)

226. The impact of mortality caused by displacement on the population is assessed in terms of the change in the baseline mortality rate which could result. It has been assumed that all age classes are equally at risk of displacement (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 screened in for assessment (Table 13.22). These were calculated using the different rates for each age class and their relative proportions in the population.

227. The first step is to calculate an average survival rate. The demographic rates for each species were taken from Horswill and Robinson (2015) and entered into a matrix population model. This was used to calculate the expected proportions in each age class. To obtain robust stable age class distributions for less well studied species (e.g. divers) the rates were modified in order 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 13.23.

Table 13.23 Average mortality across all age classes. Average mortality calculated using age specific demographic rates and age class proportions.

Species	Parameter	Survival (age class)						Productivity	Average mortality
		0-1	1-2	2-3	3-4	5-6	Adult		
Red-throated diver	Demographic rate	0.6	0.62	-	-	-	0.84	0.571	0.228
	Population age ratio	0.179	0.145	-	-	-	0.676	-	
Gannet	Demographic rate	0.424	0.829	0891	0.895	-	0.912	0.7	0.191
	Population age ratio	0.191	0.081	0.067	0.06	-	0.6	-	
Guillemot	Demographic rate	0.56	0.792	0.917	0.939	0.939	0.939	0.672	0.14
	Population age ratio	0.168	0.091	0.069	0.062	0.056	0.552	-	
Razorbill	Demographic rate	0.63	0.63	0.895	0.895	-	0.895	0.57	0.174

Species	Parameter	Survival (age class)						Productivity	Average mortality
		0-1	1-2	2-3	3-4	5-6	Adult		
	Population age ratio	0.159	0.102	0.065	0.059	-	0.613	-	
Puffin	Demographic rate	0.709	0.709	0.76	0.805	-	0.906	0.617	0.167
	Population age ratio	0.162	0.115	0.082	0.063	-	0.577	-	

13.7.5.1.1 Project scenarios

228. Two project scenarios have been assessed for operational displacement (Table 13.15) which bracket the maximum development in each of NV East and NV West (i.e. all turbines installed in one or other site). In addition, following advice from Natural England (2017) an absolute worst case impact with respect to displacement has been considered, which combines the assessed impacts for both NV east and NV West on the basis that birds are completely displaced from both. For several reasons this outcome is highly unrealistic, since the maximum number of turbines will remain 200 (9MW) and these would either cover a proportionally smaller area of each site (e.g. 50% of NV East and 50% of NV West) or the inter-turbine distances would be much greater (e.g. up to twice the minimum described in Table 13.16).

229. There is evidence to suggest that the density of turbines influences the magnitude of displacement (Leopold *et al*. 2011). Indeed, since the cause of operational displacement is bird responses to the turbines, it is logical to infer that a wind farm with a lower turbine density will cause lower displacement levels than one with a higher density of turbines. Therefore, in either case, the magnitude of displacement from each site would be less than the highly precautionary 100% which has been assumed for this combined assessment.

230. Natural England guidance 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, and also the biogeographic population. Natural England have 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.

13.7.5.1.2 Red-throated diver

231. Red-throated divers are considered to have a very high general sensitivity to disturbance and displacement and they are notoriously shy and prone to avoiding disturbed areas (Garthe & Hüppop, 2004; Petersen, 2006; Furness and Wade, 2012; Percival, 2014; Dierschke *et al.,* 2016; Dierschke *et al.,* 2017). Monitoring studies of red-throated divers at the Kentish Flats offshore wind farm found an observable shift of birds away from the turbines, particularly within 500m of the site (Percival, 2010). This is consistent with a study of pre-construction and post-construction abundance and distribution of birds conducted at Horns Rev, Denmark. This study 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 wind farm, and that this effect remained for a period of three years (Peterson *et al.,* 2006). Further pre-construction and post-construction abundance and distribution studies published more recently on red-throated divers at the Kentish Flats site (Percival, 2014) have provided displacement values for both the site footprint and within distance bands away from the site boundary and indicate how displacement has changed over the periods following construction.

232. Natural England's preferred method assumes that displacement will occur at a constant level to a distance of 4km and that within this area, 90-100% of birds will be displaced and mortality of displaced birds will be 10%. This is considered to be over-precautionary since it combines high values for three aspects of the assessment: the distance over which birds will be affected (4km), the rate of displacement within this distance (90-100%) and the mortality rate of displaced individuals (10%). Further consideration of these is provided below.

233. Studies at Kentish Flats and Thanet have provided evidence that red-throated divers are displaced to a decreasing extent with increasing distance from wind turbines (Percival 2013, 2014). Percival (2014) reported that at Kentish Flats, while displacement within the wind farm boundary was around 80% (compared to pre-construction), this declined to 10% at 1km from the wind farm and was 0% from 2km. A similar within wind farm reduction in density was reported at Thanet, but there was no detectable displacement beyond the wind farm boundary (Percial 2013). Displacement rates of 60% to 80% were reported for OWEZ (Leopold *et al*. 2011) and the review by Dierschke *et al.* (2016) also suggested a figure in this range. The 4km exclusion distance advised by Natural England is greater than the evidence suggests is required for this species, and it is therefore considered over-precautionary to combine this with a displacement rate as high as 100%.

234. A review of evidence undertaken by a panel of experts brought together by JNCC concluded that mortality associated with displacement of red-throated divers may well be zero (Dierschke *et al.,* 2017) and is certainly very unlikely to be as high as the 10% recommended by Natural England. This conclusion is also supported by modelling of individual energy budgets (Topping and Petersen, 2011).

235. Therefore, on the basis of the evidence outlined above, this assessment uses rates of 80% for displacement and 5% for mortality applied to the population of birds within 4km. This combination is considered to balance precaution and evidence in the assessment.

236. The displacement matrices in Table 13.24 to Table 13.26 have been populated with data for red-throated diver during the autumn migration, nonbreeding and spring migration periods within the site and those calculated within a 4km buffer. These tables present displacement from 0 – 100% at 10% increments and mortality from 0 – 100% at 1% increments up to 10% and larger gaps thereafter. Shading has been used to highlight the 60-80% displacement and 1-5% mortality ranges.

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237. Using the seasonal peak autumn migration abundance on NV East of 50, the predicted number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement has been estimated as two individuals at a displacement rate of 80% and mortality of 5% (Table 13.24).

238. The BDMPS for red-throated diver in autumn is 13,277 (Furness, 2015). At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die is 3,027 (13,277 x 0.228). The addition of two individuals to this would increase the mortality rate by 0.06%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the autumn migration period, the magnitude of effect is assessed as negligible even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.24 Displacement matrix presenting the number of red-throated divers in Norfolk Vanguard East (and 4km buffer) during the autumn migration season that may be subject to mortality (highlighted) on the assumption of complete development of this site.

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	1	1	1	1	1	1
3	0	0	0	1	1	1	1	1	1	2
4	0	0	1	1	1	1	1	2	2	2
5	0	1	1	1	1	2	2	2	2	3
6	0	1	1	1	2	2	2	2	3	3
7	0	1	1	1	2	2	2	3	3	4
8	0	1	1	2	2	2	3	3	4	4
9	0	1	1	2	2	3	3	4	4	5
10	1	1	2	2	3	3	4	4	5	5
20	1	2	3	4	5	6	7	8	9	10
30	2	3	5	6	8	9	11	12	14	15
50	3	5	8	10	13	15	18	20	23	25
75	4	8	11	15	19	23	26	30	34	38
100	5	10	15	20	25	30	35	40	45	50

239. Using the seasonal peak winter abundance on NV East of 25, the maximum number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement has been estimated as one individual at a displacement rate of 80% and mortality of 5% (Table 13.25).

240. The BDMPS for red-throated diver in winter is 10,177 (Furness, 2015). At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die is 2,320 (10,177 x 0.228). The addition of one individual to this would increase the mortality rate by 0.04%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the winter period, the magnitude of effect is assessed as negligible. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.25 Displacement matrix presenting the number of red-throated divers in Norfolk Vanguard East (and 4km buffer) during the winter period that may be subject to mortality (highlighted) on the assumption of complete development of this site.

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	1
3	0	0	0	0	0	0	1	1	1	1
4	0	0	0	0	1	1	1	1	1	1
5	0	0	0	1	1	1	1	1	1	1
6	0	0	0	1	1	1	1	1	1	2
7	0	0	1	1	1	1	1	1	2	2
8	0	0	1	1	1	1	1	2	2	2
9	0	0	1	1	1	1	2	2	2	2
10	0	1	1	1	1	2	2	2	2	3
20	1	1	2	2	3	3	4	4	5	5
30	1	2	2	3	4	5	5	6	7	8
50	1	3	4	5	6	8	9	10	11	13
75	2	4	6	8	9	11	13	15	17	19
100	3	5	8	10	13	15	18	20	23	25

241. Using the seasonal peak spring migration abundance on NV East of 119 the maximum number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement has been estimated as 5 individuals at a displacement rate of 80% and mortality of 5% (Table 13.26).

242. At an average mortality rate of 0.228 (Table 13.23), the number of individuals expected to die is 3,027 (13,277 x 0.228). The addition of 5 individuals to this would increase the mortality rate by 0.16%. 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 even on the basis of this highly precautionary approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.26 Displacement matrix presenting the number of red-throated divers in Norfolk Vanguard East (and 4km buffer) during the spring migration period that may be subject to mortality (highlighted) on the assumption of complete development of this site.

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	1	1	1	1	1	1
2	0	0	1	1	1	1	2	2	2	2
3	0	1	1	1	2	2	2	3	3	4
4	0	1	1	2	2	3	3	4	4	5
5	1	1	2	2	3	4	4	5	5	6
6	1	1	2	3	4	4	5	6	6	7
7	1	2	2	3	4	5	6	7	7	8
8	1	2	3	4	5	6	7	8	9	10
9	1	2	3	4	5	6	7	9	10	11
10	1	2	4	5	6	7	8	10	11	12
20	2	5	7	10	12	14	17	19	21	24
30	4	7	11	14	18	21	25	29	32	36
50	6	12	18	24	30	36	42	48	54	60
75	9	18	27	36	45	54	62	71	80	89
100	12	24	36	48	60	71	83	95	107	119

243. The summed NV East displacement mortality for autumn, winter and spring is estimated at 8 individuals (at 80% displaced and 5% mortality), although this figure includes an unknown degree of double counting due to overlaps in the populations in each period. This additional mortality would increase the background mortality by 0.26% which would be undetectable. Therefore, during the entire nonbreeding period, the magnitude of effect is assessed as negligible even on the basis of the highly precautionary assessment approach. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

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244. Using the seasonal peak autumn migration abundance on NV West of 6, the maximum number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement has been estimated as 0 at a displacement rate of 80% and mortality rate of 5% (Table 13.27).

245. Therefore, during the autumn migration period, there would be no impact.

Table 13.27 Displacement matrix presenting the number of red-throated divers in Norfolk Vanguard West (and 4km buffer) during the autumn migration season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	1
10	0	0	0	0	0	0	0	0	1	1
20	0	0	0	0	1	1	1	1	1	1
30	0	0	1	1	1	1	1	1	2	2
50	0	1	1	1	2	2	2	2	3	3
75	0	1	1	2	2	3	3	4	4	5
100	1	1	2	2	3	4	4	5	5	6

246. Using the seasonal peak winter abundance on NV West of 330 the maximum number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement has been estimated as 13 individuals at a displacement rate of 80% and mortality of 5% (Table 13.28).

247. The BDMPS for red-throated diver in winter is 10,177 (Furness, 2015). At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die in the winter BDMPS is 2,320 (10,177 x 0.228). The addition of 13 individuals to this would increase the mortality rate by 0.56%. This magnitude of increase in mortality would generate a negligible magnitude of effect. As the species is of high sensitivity to disturbance, the impact significance would be **minor adverse**.

Table 13.28 Displacement matrix presenting the number of red-throated divers in Norfolk Vanguard West (and 4km buffer) during the winter period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	1	2	2	2	3	3	3
2	1	1	2	3	3	4	5	5	6	7
3	1	2	3	4	5	6	7	8	9	10
4	1	3	4	5	7	8	9	11	12	13
5	2	3	5	7	8	10	12	13	15	17
6	2	4	6	8	10	12	14	16	18	20
7	2	5	7	9	12	14	16	18	21	23
8	3	5	8	11	13	16	18	21	24	26
9	3	6	9	12	15	18	21	24	27	30
10	3	7	10	13	17	20	23	26	30	33
20	7	13	20	26	33	40	46	53	59	66
30	10	20	30	40	50	59	69	79	89	99
50	17	33	50	66	83	99	116	132	149	165
75	25	50	74	99	124	149	173	198	223	248
100	33	66	99	132	165	198	231	264	297	330

248. Using the seasonal peak spring migration abundance on NV West of 197 the maximum number of individual red-throated divers which could potentially suffer mortality as a consequence of displacement has been estimated as 8 individuals at a displacement rate of 80% and mortality of 5% (Table 13.29).

249. The BDMPS for red-throated diver in spring is 13,277 (Furness, 2015). At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die is 3,027 (13,277 x 0.228). The addition of 8 individuals to this would increase the mortality rate by 0.26%. 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 high sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.29 Displacement matrix presenting the number of red-throated divers in Norfolk Vanguard West (and 4km buffer) during the spring migration period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	1	1	1	1	1	2	2	2
2	0	1	1	2	2	2	3	3	4	4
3	1	1	2	2	3	4	4	5	5	6
4	1	2	2	3	4	5	6	6	7	8
5	1	2	3	4	5	6	7	8	9	10
6	1	2	4	5	6	7	8	9	11	12
7	1	3	4	6	7	8	10	11	12	14
8	2	3	5	6	8	9	11	13	14	16
9	2	4	5	7	9	11	12	14	16	18
10	2	4	6	8	10	12	14	16	18	20
20	4	8	12	16	20	24	28	32	35	39
30	6	12	18	24	30	35	41	47	53	59
50	10	20	30	39	49	59	69	79	89	99
75	15	30	44	59	74	89	103	118	133	148
100	20	39	59	79	99	118	138	158	177	197

250. The NV West displacement mortality for autumn, winter and spring combined is estimated at 21 (80% displaced and 5% mortality). This would increase background mortality by 0.69%. Therefore, during the entire nonbreeding period, the magnitude of effect is assessed as negligible even on the basis of the highly precautionary assessment. As the species is of high sensitivity to disturbance, the impact significance is **minor adverse**.

Norfolk Vanguard East and Norfolk Vanguard West

251. The worst case displacement impact has been assessed on the basis that both NV East and NV West would be completely developed, although this is highly precautionary since even if each site contains half the total number of turbines these would be very unlikely to be distributed across the entirety of both sites.

252. The combined displacement mortality across both NV East and NV West for the complete nonbreeding period would be 29 individuals (80% displaced and 5% mortality). This would increase background mortality by 0.96%. At this magnitude of increase in mortality a negligible magnitude of effect would be predicted. As the

species is of high sensitivity to disturbance, the impact significance would be **minor adverse**.

13.7.5.1.3 Gannet

253. Gannets show a low level of sensitivity to ship and helicopter traffic (Garthe and Hüppop, 2004, Furness and Wade, 2012); however, a detailed study (Krijgsveld *et al.*, 2011) using radar and visual observations to monitor the post-construction effects of the Windpark Egmond aan Zee OWEZ established that 64% of gannets avoided entering the wind farm (macro-avoidance). Leopold *et al.,* (2013) reported that most gannets avoided Dutch offshore wind farms and did not forage within these. Dierschke *et al.,* (2016) concluded that gannets show high avoidance of offshore wind farms despite showing little avoidance of ships.

254. The displacement matrices have been populated with data for gannets during the autumn and spring migration periods within the site and those calculated within a 2km buffer, in line with guidance (JNCC, 2017). It should be noted that the inclusion of birds within the 2km buffer to determine the total number of birds subject to displacement is precautionary since 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 wind farm (APEM, 2014).

255. For the purpose of this assessment, percentage displacement rates between 10 and 100% at 10% increments have been combined with mortality between 1 and 100% at varying increments. The highlighted cells in the matrices indicate displacement rates of 60% to 80% (as the OWEZ data suggest the actual rate lies between these two figures based on macro-avoidance; Leopold *et al*., 2013) and the most likely mortality rate during the nonbreeding seasons, which is assumed to be no more than 1% (as they score highly for habitat flexibility; Furness and Wade, 2012). A high score in habitat flexibility is given to species that use a wide range of habitats over a large area, and usually with a relatively wide range of foods (Furness and Wade, 2012).

Norfolk Vanguard East

256. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from NV East during the autumn migration period has been estimated as 13 individuals (Table 13.30).

257. The BDMPS for gannet in autumn is 456,298 (Furness, 2015). At the average baseline mortality rate for gannet of 0.191 (Table 13.23), the number of individuals expected to die is 87,153 (456,298 x 0.191). The addition of a maximum of 13 to this increases the mortality rate by 0.015%. 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. Although gannets are considered to show high macro-avoidance of wind farms, which would suggest a high sensitivity score, this has been accounted for in the assessment in the application of a precautionary level of displacement (60-80%). Therefore, since this species has low sensitivity to other sources of disturbance such as vessels, a medium to low sensitivity has been assumed for displacement, with impact significance assessed as **negligible to minor adverse**.

Table 13.30 Displacement matrix presenting the number of gannets in Norfolk Vanguard East (and 2km buffer) during the autumn migration season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	2	3	5	7	8	10	11	13	15	16
2	3	7	10	13	16	20	23	26	29	33
3	5	10	15	20	24	29	34	39	44	49
4	7	13	20	26	33	39	46	52	59	65
5	8	16	24	33	41	49	57	65	73	82
6	10	20	29	39	49	59	68	78	88	98
7	11	23	34	46	57	68	80	91	103	114
8	13	26	39	52	65	78	91	104	117	130
9	15	29	44	59	73	88	103	117	132	147
10	16	33	49	65	82	98	114	130	147	163
20	33	65	98	130	163	196	228	261	293	326
30	49	98	147	196	245	293	342	391	440	489
50	82	163	245	326	408	489	571	652	734	815
75	122	245	367	489	611	734	856	978	1100	1223
100	163	326	489	652	815	978	1141	1304	1467	1630

258. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from NV East during the spring migration period has been estimated as three individuals (Table 13.31).

259. The BDMPS for gannet in spring is 248,385 (Furness, 2015). At the average baseline mortality rate for gannet of 0.191 (Table 13.23), the number of individuals expected to die is 47,441 (248,385 x 0.191). The addition of a maximum of three to this increases the mortality rate by 0.006%. 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. Although gannets are considered to show high macro-avoidance of wind farms, which would suggest a high sensitivity score, this has been accounted for in the assessment in the application of a precautionary level of displacement (60-80%). Therefore, since this species has low sensitivity to other sources of disturbance such as vessels, a medium to low sensitivity has been assumed for displacement, with impact significance assessed as **negligible to minor adverse**.

Table 13.31 Displacement matrix presenting the number of gannets in Norfolk Vanguard East (and 2km buffer) during the spring period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	2	2	3	3	3	4	4
2	1	2	3	3	4	5	6	7	8	8
3	1	3	4	5	6	8	9	10	11	13
4	2	3	5	7	8	10	12	13	15	17
5	2	4	6	8	10	13	15	17	19	21
6	3	5	8	10	13	15	18	20	23	25
7	3	6	9	12	15	18	21	23	26	29
8	3	7	10	13	17	20	23	27	30	34
9	4	8	11	15	19	23	26	30	34	38
10	4	8	13	17	21	25	29	34	38	42
20	8	17	25	34	42	50	59	67	75	84
30	13	25	38	50	63	75	88	101	113	126
50	21	42	63	84	105	126	147	168	189	210
75	31	63	94	126	157	189	220	251	283	314
100	42	84	126	168	210	251	293	335	377	419

260. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from NV East during the breeding season has been estimated as one individual (Table 13.32).

261. Although NV East is within the mean maximum gannet foraging range from the colony at Bempton Cliffs, the degree of connectivity indicated from tagging studies is considered to be low (e.g. Langston *et al*. 2013). However, as a precautionary assessment the breeding season impact has been assessed against this population.

The population was estimated at 11,061 pairs in 2012 (Furness 2015) but had risen to 13,391 pairs in 2017 (RSPB unpublished colony report). At the average baseline mortality rate for gannet of 0.191 (Table 13.23), the number of individual adults predicted to die would be between 4,225 and 5,115 (22,122 to 26,782 x 0.191). The addition of one individual to these would increases the mortality rate by 0.02% (note that this has been calculated for the adult breeding population only, which would be expected to comprise around 60% of the total population, thus adding further precaution to this assessment). This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding season, and assessing the impact against a small adult population, the magnitude of effect is assessed as negligible. Although gannets are considered to show high macro-avoidance of wind farms, which would suggest a high sensitivity score, this has been accounted for in the assessment in the application of a precautionary level of displacement (60-80%). Therefore, since this species has low sensitivity to other sources of disturbance such as vessels, a low to medium sensitivity has been assumed for displacement, with impact significance assessed as **negligible to minor adverse**.

Table 13.32 Displacement matrix presenting the number of gannets in Norfolk Vanguard East (and 2km buffer) during the breeding season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	1	1	1	1	1	1	2
2	0	1	1	1	2	2	2	3	3	3
3	0	1	1	2	2	3	3	4	4	5
4	1	1	2	3	3	4	5	5	6	6
5	1	2	2	3	4	5	6	6	7	8
6	1	2	3	4	5	6	7	8	9	10
7	1	2	3	5	6	7	8	9	10	11
8	1	3	4	5	6	8	9	10	12	13
9	1	3	4	6	7	9	10	12	13	15
10	2	3	5	6	8	10	11	13	15	16
20	3	6	10	13	16	19	23	26	29	32
30	5	10	15	19	24	29	34	39	44	49
50	8	16	24	32	41	49	57	65	73	81
75	12	24	36	49	61	73	85	97	109	122
100	16	32	49	65	81	97	113	130	146	162

262. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from NV East during the breeding, autumn migration and spring migration periods combined has been estimated as 17 individuals. The biogeographic gannet population is 1,180,000 (Furness, 2015).

263. At the average baseline mortality rate for gannet of 0.191 (Table 13.23) the number of individuals expected to die during the annual period is 225,380 (1,180,000 x 0.191). The addition of a maximum of 17 to this increases the mortality rate by 0.007%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the whole year, the magnitude of effect is assessed as negligible. Although gannets are considered to show high macro-avoidance of wind farms, which would suggest a high sensitivity score, this has been accounted for in the assessment in the application of a precautionary level of displacement (60-80%). Therefore, since this species has low sensitivity to other sources of disturbance such as vessels, a low to medium sensitivity has been assumed for displacement, with impact significance assessed as **negligible to minor adverse**.

Norfolk Vanguard West

264. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from NV West during the autumn migration period has been estimated as seven individuals (Table 13.33).

265. The BDMPS for gannet in autumn is 456,298 (Furness, 2015). At the average baseline mortality rate for gannet of 0.191 (Table 13.23) the number of individuals expected to die is 87,153 (456,298 x 0.191). The addition of a maximum of seven 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. Although gannets are considered to show high macro-avoidance of wind farms, which would suggest a high sensitivity score, this has been accounted for in the assessment in the application of a precautionary level of displacement (60-80%). Therefore, since this species has low sensitivity to other sources of disturbance such as vessels, a low to medium sensitivity has been assumed for displacement, with impact significance assessed as **negligible to minor adverse**.

Table 13.33 Displacement matrix presenting the number of gannets in Norfolk Vanguard West (and 2km buffer) during the autumn migration season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	2	2	3	4	5	6	7	7	8
2	2	3	5	7	8	10	12	13	15	16
3	2	5	7	10	12	15	17	20	22	25
4	3	7	10	13	16	20	23	26	30	33
5	4	8	12	16	21	25	29	33	37	41
6	5	10	15	20	25	30	35	40	44	49
7	6	12	17	23	29	35	40	46	52	58
8	7	13	20	26	33	40	46	53	59	66
9	7	15	22	30	37	44	52	59	67	74
10	8	16	25	33	41	49	58	66	74	82
20	16	33	49	66	82	99	115	132	148	165
30	25	49	74	99	123	148	173	198	222	247
50	41	82	123	165	206	247	288	329	370	412
75	62	123	185	247	309	370	432	494	556	617
100	82	165	247	329	412	494	576	658	741	823

266. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from NV West during the spring migration period has been estimated as zero individuals (Table 13.34). With no additional mortality during the spring migration period, the impact significance is assessed as **no change**.

Table 13.34 Displacement matrix presenting the number of gannets in Norfolk Vanguard West (and 2km buffer) during the spring migration period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%) 10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	1
4	0	0	0	0	0	0	1	1	1	1
5	0	0	0	0	0	1	1	1	1	1
6	0	0	0	0	1	1	1	1	1	1
7	0	0	0	1	1	1	1	1	1	1
8	0	0	0	1	1	1	1	1	1	1
9	0	0	0	1	1	1	1	1	1	2
10	0	0	1	1	1	1	1	1	2	2
20	0	1	1	1	2	2	3	3	3	4
30	1	1	2	2	3	3	4	4	5	5
50	1	2	3	4	5	5	6	7	8	9
75	1	3	4	5	7	8	9	11	12	14
100	2	4	5	7	9	11	13	14	16	18

267. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from NV West during the breeding season has been estimated as one individual (Table 13.35).

268. Although NV West is within the mean maximum gannet foraging range from the colony at Bempton Cliffs, the degree of connectivity indicated from tagging studies is considered to be low (e.g. Langston *et al*. 2013). However, as a precautionary assessment the breeding season impact has been assessed against this population. The population was estimated at 13,391 pairs in 2017 (RSPB unpublished colony report). At the average baseline mortality rate for gannet of 0.191 (Table 13.23), the number of individual adults predicted to die would be 5,115 (26,782 x 0.191). The addition of one individual to this would increases the mortality rate by 0.02% (note that this has been calculated for the adult breeding population only, which would be expected to comprise around 60% of the total population, thus adding further precaution to this assessment). This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding season, and assessing the impact against a small adult population, the magnitude of effect is assessed as negligible.

Although gannets are considered to show high macro-avoidance of wind farms, which would suggest a high sensitivity score, this has been accounted for in the assessment in the application of a precautionary level of displacement (60-80%). Therefore, since this species has low sensitivity to other sources of disturbance such as vessels, a low to medium sensitivity has been assumed for displacement, with impact significance assessed as **negligible to minor adverse**.

Table 13.35 Displacement matrix presenting the number of gannets in Norfolk Vanguard West (and 2km buffer) during the breeding season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	1	1	1	1	1
2	0	0	1	1	1	1	1	2	2	2
3	0	1	1	1	1	2	2	2	3	3
4	0	1	1	2	2	2	3	3	3	4
5	0	1	1	2	2	3	3	4	4	5
6	1	1	2	2	3	3	4	5	5	6
7	1	1	2	3	3	4	5	5	6	7
8	1	2	2	3	4	5	5	6	7	8
9	1	2	3	3	4	5	6	7	8	9
10	1	2	3	4	5	6	7	8	9	10
20	2	4	6	8	10	11	13	15	17	19
30	3	6	9	11	14	17	20	23	26	29
50	5	10	14	19	24	29	33	38	43	48
75	7	14	21	29	36	43	50	57	64	71
100	10	19	29	38	48	57	67	76	86	95

269. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from NV West during the breeding, autumn and spring migration periods combined has been estimated as eight individuals. The biogeographic gannet population is 1,180,000 (Furness, 2015).

270. At the average baseline mortality rate for gannet of 0.191 (Table 13.23) the number of individuals expected to die during the annual period is 225,380 (1,180,000 x 0.191). The addition of a maximum of eight to this increases the mortality rate by 0.003%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the whole year, the magnitude of effect is assessed as negligible. Although

gannets are considered to show high macro-avoidance of wind farms, which would suggest a high sensitivity score, this has been accounted for in the assessment in the application of a precautionary level of displacement (60-80%). Therefore, since this species has low sensitivity to other sources of disturbance such as vessels, a low to medium sensitivity has been assumed for displacement, with impact significance assessed as **negligible to minor adverse**.

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271. The worst case displacement impact has been assessed on the basis that both NV East and NV West would be completely developed, although this is highly precautionary since even if each site contains half the total number of turbines these would be very unlikely to be distributed across the entirety of both sites or to cause the same levels of displacement.

272. The combined displacement mortality across both NV East and NV West for the annual period would be 25 individuals. This would increase the background mortality for largest BDMPS population and the biogeographic population by 0.03% and 0.01% respectively. At these magnitudes of increase in mortality a negligible magnitude of effect would be predicted. Although gannets are considered to show high macro-avoidance of wind farms, which would suggest a high sensitivity score, this has been accounted for in the assessment in the application of a precautionary level of displacement (60-80%). Therefore, since this species has low sensitivity to other sources of disturbance such as vessels, a low to medium sensitivity has been assumed for displacement, with impact significance assessed as **negligible to minor adverse**.

13.7.5.1.4 Auks (Guillemot, Razorbill and Puffin)

273. Puffin is considered to have a low to medium sensitivity and razorbill and guillemot medium sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004), Langston (2010), an interpretation of the Furness and Wade (2012) species concern index value in the context of disturbance and/or displacement from a habitat, and the meta-analysis of avoidance and attraction responses of seabirds to offshore wind farms by Dierschke *et al.* (2016).

274. Displacement of foraging seabirds due to the presence of wind turbines cannot readily be assessed from observing birds in flight as only a very small proportion of flying seabirds land in any particular location. There is not yet very much empirical data on displacement of foraging seabirds from offshore wind farms with the consequence that assessment of the amount of displacement arising from developments is somewhat speculative. Available pre- and post-construction data

have yielded variable results but indicate that auks may be displaced to some extent by some wind farms, but this is partial, and apparently negligible in some sites (Dierschke *et al.,* 2016).

275. Common guillemots were displaced at Blighbank (Vanermen *et al.,* 2012), were displaced only in a minority of surveys at two Dutch wind farms (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 wind farms (OWEZ and PAWP; Leopold *et al.,* 2011, Krijgsveld *et al.,* 2011), but not at Horns Rev (Petersen *et al.,* 2006), Thornton Bank or Blighbank (Vanermen *et al.,* 2012).

276. Following statutory guidance (Joint SNCB Note 2017), the abundance estimates for the most relevant biological periods have each been placed into individual displacement matrices. Each displacement matrix contains the abundance of each auk species within the OWF sites and the 2km buffer. The estimates for razorbill and guillemot also include unidentified auks added in the same proportion as the positively identified individuals and adjustment for availability bias (i.e. for individuals underwater at the time the aerial survey images were taken; for details of estimation methods see Technical Appendix 13.1).

277. Each matrix displays displacement rates and mortality rates for each species. For the purpose of this assessment a displacement rate range of 30 to 70% and a mortality rate range of 1 to 10% are highlighted in each matrix (based on advice from Natural England), with the 70% / 10% combination representing a precautionary worst case scenario.

140. There are no breeding colonies for any of these auk species within foraging range of the OWF sites. Therefore, it is reasonable to assume that individuals seen during the breeding season are nonbreeding individuals (e.g. immature birds). Since immature seabirds are known to remain in wintering areas, the number of immature birds in the relevant populations during the breeding season may be estimated as 43% of the total wintering BDMPS population for guillemot and razorbill and 45% for puffin (Furness, 2015). This gives breeding season populations of nonbreeding individuals of 695,441 guillemots (BDMPS for the UK North Sea and Channel, 1,617,306 x 43%), 94,007 razorbills (BDMPS for the UK North Sea and Channel, 218622 x 43%) and 104,381 puffins (BDMPS for UK North Sea and Channel, 231,957 x 45%). For guillemot and puffin there is only one defined nonbreeding season (August - February and mid-August to March respectively), while for razorbill there are three (August - October, November - December and January - March; Table 13.11). The number of birds which could potentially be displaced has been estimated for each species-specific relevant season.

13.7.5.1.5 Puffin

Norfolk Vanguard East

278. The estimated number of puffins subject to mortality during the breeding period due to displacement from NV East (Table 13.36) is between zero and five individuals (from 30%/1% to 70%/10%).

279. At the average baseline mortality rate for puffin of 0.167 (Table 13.23) the number of individuals expected to die in the breeding season is 17,432 (104,381 x 0.167). The addition of a maximum of five 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 breeding season, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible to minor adverse**.

Table 13.36 Displacement matrix presenting the number of puffins in Norfolk Vanguard East (and 2km buffer) during the breeding season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	0	0	1	1	1
2	0	0	0	1	1	1	1	1	1	1
3	0	0	1	1	1	1	1	2	2	2
4	0	1	1	1	1	2	2	2	2	3
5	0	1	1	1	2	2	2	3	3	3
6	0	1	1	2	2	2	3	3	4	4
7	0	1	1	2	2	3	3	4	4	5
8	1	1	2	2	3	3	4	4	5	5
9	1	1	2	2	3	4	4	5	5	6
10	1	1	2	3	3	4	5	5	6	7
20	1	3	4	5	7	8	9	11	12	13
30	2	4	6	8	10	12	14	16	18	20
50	3	7	10	13	17	20	23	27	30	34
75	5	10	15	20	25	30	35	40	45	50
100	7	13	20	27	34	40	47	54	60	67

280. The estimated number of puffins subject to mortality during the nonbreeding season due to displacement from NV East (Table 13.37) is between zero and eight individuals (from 30%/1% to 70%/10%).

281. At the average baseline mortality rate for puffin of 0.167 (Table 13.23) the number of individuals expected to die in the nonbreeding season is 38,737 (231,957 x 0.167). The addition of a maximum of eight 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 nonbreeding season, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible to minor adverse**.

Table 13.37 Displacement matrix presenting the number of puffins in Norfolk Vanguard East (and 2km buffer) during the nonbreeding season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	1	1	1	1	1	1
2	0	0	1	1	1	1	2	2	2	2
3	0	1	1	1	2	2	2	3	3	3
4	0	1	1	2	2	3	3	4	4	4
5	1	1	2	2	3	3	4	4	5	6
6	1	1	2	3	3	4	5	5	6	7
7	1	2	2	3	4	5	5	6	7	8
8	1	2	3	4	4	5	6	7	8	9
9	1	2	3	4	5	6	7	8	9	10
10	1	2	3	4	6	7	8	9	10	11
20	2	4	7	9	11	13	16	18	20	22
30	3	7	10	13	17	20	24	27	30	34
50	6	11	17	22	28	34	39	45	50	56
75	8	17	25	34	42	50	59	67	76	84
100	11	22	34	45	56	67	78	90	101	112

282. The estimated number of puffins subject to mortality combined across all seasons due to displacement from NV East (Table 13.38) is between one and 13 individuals (from 30%/1% to 70%/10%).

283. At the average baseline mortality rate for puffin of 0.167 (Table 13.23) the number of individuals from the largest BDMPS population expected to die across all seasons is 38,737 (231,957 x 0.167). The addition of a maximum of 13 to this increases the mortality rate by 0.03%. The number of individuals from the biogeographic population expected to die across all seasons is 1,977,280 (11,840,000 x 0.167). The

addition of a maximum of 13 to this increases the mortality rate by 0.0007%. Thus, the increase in background mortality is between 0.0007% and 0.03%.

284. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during all seasons combined, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible to minor adverse**.

Table 13.38 Displacement matrix presenting the number of puffins in Norfolk Vanguard East (and 2km buffer) combined across the breeding and nonbreeding seasons that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	1	1	1	1	1	1	2	2
2	0	1	1	1	2	2	3	3	3	4
3	1	1	2	2	3	3	4	4	5	5
4	1	1	2	3	4	4	5	6	6	7
5	1	2	3	4	4	5	6	7	8	9
6	1	2	3	4	5	6	8	9	10	11
7	1	3	4	5	6	8	9	10	11	13
8	1	3	4	6	7	9	10	11	13	14
9	2	3	5	6	8	10	11	13	14	16
10	2	4	5	7	9	11	13	14	16	18
20	4	7	11	14	18	21	25	29	32	36
30	5	11	16	21	27	32	38	43	48	54
50	9	18	27	36	45	54	63	72	81	90
75	13	27	40	54	67	81	94	107	121	134
100	18	36	54	72	90	107	125	143	161	179

Norfolk Vanguard West

285. No puffins were recorded in NV West therefore there is no predicted operational displacement impact to be assessed.

Norfolk Vanguard East and Norfolk Vanguard West

286. The combined NV East and NV West operation disturbance and displacement assessment is the same as that for NV East, presented above.

287. The potential additional mortality of a maximum of 13 individuals would not materially alter the background mortality of the population and would be

undetectable. Therefore, during the nonbreeding period, the magnitude of effect is assessed as negligible. As the species is of low to medium sensitivity to disturbance, the impact significance is **negligible to minor adverse**.

13.7.5.1.6 Razorbill

Norfolk Vanguard East

288. The estimated number of razorbills subject to mortality during the breeding period due to displacement from NV East (Table 13.39) is between 2 and 42 individuals (from 30%/1% to 70%/10%).

289. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) 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 42 to this increases the mortality rate by 0.26%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding season, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.39 Displacement matrix presenting the number of razorbills in Norfolk Vanguard East (and 2km buffer) during the breeding season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	1	2	2	3	4	4	5	5	6
2	1	2	4	5	6	7	8	10	11	12
3	2	4	5	7	9	11	13	14	16	18
4	2	5	7	10	12	14	17	19	22	24
5	3	6	9	12	15	18	21	24	27	30
6	4	7	11	14	18	22	25	29	32	36
7	4	8	13	17	21	25	29	34	38	42
8	5	10	14	19	24	29	34	38	43	48
9	5	11	16	22	27	32	38	43	49	54
10	6	12	18	24	30	36	42	48	54	60
20	12	24	36	48	60	72	84	96	108	120
30	18	36	54	72	90	108	126	144	162	180
50	30	60	90	120	150	180	210	240	270	300
75	45	90	135	180	225	270	314	359	404	449
100	60	120	180	240	300	359	419	479	539	599

290. The estimated number of razorbills subject to mortality during the autumn migration period due to displacement from NV East (Table 13.40) is between 1 and 34 individuals (from 30%/1% to 70%/10%).

291. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) 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 34 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 autumn migration period, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.40 Displacement matrix presenting the number of razorbills in Norfolk Vanguard East (and 2km buffer) during the autumn migration period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	2	2	3	3	4	4	5
2	1	2	3	4	5	6	7	8	9	10
3	1	3	4	6	7	9	10	12	13	15
4	2	4	6	8	10	12	14	16	18	20
5	2	5	7	10	12	15	17	20	22	25
6	3	6	9	12	15	18	21	24	27	29
7	3	7	10	14	17	21	24	27	31	34
8	4	8	12	16	20	24	27	31	35	39
9	4	9	13	18	22	27	31	35	40	44
10	5	10	15	20	25	29	34	39	44	49
20	10	20	29	39	49	59	69	79	88	98
30	15	29	44	59	74	88	103	118	133	147
50	25	49	74	98	123	147	172	196	221	246
75	37	74	110	147	184	221	258	295	331	368
100	49	98	147	196	246	295	344	393	442	491

292. The estimated number of razorbills subject to mortality during the winter period due to displacement from NV East (Table 13.41) is between 1 and 20 individuals (from 30%/1% to 70%/10%).

At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the winter is 38,040 (218,622 x 0.174). The addition of a maximum of 20 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 winter, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.41 Displacement matrix presenting the number of razorbills in Norfolk Vanguard East (and 2km buffer) during the winter period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	1	1	2	2	2	3	3
2	1	1	2	2	3	3	4	4	5	6
3	1	2	3	3	4	5	6	7	8	8
4	1	2	3	4	6	7	8	9	10	11
5	1	3	4	6	7	8	10	11	13	14
6	2	3	5	7	8	10	12	13	15	17
7	2	4	6	8	10	12	14	16	18	20
8	2	4	7	9	11	13	16	18	20	22
9	3	5	8	10	13	15	18	20	23	25
10	3	6	8	11	14	17	20	22	25	28
20	6	11	17	22	28	33	39	45	50	56
30	8	17	25	33	42	50	59	67	75	84
50	14	28	42	56	70	84	98	112	126	140
75	21	42	63	84	105	126	146	167	188	209
100	28	56	84	112	140	167	195	223	251	279

293. The estimated number of razorbills subject to mortality during the spring migration period due to displacement from NV East (Table 13.42) is between 2 and 53 individuals (from 30%/1% to 70%/10%).

294. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the spring migration season is 102,986 (591,874 x 0.174). The addition of a maximum of 53 to this increases the mortality rate by 0.05%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the spring migration period, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.42 Displacement matrix presenting the number of razorbills in Norfolk Vanguard East (and 2km buffer) during the spring migration period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	2	2	3	4	5	5	6	7	8
2	2	3	5	6	8	9	11	12	14	15
3	2	5	7	9	11	14	16	18	20	23
4	3	6	9	12	15	18	21	24	27	30
5	4	8	11	15	19	23	26	30	34	38
6	5	9	14	18	23	27	32	36	41	45
7	5	11	16	21	26	32	37	42	47	53
8	6	12	18	24	30	36	42	48	54	60
9	7	14	20	27	34	41	47	54	61	68
10	8	15	23	30	38	45	53	60	68	75
20	15	30	45	60	75	90	105	120	135	150
30	23	45	68	90	113	135	158	180	203	226
50	38	75	113	150	188	226	263	301	338	376
75	56	113	169	226	282	338	395	451	508	564
100	75	150	226	301	376	451	526	602	677	752

295. The estimated number of razorbills subject to mortality combined across all seasons due to displacement from NV East (Table 13.43) is between 6 and 148 individuals (from 30%/1% to 70%/10%).

296. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals from the largest BDMPS population expected to die across all seasons is 102,986 (591,874 x 0.174). The addition of a maximum of 148 to this increases the mortality rate by 0.14%. The number of individuals from the biogeographic population expected to die across all seasons is 297,018 (1,707,000 x 0.174). The addition of a maximum of 148 to this increases the mortality rate by 0.05%. Thus, the increase in background mortality is between 0.05% and 0.14%.

297. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during all seasons combined, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.43 Displacement matrix presenting the number of razorbills in Norfolk Vanguard East (and 2km buffer) combined across the breeding, autumn migration, winter and spring migration periods that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	2	4	6	8	11	13	15	17	19	21
2	4	8	13	17	21	25	30	34	38	42
3	6	13	19	25	32	38	45	51	57	64
4	8	17	25	34	42	51	59	68	76	85
5	11	21	32	42	53	64	74	85	95	106
6	13	25	38	51	64	76	89	102	115	127
7	15	30	45	59	74	89	104	119	134	148
8	17	34	51	68	85	102	119	136	153	170
9	19	38	57	76	95	115	134	153	172	191
10	21	42	64	85	106	127	148	170	191	212
20	42	85	127	170	212	255	297	339	382	424
30	64	127	191	255	318	382	445	509	573	636
50	106	212	318	424	530	636	742	848	954	1061
75	159	318	477	636	795	954	1114	1273	1432	1591
100	212	424	636	848	1061	1273	1485	1697	1909	2121

Norfolk Vanguard West

298. The estimated number of razorbills subject to mortality during the breeding period due to displacement from NV West (Table 13.44) is between 1 and 20 individuals (from 30%/1% to 70%/10%).

299. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) 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%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding season, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.44 Displacement matrix presenting the number of razorbills in Norfolk Vanguard West (and 2km buffer) during the breeding season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	1	1	2	2	2	3	3
2	1	1	2	2	3	3	4	4	5	6
3	1	2	3	3	4	5	6	7	8	8
4	1	2	3	4	6	7	8	9	10	11
5	1	3	4	6	7	8	10	11	13	14
6	2	3	5	7	8	10	12	13	15	17
7	2	4	6	8	10	12	14	16	18	20
8	2	4	7	9	11	13	16	18	20	22
9	3	5	8	10	13	15	18	20	23	25
10	3	6	8	11	14	17	20	22	25	28
20	6	11	17	22	28	34	39	45	50	56
30	8	17	25	34	42	50	59	67	76	84
50	14	28	42	56	70	84	98	112	126	140
75	21	42	63	84	105	126	147	168	189	210
100	28	56	84	112	140	168	196	224	252	280

300. The estimated number of razorbills subject to mortality during the autumn migration period due to displacement from NV West (Table 13.45) is between 1 and 26 individuals (from 30%/1% to 70%/10%).

301. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) 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 26 to this increases the mortality rate by 0.02%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the autumn migration period, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.45 Displacement matrix presenting the number of razorbills in Norfolk Vanguard West (and 2km buffer) during the autumn migration period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	2	2	2	3	3	3	4
2	1	2	2	3	4	5	5	6	7	8
3	1	2	3	5	6	7	8	9	10	11
4	2	3	5	6	8	9	11	12	14	15
5	2	4	6	8	9	11	13	15	17	19
6	2	5	7	9	11	14	16	18	20	23
7	3	5	8	11	13	16	18	21	24	26
8	3	6	9	12	15	18	21	24	27	30
9	3	7	10	14	17	20	24	27	30	34
10	4	8	11	15	19	23	26	30	34	38
20	8	15	23	30	38	45	53	60	68	75
30	11	23	34	45	56	68	79	90	101	113
50	19	38	56	75	94	113	131	150	169	188
75	28	56	84	113	141	169	197	225	253	281
100	38	75	113	150	188	225	263	300	338	375

302. The estimated number of razorbills subject to mortality during the winter period due to displacement from NV West (Table 13.46) is between 1 and 24 individuals (from 30%/1% to 70%/10%).

303. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the winter is 38,040 (218,622 x 0.174). The addition of a maximum of 24 to this increases the mortality rate by 0.06%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the winter, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.46 Displacement matrix presenting the number of razorbills in Norfolk Vanguard West (and 2km buffer) during the winter that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	1	2	2	2	3	3	3
2	1	1	2	3	3	4	5	6	6	7
3	1	2	3	4	5	6	7	8	9	10
4	1	3	4	6	7	8	10	11	13	14
5	2	3	5	7	9	10	12	14	16	17
6	2	4	6	8	10	13	15	17	19	21
7	2	5	7	10	12	15	17	19	22	24
8	3	6	8	11	14	17	19	22	25	28
9	3	6	9	13	16	19	22	25	28	31
10	3	7	10	14	17	21	24	28	31	35
20	7	14	21	28	35	42	49	56	63	70
30	10	21	31	42	52	63	73	84	94	104
50	17	35	52	70	87	104	122	139	157	174
75	26	52	78	104	131	157	183	209	235	261
100	35	70	104	139	174	209	244	278	313	348

304. The estimated number of razorbills subject to mortality during the spring migration period due to displacement from NV West (Table 13.47) is between 1 and 12 individuals (from 30%/1% to 70%/10%).

305. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals expected to die in the spring season is 102,986 (591,874 x 0.174). The addition of a maximum of 12 to this increases the mortality rate by 0.012%. 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 **minor adverse**.

Table 13.47 Displacement matrix presenting the number of razorbills in Norfolk Vanguard West (and 2km buffer) during the spring migration period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	1	1	1	1	1	1	2	2
2	0	1	1	1	2	2	2	3	3	3
3	1	1	2	2	3	3	4	4	5	5
4	1	1	2	3	3	4	5	6	6	7
5	1	2	3	3	4	5	6	7	8	9
6	1	2	3	4	5	6	7	8	9	10
7	1	2	4	5	6	7	8	10	11	12
8	1	3	4	6	7	8	10	11	12	14
9	2	3	5	6	8	9	11	12	14	15
10	2	3	5	7	9	10	12	14	15	17
20	3	7	10	14	17	21	24	28	31	34
30	5	10	15	21	26	31	36	41	46	52
50	9	17	26	34	43	52	60	69	77	86
75	13	26	39	52	65	77	90	103	116	129
100	17	34	52	69	86	103	120	138	155	172

306. The estimated number of razorbills subject to mortality combined across all seasons due to displacement from NV West (Table 13.48) is between 4 and 82 individuals (from 30%/1% to 70%/10%).

307. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals from the largest BDMPS population expected to die across all seasons is 102,986 (591,874 x 0.174). The addition of a maximum of 82 to this increases the mortality rate by 0.08%. The number of individuals from the biogeographic population expected to die across all seasons is 297,018 (1,707,000 x 0.174). The addition of a maximum of 82 to this increases the mortality rate by 0.03%. Thus, the increase in background mortality is between 0.03% and 0.08%.

308. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during all seasons combined, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.48 Displacement matrix presenting the number of razorbills in Norfolk Vanguard West (and 2km buffer) combined across the breeding, autumn migration, winter and spring migration periods that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%) 10	20	30	40	50	60	70	80	90	100
1	1	2	4	5	6	7	8	9	11	12
2	2	5	7	9	12	14	16	19	21	24
3	4	7	11	14	18	21	25	28	32	35
4	5	9	14	19	24	28	33	38	42	47
5	6	12	18	24	29	35	41	47	53	59
6	7	14	21	28	35	42	49	56	63	71
7	8	16	25	33	41	49	58	66	74	82
8	9	19	28	38	47	56	66	75	85	94
9	11	21	32	42	53	63	74	85	95	106
10	12	24	35	47	59	71	82	94	106	118
20	24	47	71	94	118	141	165	188	212	235
30	35	71	106	141	176	212	247	282	317	353
50	59	118	176	235	294	353	411	470	529	588
75	88	176	264	353	441	529	617	705	793	881
100	118	235	353	470	588	705	823	940	1058	1175

Norfolk Vanguard East and Norfolk Vanguard West

309. The worst case displacement impact has been assessed on the basis that both NV East and NV West would be completely developed, although this is highly precautionary since even if each site contains half the total number of turbines these would be very unlikely to be distributed across the entirety of both sites or to cause the same levels of displacement.

310. The estimated number of razorbills subject to mortality combined across all seasons due to displacement from both NV East and NV West (Table 13.49) is between 10 and 231 individuals (from 30%/1% to 70%/10%).

311. At the average baseline mortality rate for razorbill of 0.174 (Table 13.23) the number of individuals from the largest BDMPS population expected to die across all seasons is 102,986 (591,874 x 0.174). The addition of a maximum of 231 to this increases the mortality rate by 0.22%. The number of individuals from the biogeographic population expected to die across all seasons is 297,018 (1,707,000 x 0.174). The addition of a maximum of 231 to this increases the mortality rate by 0.08%. Thus, the increase in background mortality is between 0.08% and 0.22%.

312. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during all seasons combined across both NV East and NV West, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.49 Displacement matrix presenting the number of razorbills in Norfolk Vanguard East and Norfolk Vanguard West (and 2km buffers) combined across the breeding, autumn migration, winter and spring migration periods that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	3	7	10	13	16	20	23	26	30	33
2	7	13	20	26	33	40	46	53	59	66
3	10	20	30	40	49	59	69	79	89	99
4	13	26	40	53	66	79	92	105	119	132
5	16	33	49	66	82	99	115	132	148	165
6	20	40	59	79	99	119	138	158	178	198
7	23	46	69	92	115	138	162	185	208	231
8	26	53	79	105	132	158	185	211	237	264
9	30	59	89	119	148	178	208	237	267	297
10	33	66	99	132	165	198	231	264	297	330
20	66	132	198	264	330	396	461	527	593	659
30	99	198	297	396	494	593	692	791	890	989
50	165	330	494	659	824	989	1154	1318	1483	1648
75	247	494	742	989	1236	1483	1730	1978	2225	2472
100	330	659	989	1318	1648	1978	2307	2637	2966	3296

13.7.5.1.7 Guillemot

Norfolk Vanguard East

313. The estimated number of guillemots subject to mortality during the breeding period due to displacement from NV East (Table 13.50) is between 9 and 205 individuals (within the range of displacement/mortality of 30%/1% to 70%/10%).

314. At the average baseline mortality rate for guillemot of 0.140 (Table 13.23) 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 205 to this increases the mortality rate by 0.21%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding season, the magnitude of effect is assessed as negligible. As the

species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.50 Displacement matrix presenting the number of guillemots in Norfolk Vanguard East (and 2km buffer) during the breeding season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	3	6	9	12	15	18	21	23	26	29
2	6	12	18	23	29	35	41	47	53	59
3	9	18	26	35	44	53	62	70	79	88
4	12	23	35	47	59	70	82	94	106	117
5	15	29	44	59	73	88	103	117	132	147
6	18	35	53	70	88	106	123	141	158	176
7	21	41	62	82	103	123	144	164	185	205
8	23	47	70	94	117	141	164	188	211	234
9	26	53	79	106	132	158	185	211	237	264
10	29	59	88	117	147	176	205	234	264	293
20	59	117	176	234	293	352	410	469	528	586
30	88	176	264	352	440	528	616	703	791	879
50	147	293	440	586	733	879	1026	1172	1319	1466
75	220	440	659	879	1099	1319	1539	1759	1978	2198
100	293	586	879	1172	1466	1759	2052	2345	2638	2931

315. The estimated number of guillemots subject to mortality during the nonbreeding period due to displacement from NV East (Table 13.51) is between 7 and 154 individuals (from 30%/1% to 70%/10%).

316. At the average baseline mortality rate for guillemot of 0.140 (Table 13.23) the number of individuals expected to die in the nonbreeding season is 226,423 (1,617,306 x 0.140). The addition of a maximum of 154 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, during the nonbreeding migration period, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

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Table 13.51 Displacement matrix presenting the number of guillemots in Norfolk Vanguard East (and 2km buffer) during the nonbreeding period that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	2	4	7	9	11	13	15	18	20	22
2	4	9	13	18	22	26	31	35	40	44
3	7	13	20	26	33	40	46	53	59	66
4	9	18	26	35	44	53	62	70	79	88
5	11	22	33	44	55	66	77	88	99	110
6	13	26	40	53	66	79	92	105	119	132
7	15	31	46	62	77	92	108	123	138	154
8	18	35	53	70	88	105	123	141	158	176
9	20	40	59	79	99	119	138	158	178	198
10	22	44	66	88	110	132	154	176	198	220
20	44	88	132	176	220	264	308	352	395	439
30	66	132	198	264	330	395	461	527	593	659
50	110	220	330	439	549	659	769	879	989	1099
75	165	330	494	659	824	989	1153	1318	1483	1648
100	220	439	659	879	1099	1318	1538	1758	1977	2197

317. The estimated number of guillemots subject to mortality combined across all seasons due to displacement from NV East (Table 13.52) is between 15 and 359 individuals (from 30%/1% to 70%/10%).

318. At the average baseline mortality rate for guillemot of 0.140 (Table 13.23) the number of individuals from the largest BDMPS population expected to die across all seasons is 226,423 (1,617,306 x 0.140). The addition of a maximum of 359 to this increases the mortality rate by 0.16%. The number of individuals from the biogeographic population expected to die across all seasons is 577,500 (4,125,000 x 0.140). The addition of a maximum of 359 to this increases the mortality rate by 0.06%. Thus, the maximum estimate of increase in background mortality is between 0.06% and 0.16%.

319. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during all seasons combined, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.52 Displacement matrix presenting the number of guillemots in Norfolk Vanguard East (and 2km buffer) combined across the breeding and nonbreeding seasons that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	5	10	15	21	26	31	36	41	46	51
2	10	21	31	41	51	62	72	82	92	103
3	15	31	46	62	77	92	108	123	138	154
4	21	41	62	82	103	123	144	164	185	205
5	26	51	77	103	128	154	179	205	231	256
6	31	62	92	123	154	185	215	246	277	308
7	36	72	108	144	179	215	251	287	323	359
8	41	82	123	164	205	246	287	328	369	410
9	46	92	138	185	231	277	323	369	415	462
10	51	103	154	205	256	308	359	410	462	513
20	103	205	308	410	513	615	718	820	923	1026
30	154	308	462	615	769	923	1077	1231	1385	1538
50	256	513	769	1026	1282	1538	1795	2051	2308	2564
75	385	769	1154	1538	1923	2308	2692	3077	3461	3846
100	513	1026	1538	2051	2564	3077	3590	4102	4615	5128

Norfolk Vanguard West

320. The estimated number of guillemots subject to mortality during the breeding period due to displacement from NV West (Table 13.53) is between 4 and 97 individuals (from 30%/1% to 70%/10%).

321. At the average baseline mortality rate for guillemot of 0.140 (Table 13.23) 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 97 to this increases the mortality rate by 0.1%. This magnitude of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during the breeding season, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.53 Displacement matrix presenting the number of guillemots in Norfolk Vanguard West (and 2km buffer) during the breeding season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	3	4	6	7	8	10	11	13	14
2	3	6	8	11	14	17	19	22	25	28
3	4	8	13	17	21	25	29	33	38	42
4	6	11	17	22	28	33	39	44	50	56
5	7	14	21	28	35	42	49	56	63	69
6	8	17	25	33	42	50	58	67	75	83
7	10	19	29	39	49	58	68	78	88	97
8	11	22	33	44	56	67	78	89	100	111
9	13	25	38	50	63	75	88	100	113	125
10	14	28	42	56	69	83	97	111	125	139
20	28	56	83	111	139	167	194	222	250	278
30	42	83	125	167	208	250	292	333	375	417
50	69	139	208	278	347	417	486	556	625	695
75	104	208	313	417	521	625	729	833	938	1042
100	139	278	417	556	695	833	972	1111	1250	1389

322. The estimated number of guillemots subject to mortality during the nonbreeding season due to displacement from NV West (Table 13.54) is between 8 and 181 individuals (from 30%/1% to 70%/10%).

At the average baseline mortality rate for guillemot of 0.140 (Table 13.23) the number of individuals expected to die in the nonbreeding season is 226,423 (1,617,306 x 0.140). The addition of a maximum of 181 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 nonbreeding season, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.54 Displacement matrix presenting the number of guillemots in Norfolk Vanguard West (and 2km buffer) during the nonbreeding season that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	3	5	8	10	13	15	18	21	23	26
2	5	10	15	21	26	31	36	41	46	52
3	8	15	23	31	39	46	54	62	70	77
4	10	21	31	41	52	62	72	83	93	103
5	13	26	39	52	64	77	90	103	116	129
6	15	31	46	62	77	93	108	124	139	155
7	18	36	54	72	90	108	126	144	162	181
8	21	41	62	83	103	124	144	165	186	206
9	23	46	70	93	116	139	162	186	209	232
10	26	52	77	103	129	155	181	206	232	258
20	52	103	155	206	258	309	361	413	464	516
30	77	155	232	309	387	464	542	619	696	774
50	129	258	387	516	645	774	903	1032	1161	1290
75	193	387	580	774	967	1161	1354	1547	1741	1934
100	258	516	774	1032	1290	1547	1805	2063	2321	2579

323. The estimated number of guillemots subject to mortality combined across all seasons due to displacement from NV West (Table 13.56) is between 12 and 278 individuals (from 30%/1% to 70%/10%).

324. At the average baseline mortality rate for guillemot of 0.140 (Table 13.23) the number of individuals from the largest BDMPS population expected to die across all seasons is 226,423 (1,617,306 x 0.140). The addition of a maximum of 278 to this increases the mortality rate by 0.12%. The number of individuals from the biogeographic population expected to die across all seasons is 577,500 (4,125,000 x 0.140). The addition of a maximum of 278 to this increases the mortality rate by 0.05%. Thus, the increase in background mortality is between 0.05% and 0.12%.

325. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during all seasons combined, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.55 Displacement matrix presenting the number of guillemots in Norfolk Vanguard West (and 2km buffer) combined across the breeding and nonbreeding seasons that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	4	8	12	16	20	24	28	32	36	40
2	8	16	24	32	40	48	56	63	71	79
3	12	24	36	48	60	71	83	95	107	119
4	16	32	48	63	79	95	111	127	143	159
5	20	40	60	79	99	119	139	159	179	198
6	24	48	71	95	119	143	167	190	214	238
7	28	56	83	111	139	167	194	222	250	278
8	32	63	95	127	159	190	222	254	286	317
9	36	71	107	143	179	214	250	286	321	357
10	40	79	119	159	198	238	278	317	357	397
20	79	159	238	317	397	476	556	635	714	794
30	119	238	357	476	595	714	833	952	1071	1190
50	198	397	595	794	992	1190	1389	1587	1786	1984
75	298	595	893	1190	1488	1786	2083	2381	2678	2976
100	397	794	1190	1587	1984	2381	2778	3174	3571	3968

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326. The worst case displacement impact has been assessed on the basis that both NV East and NV West would be completely developed, although this is highly precautionary since even if each site contains half the total number of turbines these would be very unlikely to be distributed across the entirety of both sites or to cause the same levels of displacement.

327. The estimated number of guillemots subject to mortality combined across all seasons due to displacement from both NV East and NV West (Table 13.56) is between 27 and 637 individuals (from 30%/1% to 70%/10%).

328. At the average baseline mortality rate for guillemot of 0.140 (Table 13.23) the number of individuals from the largest BDMPS population expected to die across all seasons is 226,423 (1,617,306 x 0.14). The addition of a maximum of 637 to this increases the mortality rate by 0.28%. The number of individuals from the biogeographic population expected to die across all seasons is 577,500 (4,125,000 x 0.140). The addition of a maximum of 637 to this increases the mortality rate by 0.11%. Thus, the increase in background mortality is between 0.11% and 0.28%.

329. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable. Therefore, during all seasons combined across both NV East and NV West, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.56 Displacement matrix presenting the number of guillemots in Norfolk Vanguard East and Norfolk Vanguard West (and 2km buffers) combined across the breeding and nonbreeding seasons that may be subject to mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	9	18	27	36	45	55	64	73	82	91
2	18	36	55	73	91	109	127	146	164	182
3	27	55	82	109	136	164	191	218	246	273
4	36	73	109	146	182	218	255	291	327	364
5	45	91	136	182	227	273	318	364	409	455
6	55	109	164	218	273	327	382	437	491	546
7	64	127	191	255	318	382	446	509	573	637
8	73	146	218	291	364	437	509	582	655	728
9	82	164	246	327	409	491	573	655	737	819
10	91	182	273	364	455	546	637	728	819	910
20	182	364	546	728	910	1092	1273	1455	1637	1819
30	273	546	819	1092	1364	1637	1910	2183	2456	2729
50	455	910	1364	1819	2274	2729	3184	3638	4093	4548
75	682	1364	2047	2729	3411	4093	4775	5458	6140	6822
100	910	1819	2729	3638	4548	5458	6367	7277	8186	9096

13.7.5.2 Impact 4: Indirect impacts through effects on habitats and prey species

330. Indirect disturbance and displacement of birds may occur during the operational 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. 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 and provision of novel habitat providing shelter for fish and invertebrates) may also occur, and changes in fishing activity could influence the communities present.

331. With regard to noise impacts on fish, Chapter 11 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 project, Chapter 11 reports 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 negligible 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 Norfolk Vanguard site during the operational phase is similarly a negligible adverse impact.

332. With regard to changes to the seabed and to suspended sediment levels, Chapter 10 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 10 Benthic Ecology) 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 Norfolk Vanguard site during the operational phase is similarly a minor adverse impact.

333. 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 10).

334. 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 at the Norfolk Vanguard site. Whilst the impact of the colonisation of introduced hard substrate is seen as a minor adverse impact in terms of benthic ecology (as it is a change from the baseline conditions), the consequences for seabirds may be positive or negative locally but are unlikely to be significant at a wider scale. Dierschke *et al.* (2016) concluded that cormorants (both great cormorant and European shag) tend to be attracted to offshore wind farms because structures provide an opportunity for cormorants to roost and to dry their wings so extend their potential foraging habitat further offshore. Several gull species and red-breasted mergansers were found to tend to increase in abundance at offshore wind farms, which Dierschke *et al.* (2016) interpreted as most likely to be responses to increased foraging opportunities resulting from higher abundance of fish and

invertebrates associated with offshore wind farm structures and possibly the reduction in fishing activity.

335. Overall 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 Norfolk Vanguard site during the operational phase is similarly a **negligible or minor adverse impact**.

13.7.5.3 Impact 5: Collision risk

336. There is a potential risk of collision with the wind turbine rotors and associated infrastructure resulting in injury or fatality to birds which fly through the Norfolk Vanguard site whilst foraging for food or commuting between breeding sites and foraging areas.

337. Initial screening for species to include in the collision risk assessment is presented in Table 13.57.

Table 13.57 Collision risk screening. Species were screened in on the basis of columns two and three.

Receptor	Risk of collisions (Garthe and Hüppop, 2004; Furness and Wade, 2012, Wade *et al.*, 2016)	Estimated density of birds in flight	Screening Result (IN or OUT)
Red-throated diver	Low	Medium	**IN**
Black-throated diver	Low	Very low	**OUT**
Great northern diver	Low	Very low	**OUT**
Fulmar	Low	High	**IN**
Gannet	Medium	Medium	**IN**
Arctic skua	Medium	Very low	**IN**
Great skua	Medium	Very low	**IN**
Puffin	Very low	Very low	**OUT**
Razorbill	Very low	High	**OUT**
Common guillemot	Very low	High	**OUT**
Common tern	Low	Low	**OUT**
Arctic tern	Low	Low	**OUT**
Kittiwake	Medium	High	**IN**
Black-headed gull	Medium	Low	**IN**
Little gull	Medium	Low	**IN**
Common gull	Medium	Low	**IN**
Lesser black-backed gull	High	Medium	**IN**

Receptor	Risk of collisions (Garthe and Hüppop, 2004; Furness and Wade, 2012, Wade *et al.*, 2016)	Estimated density of birds in flight	Screening Result (IN or OUT)
Herring gull	High	Low	**IN**
Great black-backed gull	High	Low	**IN**

338. Collision Risk Modelling (CRM) has been used in this assessment to estimate the risk to birds associated with the proposed project. CRM, using the Band model (Band, 2012) options 1 and 2 has been used to produce predictions of mortality for particular species across set time periods (biological seasons). The approach to CRM is summarised here and further details are provided in Appendix 13.1.

339. The difference between Options 1 and 2 is the source of flight height data used to estimate the proportion of time each species will spend at potential collision height (PCH). Option 1 uses site and species-specific data collected during site characterisation surveys. Option 2 uses generic estimates of flight height for each species (Johnston *et al*. 2014 a,b) to estimate PCH. Natural England advice is to present the results from both options, but to base assessment on option 1 if sufficient height data records are available. The minimum threshold for use of Option 1 for a particular species which has typically been applied is 100 flight height observations.

340. However, following a review of their data collection and analysis methods, the aerial survey contractor appointed by Vattenfall to undertake the site-specific surveys has advised Vattenfall that the flight height estimates supplied as part of the survey data were not sufficiently reliable for use in collision risk modelling. Furthermore, the parameters required to correct for the methodological errors had not been recorded during the surveys and therefore it was not possible to re-estimate the heights.

341. Consequently, and in agreement with Natural England, the collision mortalities used for impact assessment for all species are those calculated using option 2 of the Band model (although the erroneous flight height estimates and option 1 results have also been provided in Technical Appendix 13.1).

342. Natural England requested that the CRM results should incorporate uncertainty in seabird density, collision avoidance rates and flight heights, and in recent correspondence with Vattenfall for the Norfolk Boreas wind farm have also requested consideration of a range of nocturnal activity rates. These requests reflect the fact that many of the CRM input parameters include both natural variation (e.g. seabird densities) and measurement error.

343. The most efficient method for incorporating uncertainty in multiple parameters is to generate multiple random values for each of the parameters from appropriate

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

344. The input parameters are provided in Technical Appendix 13.1 Annex 3 and complete CRM results are provided in Technical Appendix 13.1 Annexes 4 and 5. For both options 1 and 2 the following model runs were undertaken:

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

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

346. Collision avoidance rates used were those recommended by the SNCBs (JNCC *et al.* 2014) following the review conducted by the British Trust for Ornithology (BTO) on behalf of Marine Scotland (Cook *et al.,* 2014). These are 98.9% for gannet and kittiwake, 99.5% for lesser black-backed gull, herring gull and great black-backed gull, 99.2% for little gull, common gull and black-headed gull and 98% for all other species. When modelled with uncertainty the variations recommended in JNCC *et al*. (2014) were used.

347. It should be noted that further work on avoidance rates for offshore wind farms is underway. For example, a study on gannet behaviour in relation to offshore wind farms (APEM, 2014) gathered evidence which suggests this species may exhibit a higher avoidance rate than the current recommended rate of 98.9%. This work,

conducted during the autumn migration period, indicated an overall wind turbine avoidance of 100%, although a suitably precautionary rate of 99.5% was proposed (for the autumn period at least). Although this rate has not been applied to the estimates presented in this assessment, it indicates that gannet collision mortality estimated at 98.9% is likely to overestimate the risk for this species, perhaps by as much as 50%. Indeed, as noted in Cook *et al.* (2014), all the recommended avoidance rates remain precautionary and thus the results presented in this assessment are worst case estimates.

348. A bird flight behaviour study has been conducted for the Offshore Renewables Joint Industry Programme (ORJIP). The final report for this study provides further evidence relating to the precautionary nature of current avoidance rates and other parameters used in wind farm assessment (Skov *et al.* 2018).

349. The nocturnal activity parameter used in the CRM defines the level of nocturnal activity of each seabird species, expressed in relation to daytime 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 ('activity' in the current context refers to flight activity). 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'.

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

351. As the relative proportion of daytime to nightime 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.

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

353. In order to more accurately estimate nocturnal activity for gannet, a review of evidence from tracking studies has been undertaken (Furness *et al*. subm.). This has revealed that appropriate (and still precautionary) values for the breeding and nonbreeding seasons respectively are 4.3% (SE 2.7%) and 2.3% (SE 0.4%). A similar review and analysis has been conducted for kittiwake (Furness *et al*. in prep.) which has identified values for the breeding and nonbreeding seasons respectively of 20% (SE 5%) and 17% (SE 1.5%). These values have considerably more merit, being based on empirical evidence, when compared with the categorical values which have been applied in CRM. Therefore, they have been used in the stochastic simulations for gannet and kittiwake in the current assessment. For the large gulls, uncertainty in nocturnal activity was modelled by selecting either 25% or 50% at random for each simulation. For all other species the previous nocturnal activity levels have been used (with no random variation in any run). In CRM runs which did not include uncertainty in nocturnal activity, the previously recommended values of 25% for gannet and 50% for kittiwake and the large gulls were used.

354. Modelling was conducted for nine turbine models from 200 x 9MW to 90 x 20MW, with all turbines located in either NV East or NV West (**Error! Reference source not found.**). The higher collision prediction from the two sites has been identified as the worst case for each species and reflected the site with the higher density of birds in flight. If a proportion of the turbines are located in both of NV East and NV West the total collision mortality will lie between the values for NV East and NV West.

355. The full results for modelling of all the candidate turbines is provided in Technical Appendix 13.1 Annexes 4 and 5. The assessment presented here uses the outputs for the worst case of 200 x 9MW turbines located in either NV East or NV West, calculated using option 2.

356. A number of the seabird species which were only recorded in small numbers during aerial surveys of the survey programme were identified as potential migrants through the Norfolk Vanguard site (i.e. great skua, Arctic skua, Arctic tern and common tern). These species were included in the CRM but were also assessed using the methods described in WWT and MacArthur Green (2013).

357. The risk of collisions for non-seabird migrants has been assessed previously for the adjacent East Anglia THREE wind farm (EATL, 2015). The population and flight activity data used in this assessment have not been updated since this work was conducted and the populations and migration routes are identical for Norfolk Vanguard as for East Anglia THREE. Therefore, the results remain valid for Norfolk Vanguard. A summary of the results of this work is provided in section 13.7.5.3.1.

358. The magnitude of effect of collision mortality was assessed for NV East and NV West separately and also for both project scenarios in Table 13.15. The technical appendix provides collision modelling results for a wide range of turbine options under consideration.

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

13.7.5.3.1 Assessment of Collision Risk Modelling results

Seabirds

360. The full CRM results for the proposed project are presented in Appendix 13.1. The following sections provide a summary of the outputs for assessment, using the seasons defined in Table 13.11. Annual collision risk estimates for all species assessed are presented in **Error! Reference source not found.**. For each species annual totals are presented for each site.

361. It is important to note that the estimates in **Error! Reference source not found.** have not been summed across NV East and NV West as the figures for each site represent the project total which would be predicted with all turbines in that site. Thus, the estimates highlighted in bold are the worst case project predictions for each species and are the ones which have been assessed for each species.

Table 13.58 Annual collision risk for NV East and NV West using the worst case 9MW turbine option and Band option 2. The higher values from either NV East or NV West are highlighted in bold for each species.

Species	Uncertainty option	Median annual (95% c.i.)	
		NV West	NV East
Red-throated diver	Full stochastic	**0 (0-60.93)**	0 (0-34.85)
	Density only	**3.23 (0-19.03)**	0 (0-17.99)
	Avoidance rate only	**3.23 (2.63-3.88)**	0 (0-0)
	Flight height only	**0 (0-41.35)**	0 (0-0)
	Nocturnal activity only	**3.23 (3.23-3.23)**	0 (0-0)
	Deterministic	**3.23 (3.23-3.23)**	0 (0-0)
Fulmar	Full stochastic	0 (0-38.03)	**0 (0-69.57)**
	Density only	3.06 (0-18.64)	**7.1 (0.3-30.86)**
	Avoidance rate only	3.05 (2.51-3.7)	**7.23 (5.9-8.75)**
	Flight height only	0 (0-34.59)	**0 (0-84.9)**
	Nocturnal activity only	3.06 (3.06-3.06)	**7.26 (7.26-7.26)**
	Deterministic	3.06 (3.06-3.06)	**7.26 (7.26-7.26)**
Gannet	Full stochastic	44.74 (7.71-205.36)	**110.64 (14.79-524.03)**
	Density only	64.39 (18.45-194.86)	**158.99 (35.11-513.5)**
	Avoidance rate only	64.88 (44.18-90.99)	**161.72 (110.81-226.21)**
	Flight height only	63.36 (28.55-115.71)	**157.58 (71.93-289.64)**
	Nocturnal activity only	51.12 (50.49-52.22)	**123.19 (121.41-126.32)**
	Deterministic	65.58 (65.58-65.58)	**163.42 (163.42-163.42)**
Arctic skua	Full stochastic	0	**0 (0-8.1)**
	Density only	0	**0 (0-4.43)**
	Avoidance rate only	0	**0 (0-0)**
	Flight height only	0	**0 (0-0)**
	Nocturnal activity only	0	**0 (0-0)**

Species	Uncertainty option	Median annual (95% c.i.)	
		NV West	NV East
	Deterministic	0	**0 (0-0)**
Great skua	Full stochastic	0.2 (0-6.71)	**0.06 (0-20.07)**
	Density only	0.93 (0-3.74)	**0.92 (0-12.67)**
	Avoidance rate only	0.93 (0.76-1.12)	**0.91 (0.75-1.11)**
	Flight height only	0.54 (0.01-3.99)	**0.54 (0.01-3.84)**
	Nocturnal activity only	0.93 (0.93-0.93)	**0.92 (0.92-0.92)**
	Deterministic	0.93 (0.93-0.93)	**0.92 (0.92-0.92)**
Kittiwake	Full stochastic	58.55 (6.02-225.92)	**158.43 (22.43-859.65)**
	Density only	73.39 (9.96-256.4)	**223.78 (40.72-991.46)**
	Avoidance rate only	73.04 (50.05-102.58)	**221.26 (151.36-309.74)**
	Flight height only	73.63 (56.62-93.51)	**222.88 (170.92-282.29)**
	Nocturnal activity only	57.93 (55.52-60.92)	**161.81 (155.05-169.66)**
	Deterministic	73.89 (73.89-73.89)	**223.78 (223.78-223.78)**
Black-headed gull	Full stochastic	**1.12 (0-31.14)**	0 (0-35.43)
	Density only	**1.17 (0-22.52)**	0 (0-27.01)
	Avoidance rate only	**1.15 (0.66-1.8)**	0 (0-0)
	Flight height only	**1.04 (0.19-2.8)**	0 (0-0)
	Nocturnal activity only	**1.17 (1.17-1.17)**	0 (0-0)
	Deterministic	**1.17 (1.17-1.17)**	0 (0-0)
Little gull	Full stochastic	1.56 (0-9.89)	**0.13 (0-90.05)**
	Density only	2.25 (0-6.92)	**2.28 (0-58.96)**
	Avoidance rate only	2.19 (1.3-3.46)	**2.23 (1.31-3.5)**
	Flight height only	2.03 (0.41-5.42)	**2.07 (0.42-5.44)**
	Nocturnal activity only	2.25 (2.25-2.25)	**2.28 (2.28-2.28)**

Species	Uncertainty option	Median annual (95% c.i.)	
		NV West	NV East
	Deterministic	2.25 (2.25-2.25)	**2.28 (2.28-2.28)**
Common gull	Full stochastic	**9.79 (0-72.16)**	1.65 (0-60.79)
	Density only	**10.94 (0-63.77)**	2.22 (0-58.27)
	Avoidance rate only	**10.7 (6.25-17.04)**	2.17 (1.29-3.45)
	Flight height only	**10.82 (7.17-15.2)**	2.17 (1.47-3.07)
	Nocturnal activity only	**10.94 (10.94-10.94)**	2.22 (2.22-2.22)
	Deterministic	**10.94 (10.94-10.94)**	2.22 (2.22-2.22)
Lesser black-backed gull	Full stochastic	**27.35 (0-150.08)**	9.1 (0-99.5)
	Density only	**32.64 (2.17-126.05)**	10.9 (0-95.58)
	Avoidance rate only	**33.98 (22.22-49.22)**	10.79 (7.09-15.61)
	Flight height only	**33.27 (14.87-58.35)**	10.71 (4.75-18.78)
	Nocturnal activity only	**32.08 (30.23-34.38)**	9.84 (9.35-10.9)
	Deterministic	**34.38 (34.38-34.38)**	10.9 (10.9-10.9)
Herring gull	Full stochastic	1.42 (0-11.84)	**5.17 (0-172.07)**
	Density only	1.8 (0-12.02)	**6.92 (0-164.06)**
	Avoidance rate only	1.78 (1.16-2.58)	**6.83 (4.55-9.82)**
	Flight height only	1.79 (1.14-2.55)	**6.88 (4.3-9.77)**
	Nocturnal activity only	1.8 (1.38-1.8)	**5.22 (5.22-6.92)**
	Deterministic	1.8 (1.8-1.8)	**6.92 (6.92-6.92)**
Great black-backed gull	Full stochastic	**22.16 (0-138.68)**	19.96 (1.43-451.73)
	Density only	**24.33 (0-135.05)**	24.59 (2.48-410.28)
	Avoidance rate only	**24.9 (16.33-35.9)**	23.11 (15.18-33.39)
	Flight height only	**25.04 (16.63-34.52)**	23.19 (15.5-32.03)
	Nocturnal activity only	**22.14 (20.36-25.17)**	17.83 (17.74-23.4)

Species	Uncertainty option	Median annual (95% c.i.)	
		NV West	NV East
	Deterministic	**25.17 (25.17-25.17)**	23.4 (23.4-23.4)

362. Several species had very low predicted annual collision risks (i.e. worst case median prediction was below approx. 10 per year). These were red-throated diver, fulmar, Arctic skua, great skua, black-headed gull, little gull, common gull and herring gull. As the magnitudes of predicted impact were so small, even for the worst case 9MW turbine, no further assessment is considered necessary for these species (although additional outputs for these species are provided in Technical Appendix 13.1).

363. The seasonal collision estimates for species with more than 10 annual collisions (gannet, kittiwake, lesser black-backed gull and great black-backed gull) are presented in more detail below (Table 13.59).

364. The full stochastic results have been used for the following assessment of potential effects as these are considered to be the most robust figures.

365. Impacts during the non-breeding periods have been assessed in relation to the relevant BDMPS (Furness, 2015). Impacts during the breeding season have been assessed in relation to reference populations calculated as described in the following sections.

Table 13.59 Seasonal and annual worst case option 2 collision risks for gannet, kittiwake, lesser black-backed gull, great black-backed gull for the worst case turbine (9MW).

Species	Model run type	Breeding season	Autumn migration	Mid-winter / nonbreeding	Spring migration	Annual
Gannet	**Full stochastic**	**18.36 (0-111.59)**	**62.32 (14.79-312.82)**		**29.96 (0-99.62)**	**110.64 (14.79-524.03)**
	Density only	20.35 (0-100.12)	82.13 (35.11-311.66)		56.51 (0-101.72)	158.99 (35.11-513.5)
	Avoidance rate only	24.42 (16.59-34.39)	81.52 (55.89-113.83)		55.78 (38.33-77.99)	161.72 (110.81-226.21)
	Flight height only	23.97 (10.96-43.91)	79.2 (36.05-145.19)		54.41 (24.92-100.54)	157.58 (71.93-289.64)
	Nocturnal activity only	22.32 (21.97-23.16)	62.01 (61.12-63.59)		38.86 (38.32-39.57)	123.19 (121.41-126.32)
	Deterministic	24.78	82.13	**N / A**	56.51	163.42
Kittiwake	**Full stochastic**	**20.85 (0-95.26)**	**61.32 (4.82-190.86)**		**76.26 (17.61-573.53)**	**158.43 (22.43-859.65)**
	Density only	22.17 (2.38-98.26)	95 (7.87-240.49)		106.61 (30.47-652.71)	223.78 (40.72-991.46)
	Avoidance rate only	21.94 (15-30.78)	93.95 (64.58-130.96)		105.37 (71.78-148)	221.26 (151.36-309.74)
	Flight height only	22.09 (17.03-27.94)	94.6 (72.37-119.94)		106.19 (81.52-134.41)	222.88 (170.92-282.29)
	Nocturnal activity only	19.48 (18.72-20.45)	65.02 (62.51-67.81)		77.31 (73.82-81.4)	161.81 (155.05-169.66)
	Deterministic	22.17	95.0	**N / A**	106.61	223.78
	Full stochastic	**23.28 (0-103.43)**	**4.07 (0-40.5)**	**0 (0-0)**	**0 (0-6.15)**	**27.35 (0-150.08)**
	Density only	26.79 (2.17-84.53)	5.85 (0-35.46)	0 (0-0)	0 (0-6.06)	32.64 (2.17-126.05)

Species	Model run type	Breeding season	Autumn migration	Mid-winter / nonbreeding	Spring migration	Annual
Lesser black-backed gull	Avoidance rate only	27.35 (17.89-39.6)	6.63 (4.33-9.62)	0 (0-0)	0 (0-0)	33.98 (22.22-49.22)
	Flight height only	26.79 (12-46.84)	6.48 (2.87-11.51)	0 (0-0)	0 (0-0)	33.27 (14.87-58.35)
	Nocturnal activity only	25.37 (24.78-27.67)	6.71 (5.45-6.71)	0 (0-0)	0 (0-0)	32.08 (30.23-34.38)
	Deterministic	27.67	6.71	0 (0-0)	0 (0-0)	34.38
Great black-backed gull	**Full stochastic**	**0 (0-40.09)**		**22.16 (0-98.59)**		**22.16 (0-138.68)**
	Density only	0 (0-38.85)		24.33 (0-96.2)		24.33 (0-135.05)
	Avoidance rate only	0 (0-0)		24.9 (16.33-35.9)		24.9 (16.33-35.9)
	Flight height only	0 (0-0)		25.04 (16.63-34.52)		25.04 (16.63-34.52)
	Nocturnal activity only	0 (0-0)		22.14 (20.36-25.17)		22.14 (20.36-25.17)
	Deterministic	0 (0-0)	**N / A**	25.17	**N / A**	25.17

Breeding season reference populations for collision assessment

Kittiwake

366. Norfolk Vanguard is beyond the range of kittiwake from any breeding colonies. It is therefore very unlikely that birds present during the breeding season are breeding. While RSPB's Future of the Atlantic Marine Environments (FAME) studies have shown some extremely long foraging trips for this species, those extreme values tend to occur at colonies where food supply is extremely poor and breeding success is low (for example Orkney and Shetland). Daunt *et al.* (2002) point out that seabirds, as central place foragers, have an upper limit to their potential foraging range from the colony, set by time constraints. For example, they assess this limit to be 73km for kittiwake based on foraging flight speed and time required to catch food, based on observations of birds from the Isle of May. This means that kittiwakes would be unable to consistently travel more than 73km from the colony and provide enough food to keep chicks alive. Hamer *et al.* (1993) recorded kittiwake foraging ranges exceeding 40km in 1990 when sandeel stock biomass was very low and breeding success at the study colony in Shetland was 0.0 chicks per nest, but <5km in 98% of trips in 1991 when sandeel abundance was higher and breeding success was 0.98 chicks per nest. Kotzerka *et al.* (2010) reported a maximum foraging range of 59km, with a mean range of around 25km for a kittiwake colony in Alaska. Consequently, the breeding season impact on kittiwake has been assessed against a reference population estimated using the same approach as that for the displacement assessment (section 13.7.5.1). 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 47.3% of the spring BDMPS populations of kittiwake (see Table 13.60). This yields a breeding season population of nonbreeding kittiwake of 296,956 (Spring BDMPS for the UK North Sea and Channel, 627,816 x 47.3%).

Lesser black-backed gulls

367. 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 Norfolk Vanguard. Thus, there is potential for connectivity with Norfolk Vanguard during the breeding season.

368. In addition to the Alde-Ore colony, non-SPA colonies of lesser black-backed gulls located within foraging range of Norfolk Vanguard include rooftop nesting gulls in several towns in Suffolk and Norfolk. The JNCC's Seabird Monitoring Programme

(SMP; http://jncc.defra.gov.uk/smp) includes the following lesser black-backed gull counts:

- Felixstowe Docks (2013) - 1,401 occupied territories,
- Ipswich (several sites; 2001) – 99 occupied nests, and
- Lowestoft (Town; 2000) – 750 occupied nests.

369. Counts have been undertaken in Norwich since 2008, although these have not been entered in the SMP, with a population estimate in the 2017 breeding season described as 'over 900 birds'[1].

370. Piotrowski (2012) reported on a survey of Suffolk breeding colonies undertaken in May 2012. Across all sites surveyed (within foraging range of Norfolk Vanguard) a total lesser black-backed gull breeding population of 4,694 pairs was estimated. However, the report noted that numbers were considered to be low due to poor weather prior to and during the survey. This would appear to be borne out in the estimate for Felixstowe which was 675 pairs in 2012, but reported as 1,400 occupied territories a year later (SMP).

371. Using the SMP data, the urban adult lesser black-backed gull population in Norfolk and Suffolk with potential connectivity to Norfolk Vanguard during the breeding season can be conservatively estimated as 5,400 (= 2,800 + 200 + 1500 + 900), noting that the Lowestoft, Ipswich and Felixstowe estimates were from 2000, 2001 and 2013 respectively and would therefore almost certainly have increased substantially since then.

372. Using the 2012 survey data (Piotrowski 2012), the Suffolk population excluding that at the Alde-Ore Estuary colonies was estimated at 2,900 pairs, yielding a Suffolk only estimate of the breeding adult population of 5,800.

373. There is also potential for connectivity between the project and colonies of lesser black-backed gulls in the Netherlands which are within 181km. However, extensive colour ringing and tracking of breeding lesser black-backed gulls from multiple colonies in the Netherlands has shown that there is very little or no connectivity during the breeding season between birds breeding in the Dutch colonies and the UK, and indeed that there is remarkably little migration of birds from the colonies in the Netherlands through UK waters even after the breeding season in autumn, winter or spring (Camphuysen 2013). Not only do breeding adult lesser black-backed gulls from colonies in the Netherlands normally remain on the continental side of the North Sea while breeding, but 95% of their foraging trips in the 1990s and 2000s

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[1] http://www.edp24.co.uk/news/environment/they-are-the-new-pigeon-seagull-numbers-triple-in-norwich-and-experts-warn-there-is-no-solution-1-5122565; quote attributed to Dr. Iain Barr from the University of East Anglia

were less than 135km from those colonies (Camphuysen 1995, 2013), and between 2008 and 2011 95% of foraging trips were within 60.5km of the colony (Camphuysen *et al.* 2015). Based on these foraging ranges, breeding adult lesser black-backed gulls from colonies in the Netherlands would be very unlikely to reach the Norfolk Vanguard site. Therefore, during the breeding season, it is likely that adult lesser black-backed gulls at the Norfolk Vanguard site will originate from the Alde-Ore Estuary SPA and other non-SPA colonies in East Anglia. However, these birds may be mixed with non-breeding birds from a variety of sources, so that any impact on lesser black-backed gulls due to the proposed Norfolk Vanguard project will be on a mixture of breeding birds from Alde-Ore Estuary, breeding birds from non-SPA colonies and immatures/nonbreeders from many different sources.

374. Thaxter *et al.* (2012b, 2015) tracked breeding adult lesser black-backed gulls from the Alde-Ore Estuary SPA and showed that birds differed in feeding habitat and area use both within and between seasons, as well as individually. Marine foraging occurred more during chick-rearing, suggesting that connectivity with the Norfolk Vanguard site would be most likely during the chick-rearing part of the breeding season, whereas early and late in the breeding season these birds foraged more in terrestrial and coastal habitats. This work has found that while the core areas, defined as the 50% and 75% kernel density estimates (KDE) respectively, remained fairly consistent across years, at the larger scale (defined as the 95% KDE) spatial distributions showed more variation. However, from the perspective of Norfolk Vanguard, there was virtually no overlap between the foraging areas and the wind farms. It is therefore likely that few of the birds recorded during the breeding season on the Norfolk Vanguard sites are breeding adults from this colony (see Norfolk Vanguard ES Technical Appendix 13.1 Annex 8 for further details).

375. As discussed above, the non-SPA adult lesser black-backed gull population with potential for connectivity to Norfolk Vanguard is likely to be at least 5,400 and could easily be twice this figure when allowance is made for population increases since surveys were last conducted. This estimate is also derived from partial coverage of urban locations at which gulls may breed (e.g. Norfolk appears to have had very limited coverage). This, together with the fact that there are over 230km of coastline within foraging range of Norfolk Vanguard, also suggests the actual non-SPA lesser black-backed gull population within range of Norfolk Vanguard is likely to be at least twice the estimate of 5,400 (e.g. approx. 11,000 adults) which would represent an all age class population in excess of 19,000 individuals (on the basis that adults comprise approximately 58% of the population, Furness 2015).

376. The Alde-Ore SPA lesser black-backed gull breeding population has been around 2,000 pairs between 2007 and 2014 (minimum 1,580 pairs in 2011, maximum 2,769 pairs in 2008; Table 5.1). This estimate for the breeding population size is considered

robust since it takes into account observed inter-annual variations over a span of representative years for which data are available. This suggests that the total population (all age classes) associated with the SPA is around 6,700 individuals.

377. Incorporating all of the above evidence, a worst case (precautionary) assumption has been made that the breeding season reference population is 25,700 individuals, 25% of which potentially originate from the Alde-Ore SPA population (tracking data suggest a much lower value than this however do not permit a robust quantification).

Gannet

378. While Norfolk Vanguard is within the foraging range of gannets from Flamborough and Filey Coast pSPA, tracking studies have found that very few foraging trips extend as far as the wind farm (e.g. Langston *et al.* 2013). Nevertheless, the potential for connectivity exists for this population, therefore assessment has been conducted against this population. To estimate the total population for these colonies (i.e. accounting for sub-adult ages classes) the number of breeding pairs has been multiplied by 2 (to obtain the number of adults) and divided by the adult proportion in Table 13.60. For gannet, the most recent census was 2017 which recorded 13,391 pairs. This gives a breeding season reference population of 44,637 ((13391 x 2)/0.6).

Great black-backed gull

379. There are no breeding colonies for this species within foraging range of Norfolk Vanguard. 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 13.7.5.1). This is based on the observation that immature birds tend to remain in wintering areas. Thus, the number of immature birds in the relevant populations during the breeding season may be estimated as the proportion of the relevant BDMPS (the one immediately preceding the breeding season) which are sub-adults. Thus, the breeding season reference population can be calculated as 57.8% of the nonbreeding BDMPS populations of great black-backed gull (see Table 13.60). This yields a breeding season population of nonbreeding great black-backed gull of 52,829 (nonbreeding BDMPS for the UK North Sea and Channel, 91,399 x 57.8%).

Nonbreeding season reference populations for collision assessment

380. The nonbreeding season reference populations were taken from Furness (2015).

Collision impacts

381. 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.

382. 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 13.60.

Table 13.60 Average mortality across all age classes. Average mortality calculated using age specific demographic rates and age class proportions.

Species	Parameter	Survival (age class)					Productivity	Average mortality
		0-1	1-2	2-3	3-4	Adult		
Gannet	Demographic rate	0.424	0.829	0891	0.895	0.912	0.7	0.191
	Population age ratio	0.191	0.081	0.067	0.06	0.6	-	
Kittiwake	Demographic rate	0.79	0.854	0.854	0.854	0.854	0.69	0.156
	Population age ratio	0.155	0.123	0.105	0.089	0.527	-	
Lesser black-backed gull	Demographic rate	0.82	0.885	0.885	0.885	0.885	0.53	0.126
	Population age ratio	0.134	0.109	0.085	0.084	0.577	-	
Great black-backed gull	Demographic rate	0.815	0.815	0.815	0.815	0.815	1.139	0.185
	Population age ratio	0.194	0.156	0.126	0.102	0.422	-	

383. Table 13.61 provides the baseline survival rates, the relevant breeding season and nonbreeding season BDMPS and the percentage increase in mortality for each seabird species due to collisions.

Table 13.61. Percentage increases in the background mortality rate of seasonal and annual populations due to predicted collisions (option 2) calculated with stochasticity in density, avoidance rate, flight height and nocturnal activity for the worst case 9MW turbine and species specific worst case project scenario. Note that the annual mortalities have been assessed against both the biogeographic populations and the largest BDMPS (as advised by Natural England) in order to bracket likely effects.

Species		Gannet			Kittiwake			Lesser black-backed gull			Great black-backed gull		
		Median	Lower c.i.	Upper c.i	Median	Lower c.i.	Upper c.i	Median	Lower c.i.	Upper c.i	Median	Lower c.i.	Upper c.i
Baseline average mortality				0.191			0.156			0.126			0.185
Breeding season	Reference population			44,637			296,956			25,970			52,829
	Seasonal mortality	18.36	0	112	20.85	0	95	23.28	0	103	0	0	40
	Increase in background mortality (%)	**0.215**	0.000	1.314	**0.045**	0.000	0.205	**0.711**	0.000	3.148	**0.000**	0.000	0.409
Autumn	Reference population			456298			829937			209007			
	Seasonal mortality	62.32	15	313	61.32	5	191	4.07	0	41			
	Increase in background mortality (%)	**0.072**	0.017	0.359	**0.047**	0.004	0.148	**0.015**	0.000	0.156			
Wintering	Reference population									39316			91399
	Seasonal mortality							0	0	0	22.16	0	99
	Increase in background mortality (%)							**0.000**	0.000	0.000	**0.131**	0.000	0.585

Species		Gannet			Kittiwake			Lesser black-backed gull			Great black-backed gull		
		Median	Lower c.i.	Upper c.i	Median	Lower c.i.	Upper c.i	Median	Lower c.i.	Upper c.i	Median	Lower c.i.	Upper c.i
Spring	Reference population	248385			627816			197483					
	Seasonal mortality	29.96	0	100	76.26	18	574	0	0	6			
	Increase in background mortality (%)	**0.063**	0.000	0.211	**0.078**	0.018	0.586	**0.000**	0.000	0.024			
Annual – largest BDMPS	Reference population	456298			829937			209007			91399		
	Seasonal mortality	110.64	14.8	524	158.4	22.4	860	27.3	0	151	22.2	0	138.7
	Increase in background mortality (%)	**0.127**	0.017	0.601	**0.122**	0.017	0.664	**0.104**	0.000	0.573	**0.131**	0.000	0.820
Annual - biogeographic	Reference population	1180000			5100000			864000			235000		
	Seasonal mortality	110.64	14.8	524	158.4	22.4	860	27.3	0	151	22.2	0	138.7
	Increase in background mortality (%)	**0.049**	0.007	0.232	**0.020**	0.003	0.108	**0.025**	0.000	0.139	**0.051**	0.000	0.319

384. The median collision predictions for all species in all seasons and also summed across the year resulted in increases in background mortality below 1%. Therefore, the magnitude of effects due to collision mortality for gannet, kittiwake, lesser black-backed gull and great black-backed gull are considered to be negligible resulting in impact significances of **negligible to minor adverse**.

385. For two species, gannet and lesser black-backed gull, the upper 95% confidence interval collision estimates for the breeding season corresponded to increases in the background mortality above 1% (1.3% for gannet and 3.1% for lesser black-backed gull). However, these results reflect a combination of worst case project design (the worst case 9MW turbines, all located in the site with the higher collision estimates) and were only obtained at the upper end of the ranges of uncertainty in seabird density, flight height, avoidance rate and nocturnal activity and therefore this does not alter the assessed impact significance.

386. Natural England (2018) questioned the basis for the assumption that only 10% of the birds recorded on the site in the breeding season originate from the Alde-Ore SPA. This estimate was based on the available tracking data which shows very low connectivity between the colony and the wind farms (e.g. Thaxter *et al*. 2015, see Technical Appendix 13.1 Annex 8). However, it is informative to consider the collision mortality values in Table 13.61 in relation to the potential for significant increases in background mortality. In order to obtain an increase in the background mortality of 1% (the level at which an increase is considered to be potentially detectable), 37% of the birds on the Norfolk Vanguard site during the breeding season would need to originate from the Alde Ore SPA colony. Given that the results in Thaxter *et al*. (2015) show virtually no overlap between tagged birds' foraging areas and the wind farm, it is considered very unlikely that there would be such a high level of site use (i.e. 37% of birds present originate from this colony). Therefore, the assessment for this species as discussed above is considered to be robust.

387. Natural England have advised that they consider gannet may potentially be at risk of both operational displacement and collision risk (although it is important to note that combining the estimated mortality for these effects will include an unknown degree of double counting). The addition of the maximum annual displacement total estimate of 25 (section 13.7.5.1.3) to the predicted annual collision mortality of 110 would not materially alter the above conclusion of at worst a minor adverse effect.

Migrant seabirds

388. Some migratory seabirds may not have been accounted for from the standard survey methods as they may move across seas in large numbers, but over a short time period. These movements are also often at night and sometimes in bad weather (Cook *et al.,* 2012). Most of the seabirds migrating through the Norfolk Vanguard

site were frequently detected on surveys, but four species (great skua, Arctic skua, common tern and Arctic tern) have been identified from previous studies as potentially traversing the region during migration seasons in large numbers (Wright *et al.,* 2012).

389. Collision risk for these migrant seabirds was estimated following the approach in WWT & MacArthur Green (2013) and using population estimates in Furness (2015). The key parameters to be considered for these species are the width of the coastal migration corridors (i.e. the routes followed on passage through the North Sea) and the percentage at collision height (Table 13.62).

Table 13.62 Key parameters for predicting collision risk for migrant seabirds

Species	Migration corridor (WWT & MacArthur Green 2013)	Percentage at rotor height calculated as >22m (Johnston *et al.* 2014a,b)
Arctic skua	0 – 20km	1.8
Great skua	0 – 40km	4.4
Arctic tern	0 – 20km	2.9
Common tern	0 – 10km	5.7
Little gull	0 – 20km	12.5

390. NV West and NV East are located 47km and 70km from the coast at their nearest points. These are farther offshore than any of the corridor widths for the migrant seabird species in Table 13.62. While a few individuals may travel beyond the outer edges of these corridors, given the low percentages at collision height the overall collision risk will be very small. Consequently, any effects from Norfolk Vanguard will be negligible and cause no material difference to current baseline mortality rates. The magnitude of effects is considered to be negligible for all species. Therefore, **no impacts** would be expected to result from collisions for any of these migrant seabird species. This conclusion is also consistent with the aerial survey data indicating low numbers of these species in the survey area even during the migration seasons.

Migrant non-seabirds

391. The assessment for the adjacent East Anglia THREE wind farm (EATL, 2015) included modelling to estimate the occurrence of other (terrestrial) migrant birds, including waders and wildfowl, in order to estimate potential collision risks.

392. Following a screening exercise, twenty-three non-seabird species with the potential to migrate through the East Anglia THREE site were assessed. Migrant collision modelling using the migrant option in the Band model Option 1 estimated that 17 of these species would be subject to one or fewer collisions per year and three would

be subject to five or fewer collisions per year (EATL, 2015). The remaining species for which more than five annual collisions were predicted, were dark bellied Brent goose, golden plover and dunlin. However, even these species were only estimated to be at risk of six, ten and ten collisions per year, respectively.

393. The East Anglia THREE wind farm is located immediately to the south of Norfolk Vanguard and, given that the migrant collision assessment conducted for the former site used wide migration corridors which also covered Norfolk Vanguard, the results from this assessment will be almost identical to those which would be generated for Norfolk Vanguard. Indeed, given the proximity of the two sites and the broad migration fronts applied in the assessment, it is difficult to perceive of circumstances by which this would not be the case (i.e. that the two sites would return different magnitudes of collision risk to migrant non-seabirds). Therefore, on the basis of a prediction of extremely low collision risks for non-seabird migrants derived from the assessment for the similarly sized and closely located East Anglia THREE wind farm, it is considered that very similar conclusions would be obtained for Norfolk Vanguard. Therefore, the significance of all migrant non-seabird collision impacts is assessed as **negligible**.

13.7.5.4 Impact 6: Barrier effects

394. The presence of the proposed project could potentially create a barrier to bird migration and foraging routes, and as a consequence, the proposed project has the potential to result in long-term changes to bird movements. It has been shown that some species (divers and scoters) avoid wind farms by making detours around wind turbine arrays which potentially increases their energy expenditure (Petersen *et al.,* 2006; Petersen and Fox, 2007), which under some circumstances could potentially decrease survival chances. Such effects may have a greater impact on birds that regularly commute around a wind farm (e.g. birds heading to / from foraging grounds and roosting / nesting sites) than on migrants that would only have to negotiate around a wind farm once per migratory period, or twice per annum, if flying the same return route (Speakman *et al.,* 2009).

395. During the spring and autumn migration periods, the route taken by migrating individuals may change due to the barrier effect created by the wind turbines. Although migrating birds may have to increase their energy expenditure to circumvent the Norfolk Vanguard site at a time when their energy budgets are typically restricted, this effect is likely to be small for one-off avoidances. 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 (including seabirds,

waders and waterbirds on passage) through the site could be considered negligible and these species have been scoped out of detailed assessment.

396. Several species of seabirds could be susceptible to a barrier effect, outside of passage movements, if the presence of wind turbines prevented access to foraging grounds or made the journey to or from foraging grounds more energetically expensive, particularly during the breeding season. The Norfolk Vanguard site is located beyond the foraging range of the majority of species during the breeding season, with the exception of fulmar, gannet and lesser black-backed gull. However, even for these species, the Norfolk Vanguard site is towards the periphery of their mean maximum foraging ranges (Thaxter *et al.,* 2012) so it is highly unlikely that anything other than a negligible magnitude barrier effect would be created. In addition, all of these species are considered to have a low sensitivity to barrier effects (Maclean *et al.,* 2009). Assessment of barrier effects of offshore wind farms in the Forth and Tay area for gannets breeding in the Forth Islands SPA concluded that even in this situation where wind farms were planned in close proximity to the Bass Rock gannet colony, the barrier effect for that population would be negligible (Searle *et al.,* 2014). The impact significance of the barrier effect for all of these species is assessed as negligible.

13.7.6 Potential Impacts during Decommissioning

397. 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.

398. Any effects generated during the decommissioning phase of the proposed Norfolk Vanguard 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 structures and materials installed, including some or all of the array cables, interconnector cables and offshore export cables, although It is anticipated that scour and cable protection would remain in situ.

399. 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. Disturbance and displacement is likely to occur due to the presence of working vessels and crews and the movement and noise associated with these. Indirect effects would occur as structures are removed.

400. As no offshore wind farms have yet been decommissioned, 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.

13.7.6.1 Impact 7: Direct disturbance and displacement

401. Disturbance and displacement is likely to occur due to the presence of working vessels and crews and the movement and noise 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.

402. Any impacts generated during the decommissioning phase of the proposed Norfolk Vanguard 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.

13.7.6.2 Impact 8: Indirect impacts through effects on habitats and prey species

403. 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.

404. 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.

13.8 Cumulative Impacts

13.8.1 Screening for cumulative impacts

405. The screened in potential effects arising from the proposed Norfolk Vanguard project alone that have been identified above are presented in Table 13.63 below, within which they are assessed for their potential to create a cumulative impact.

Table 13.63 Potential cumulative impacts

Impact	Potential for cumulative impact	Data confidence	Rationale
Construction			
1. Disturbance and displacement	No	High	There is a possibility that construction would overlap temporally with construction of East Anglia THREE to the south of NV East. However, the Norfolk Vanguard assessment identified very small magnitudes of impact, and even if these occurred to the same extent on the East Anglia THREE site at the same time (i.e. double the impact) this would not constitute a significant effect. This also applies to the installation of the export cable, as it is very unlikely that this would coincide both spatially and temporally with installation for other wind farms. Furthermore, the magnitudes of project alone impact (for NV and East Anglia THREE) were very small, therefore even if these should overlap temporally this would still not constitute a significant impact.
2. Indirect impacts through effects on habitats and prey species	No	High	There is a possibility that construction would overlap temporally with construction of East Anglia THREE to the south of NV East. However, the Norfolk Vanguard assessment identified very small magnitudes of impact, as was the case for East

Impact	Potential for cumulative impact	Data confidence	Rationale
			Anglia THREE site. Thus, even when these impacts are doubled (i.e. effects occur at the same time) this would not constitute a significant effect.
Operation			
3. Disturbance and displacement	Yes	Medium-Low	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
4. 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.
5. Collision risk	Yes	Medium	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
6. Barrier effect	No	High	The likelihood that there would be a cumulative impact is low for the following reasons; the region has very low presence of breeding seabirds (only lesser black-backed gulls breed within foraging range, but no evidence for barrier effects in this species) so no risk of daily barrier to movement. Diversion around wind farms by migrating seabirds has negligible costs and non-seabird migrants will primarily fly over the wind farm and therefore

Impact	Potential for cumulative impact	Data confidence	Rationale
			will not face a barrier to movement.
Decommissioning			
7. 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.
8. 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.

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

- Offshore wind farms;
- Marine aggregate extraction;
- Oil and gas exploration and extraction;
- Subsea cables and pipelines; and
- Commercial shipping.

407. The identification of plans and projects 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 Norfolk Vanguard project.

408. 'Foreseeable' projects, that is those for which an application has not been made but they have been the subject of consultation by the developer, or they are listed in plans that have clear delivery mechanisms, have been included for consideration, but the absence of firm or any relevant data could preclude a quantitative cumulative assessment being carried out.

13.8.2 Screened in sources of effect for the Cumulative Impact Assessment (CIA)

409. Potential plans and projects have been considered for how they might act cumulatively with the proposed project and a screening process carried out.

13.8.2.1 Benthic habitats

410. The potential for cumulative indirect impacts acting through adverse effects on benthic habitats and consequently on bird prey species was considered as part of Chapter 10 Benthic Ecology, Section 10.7. This identified that the potential cumulative impacts to the benthos caused by interactions of the proposed Norfolk Vanguard project and other activities are:

- Physical disturbance and habitat loss;
- Increased suspended sediment concentrations;
- Re-mobilisation of contaminated sediments;
- Underwater noise and vibration; and
- Colonisation of foundations and cable protection.

411. The cumulative assessment identified that these impacts would mostly be temporary, small scale and localised. Given the distances to other activities in the region (e.g. other offshore wind farms and aggregate extraction) and the highly localised nature of the impacts above, it concluded that there is no pathway for interaction between impacts cumulatively. Whilst it is recognised that across the East Anglia Zone and wider southern North Sea there would be additive impacts, the combined magnitude of these would be negligible relative to the scale of the habitats affected. Accordingly, the cumulative impacts on birds through these effects could be no more than **negligible** and these are screened out from further assessment.

13.8.2.2 Shipping and navigation

412. Wide ranging species such as gannet and fulmar have low sensitivity to human activity disturbance and are relatively flexible in their habitat choice (Garthe & Hüppop, 2004). These species are therefore unlikely to be subject to cumulative

effects of disturbance from the proposed Norfolk Vanguard project and existing ship traffic.

413. Gulls are undisturbed by the close proximity of boats, and therefore no potential adverse cumulative effects are expected for kittiwake, common gull, lesser black-backed gull, herring gull or great black-backed gull.

414. Divers, particularly red-throated divers, are known to be sensitive to disturbance from shipping. Consequently, they usually occur in areas with light sea traffic (Mitschke *et al.,* 2001). It has been noted from aerial survey data that while red-throated divers avoid shipping lanes (tending to prefer areas 1km or more away), they do not display complete absence, and vessel activity in these shipping lanes is considerably higher than any proposed wind farm service boat activity (DTI, 2006). The high shipping activity in the Thames Strategic Area due to bulk carriers, tankers and passenger ferries, does not seem to affect the overwintering population of red-throated divers inside and outside of the Outer Thames SPA. Auks also tend to move away from vessels, although their responses are less marked than for divers. While it can be expected that red-throated divers, guillemots and razorbills will be displaced from shipping lanes, it is reasonable to assume that such effects are accounted for in the baseline data which underpin this assessment.

415. In conclusion, it is likely that the seabirds present in the vicinity of the proposed Norfolk Vanguard project have already adapted to shipping operations in the area. The increase in shipping activities associated with construction of Norfolk Vanguard would be short-term and temporary. Therefore, **no significant cumulative disturbance and displacement effects** are predicted for any seabird species and shipping and navigation is screened out of further cumulative assessment.

13.8.2.3 Wind farms

416. In the offshore environment other wind farms that are operational, under construction, consented but not constructed, subject to current applications, subject to consultation or notified to the Planning Inspectorate are screened in. This list of wind farms with their status is provided in Table 13.66. Although some of the wind farms included in this list have been operational for over 10 years, in most cases the seabird population data pre-date the installations (e.g. Seabird 2000, Mitchell *et al*. 2004) and therefore the baseline cannot be assumed to include the effects of these wind farms.

417. The wind farms listed in Table 13.64 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 13.64 Summary of projects considered for the CIA in relation to offshore ornithology

Project	Tier	Status	Development period	[2]Distance from Norfolk Vanguard site (km)	Project data status	Included in CIA	Rationale
Greater Gabbard	1	Built and operational	Fully commissioned Aug 2013	96	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	141	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	174	Complete but limited quantitative species assessment	Yes	Operational for a sufficiently long time that its effects will have been incorporated in surveys but not yet in population responses
Lincs	1	Built and operational	Fully commissioned Sep 2013	122	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
London Array (Phase 1)	1	Built and operational	Fully commissioned Apr 2013	138	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	125	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.

[2] Shortest distance between the considered project and Norfolk Vanguard – unless specified otherwise.

Project	Tier	Status	Development period	[2]Distance from Norfolk Vanguard site (km)	Project data status	Included in CIA	Rationale
Scroby Sands	1	Built and operational	Fully commissioned Dec 2004	45	Complete but limited quantitative species assessment	Yes	Operational for a sufficiently long time that its effects will have been incorporated in surveys but not yet in population responses
Sheringham Shoal	1	Built and operational	Fully commissioned Sep 2012	75	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 Sep 2007	668	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
Thanet	1	Built and operational	Fully commissioned Sep 2010	159	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	292	Complete but limited quantitative species assessment	Yes	Included as an operational project that does not yet form part of the baseline.
Westermost Rough	1	Built and operational	Fully commissioned May 2015	169	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Humber Gateway	1	Built and operational	Fully commissioned May 2015	153	Complete but limited quantitative species assessment	Yes	Included as a consented project that does not yet form part of the baseline.

Project	Tier	Status	Development period	[2]Distance from Norfolk Vanguard site (km)	Project data status	Included in CIA	Rationale
Galloper	1	Built and operational	Fully commissioned March 2018	93	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Dudgeon	1	Built and operational	Fully commissioned November 2017	66	Complete but limited quantitative species assessment	Yes	Included as a consented project that does not yet form part of the baseline.
Race Bank	1	Built and operational	Fully commissioned February 2018	99	Complete but limited quantitative species assessment	Yes	Included as a consented project that does not yet form part of the baseline.
Beatrice	2	Under construction	Consent Mar 2014. Construction commenced Jan 2017	668	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
East Anglia ONE	2	Under construction	Consent Jun 2014, offshore construction due to commence August 2018	49	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
EOWDC (Aberdeen OWF)	2	Under construction	Consent August 2014, offshore construction commenced April 2018	546	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 period	[2]Distance from Norfolk Vanguard site (km)	Project data status	Included in CIA	Rationale
Hornsea Project 1	2	Under construction	Consent Dec 2014, no construction start date	95	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Rampion	2	Under construction	Consent Aug 2014. Construction commenced Apr 2017 (expected to be commissioned 2018)	293	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Blyth (NaREC Demonstration)	3	Consented	Consent Nov 2013, no construction start date	Tbc	Complete but limited quantitative species assessment	Yes	Included as a consented project that does not yet form part of the baseline.
Dogger Bank Creyke Beck A & B	3	Consented	Consent Feb 2015, no construction start date	184	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	481	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Neart ne Goithe	3	Consented	Consent Oct 2014, no construction start date	465	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	461	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 period	Distance from Norfolk Vanguard site (km)[2]	Project data status	Included in CIA	Rationale
Moray Firth (EDA)	3	Consented	Consent Mar 2014, no construction start date	653	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 & B	3	Consented	Consent Aug 2015, no construction start date	201	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Hornsea Project 2	3	Consented	Consent Aug 2016, no construction start date	107	Complete for the ornithology receptors being assessed	Yes	Included as a consented project that does not yet form part of the baseline.
Triton Knoll	3	Consented	Consent Jul 2013, no construction start date	101	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	0	Complete for the ornithology receptors being assessed	Yes	Included as a foreseeable project.
Hornsea Project 3	5	In planning PEIR submitted, Final submission expected 2018.	ES expected Q2 2018	73	ES not yet available	Yes	In the absence of final data, the outputs from the PEIR have been included.
Thanet Extension	5	In planning PEIR submitted,	Submission expected Q1 2018	159	ES not yet available	Yes	In the absence of final data, the outputs from the PEIR have been included.

Project	Tier	Status	Development period	[2]Distance from Norfolk Vanguard site (km)	Project data status	Included in CIA	Rationale
		Final submission expected 2018.					
East Anglia ONE North	5	Pre-planning application		38	Not yet available	Yes	In the absence of data, the inclusion of this project is only on a qualitative basis.
East Anglia TWO	5	Pre-planning application		56	Not yet available	Yes	In the absence of data, the inclusion of this project is only on a qualitative basis.
Hornsea Project 4	5	Pre-planning application		115	Not yet available	Yes	In the absence of data, the inclusion of this project is only on a qualitative basis.
Norfolk Boreas	5	Pre-planning application		1	Not yet available	Yes	In the absence of data, the inclusion of this project is only on a qualitative basis.

418. The level of data available and the ease with which impacts can be combined across the wind farms in Table 13.66 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.

419. Two further wind farms identified in Table 13.66 are expected to submit applications at similar times as Norfolk Vanguard: Hornsea Project 3 and Thanet Extension. At present the only quantitative impact estimates available for these wind farms are those within the projects' Preliminary Environmental Information Reports. The impact figures in the final assessments are expected to differ from these, however these are the only data currently available and have been included here in order to provide an indication of the potential cumulative impacts including these projects.

13.8.2.4 Bird species included in the cumulative assessment of operation displacement

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

13.8.2.5 Bird species included in the cumulative assessment of collision risk

421. The species assessed for project alone collision impacts (and the relevant seasons) were those for which annual collision mortality greater than or equal to approximately 10 individuals was estimated on Norfolk Vanguard. Thus, cumulative collision risk both annually and for key seasons was assessed for gannet, kittiwake, lesser black-backed gull and great black-backed gull.

13.8.2.6 Cumulative assessment of operation displacement risk

13.8.2.6.1 Red-throated diver

422. Cumulative red-throated diver displacement mortality has been calculated for wind farms in the former East Anglia zone which have the potential to contribute to a cumulative effect. This has been conducted using the same precautionary magnitudes of displacement (80%) and mortality (5%) applied to all birds within the 4km wind farm buffer, as defined in section 13.7.5.1.2.

423. The red-throated diver displacement mortality across wind farms in the East Anglia Zone is presented in Table 13.66. Displacement from these wind farms is considered to be the most likely source of cumulative impact in combination with Norfolk Vanguard. However, there is potential for other wind farms in the southern North Sea (e.g. Round 1 and 2 projects) to also contribute to cumulative red-throated diver

displacement. Table 13.65 summarises the results of a review of older project environmental statements.

Table 13.65 Summary of red-throated diver assessments for wind farms in southern North Sea (excluding former East Anglia zone wind farms) with potential to contribute to a cumulative operational displacement impact.

Wind farm	Year turbines installed	Red-throated diver assessment method	Estimated no. of red-throated diver mortalities due to displacement	Conclusion for NV cumulative assessment
Scroby Sands	2004	None	No number presented	Part of baseline
Kentish Flats	2005	Qualitative	No number presented	Part of baseline
Lynn & Inner Dowsing	2009	Qualitative	No number presented	Part of baseline
Gunfleet Sands	2010	Qualitative	very small'	Part of baseline
Thanet	2010	Quantitative	<1	Part of baseline
Sheringham Shoal	2011	None	No number presented	Part of baseline
Greater Gabbard	2012	Quantitative	16	Part of baseline
London Array	2012	Qualitative	No number presented	Part of baseline
Lincs	2012	Qualitative	No number presented	Part of baseline
Kentish Flats Extension	2015	Qualitative	No number presented	Assumed very small
Galloper	2017	Quantitative	5.5	Very small impact
Dudgeon	2017	Not assessed	No number presented	Assumed very small
Race Bank	2017	Not assessed	No number presented	Assumed very small
Triton Knoll	NA	Not assessed	No number presented	Assumed very small
Thanet Extension	NA	Quantitative	1-2	Very small impact

424. Wind farms at which turbines were installed before or during 2012 are considered to form part of the NV baseline since any displacement effect will have occurred at these sites prior to the first nonbreeding period surveyed at Norfolk Vanguard (2012-2013) and therefore any modifications in the red-throated diver distribution and densities will be fully reflected in this assessment.

425. Of the remaining projects (Kentish Flats Extension, Galloper, Dudgeon, Race Bank, Triton Knoll and Thanet Extension), only three assessed displacement impacts for red-throated diver and only two included an estimate of the number of individuals

expected to be affected; Galloper and Thanet Extension (note the latter are preliminary values form the project's PEIR). In total, these assessments indicated that very small numbers (total 7.5) would be at risk of mortality. This total has been included in the cumulative assessment, together with the former East Anglia zone wind farms.

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

- Each wind farm assessment has assumed that all birds within 4km of the wind farm lease boundary are potentially affected, whereas the evidence suggests displacement declines with distance from wind farm 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;
- The Norfolk Vanguard East 4km buffer includes part of the East Anglia THREE wind farm and 4km buffer and vice versa so including both sites double counts birds in the overlapping area; and
- Half of the total was predicted to occur during the spring migration period 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.

Table 13.66 Red-throated diver cumulative displacement mortality calculated on the basis of a precautionary assumption of 80% displacement within 4km of the wind farm and 5% mortality of displaced individuals.

Wind farm	Autumn	Midwinter	Spring	Annual
Older projects (see Table 13.65)	N/A	N/A	N/A	7.5
East Anglia ONE	2	4	6	12
East Anglia THREE	2	1	8	11
Norfolk Vanguard East	2	1	5	8
Norfolk Vanguard West	0	13	8	21
Total	6	19	27	59.5

427. The largest BDMPS for red-throated diver is 13,277 (Furness, 2015). At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die is 3,027 (13,277 x 0.228). The addition of a maximum of 59.7 to this would increase the mortality rate by 1.9%. The biogeographic population for red-throated diver is 27,000 (Furness, 2015). At the average baseline mortality rate for red-throated diver of 0.228 (Table 13.23) the number of individuals expected to die is 6,156 (27,000 x 0.228). The addition of a maximum of 59.5 to this would increase the mortality rate by 0.97%. Therefore, against the smaller BDMPS

population the worst case mortality would result in an increase in background mortality of slightly less than 2%, while against the biogeographic population the increase would be below the 1% threshold of detectability.

428. The assessment methodology makes no allowance for the fact that turbine densities (and hence the negative stimulus to which the birds respond) within the built wind farms will be much lower than the worst case designs on which the projects were consented. For example, East Anglia ONE was originally assessed on the basis of 333 turbines, reduced to 240 for consent and currently being constructed with 102. Thus, the final wind farm will have less than one third the original number of proposed (and assessed) turbines. This will almost certainly reduce the magnitude of displacement. The total also includes an unrealistic worst case scenario for Norfolk Vanguard with complete displacement from both NV East and NV West. In reality, it is more reasonable to assume that combined displacement would lie between the values obtained for NV East and NV West (i.e. rather than the sum total of 29, this would be between 8 and 21).

429. To inform the combinations of displacement and mortality which result in increases in background mortality for the smaller BDMPS population of <1% and between 1% and 2% for the total mortality in Table 13.66, a displacement matrix with highlighted cells has been produced (Table 13.67). This indicates that, for example, cumulative displacement of 70% combined with 3% mortality, or 50% displacement and 4% mortality would result in increases below 1% in background mortality.

Table 13.67 Red-throated diver cumulative displacement matrix. Levels of mortality which would increase the baseline mortality of the smaller BDMPS population by percentage thresholds indicated by shading: green <1%; orange >1% and <2%; clear >2%.

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	3	4	5	7	8	9	10	12	13
2	3	5	8	10	13	16	18	21	23	26
3	4	8	12	16	20	23	27	31	35	39
4	5	10	16	21	26	31	36	42	47	52
5	7	13	20	26	33	39	46	52	59	65
6	8	16	23	31	39	47	55	62	70	78
7	9	18	27	36	46	55	64	73	82	91
8	10	21	31	42	52	62	73	83	94	104
9	12	23	35	47	59	70	82	94	105	117
10	13	26	39	52	65	78	91	104	117	130

430. Given the various additive sources of precaution in this assessment, there is a very high likelihood that cumulative displacement would be lower than the worst case totals presented here, resulting in increases in background mortality below 1%, and thus the magnitude of cumulative displacement is assessed as negligible. Therefore, as the species is of high sensitivity to disturbance, the cumulative impact significance would be **minor adverse**.

13.8.2.6.2 Gannet

431. There is evidence that gannets avoid flying through wind farms (Krijgsveld *et al.* 2011). If this prevents them accessing important foraging areas this could have an impact on affected individuals. However, for the reasons set out below the potential for the proposed project to contribute to a cumulative effect such as this is considered to be very low. The period when gannet displacement is of potential concern is during autumn migration. At this time very large numbers of gannets migrate from breeding colonies in Northern Europe to wintering areas farther south (off southern Europe and off the coast of West Africa). Thus, displacement due to wind farms in the North Sea is trivial when compared with the range over which individuals of this species travel (Garthe *et al.* 2012, see also Masden *et al.* 2010, 2012). Furthermore, gannets are considered to be highly flexible in their foraging requirements (capable of catching a wide range of prey species), and exclusion from wind farms in the southern North Sea during the migration period, when combined with the low overall numbers of birds present, is very unlikely to represent a loss of any importance. Consequently, the potential that even the worst case precautionary prediction of 25 displacement mortalities at the proposed Norfolk Vanguard project could contribute to a significant cumulative displacement effect on gannets during migration is considered to be very small and the impact significance of cumulative displacement is **negligible**.

13.8.2.6.3 Auks

432. Post-construction monitoring of nonbreeding season auks has found evidence of wind farm avoidance behaviour, with indications that wind turbine density may affect the magnitude of avoidance (Leopold *et al.,* 2011; Krijgsveld *et al.,* 2011; Dierschke *et al.,* 2016). The only auk species present in sufficient numbers in these studies to permit robust estimation of wind farm avoidance was guillemot, for which an avoidance rate of around 68% was calculated, although it should be noted that this was based on observations of flying birds and this value may not be appropriate for swimming birds. Furthermore, these studies were conducted at sites with relatively closely spaced wind turbines (e.g. 550m), while the minimum spacing at NV East will be 680m (within rows) and 680m (between rows), which equates to a

minimum turbine density reduction of almost 25%. Thus, a figure of 70% displacement represents a precautionary estimate.

433. The pressures on nonbreeding birds in terms of energy requirements are lower outside the breeding season when they only need to obtain sufficient food to maintain their own survival. In addition, species such as auks remain at sea for extended periods and thus flight costs are minimised. Recoveries of ringed auks have revealed wide winter distributions, with birds spread throughout the North Sea (Furness, 2015). This pattern has received further support from recent studies using geolocator tags, which have revealed that birds from Scottish colonies spread out through much of the North Sea (S. Wanless pers. comm.). These studies have also found quite marked levels of variation between years, which suggests that birds are relatively flexible in terms of where they spend the winter and are not dependent on particular foraging locations. Hence, the consequence of winter displacement from wind farms in terms of increased mortality is likely to be minimal. Given that, even when fish stocks have collapsed, seabird adult survival rates have shown declines of no more than 6 - 7% (e.g. kittiwake, Frederiksen *et al.,* 2004) an increase in mortality due to displacement from wind farm sites seems likely to be at the low end of the proposed 1 - 10% range, and a value of 1% when combined with the precautionary 70% displacement rate is considered appropriate for wintering auks.

434. During the examination for the adjacent East Anglia THREE project (EATL, 2016) tables of potential auk displacement at North Sea wind farms were presented for cumulative assessment. These tables have been reproduced here with the addition of the potential displacement at Norfolk Vanguard.

Table 13.68. Auk populations in UK North Sea waters (see Natural England 2015) used in the displacement assessment, the baseline mortality averaged across age classes (Table 13.23) and the additional mortality which would increase the baseline rate by 1%, 2% and 3%.

Species	Largest BDMPS	Average baseline mortality	Magnitude of additional mortality which increases baseline rate by:		
			1%	2%	3%
Guillemot	2,045,078	0.140	2,863	5,726	8,589
Razorbill	591,874	0.174	1,030	2,060	3,090
Puffin	868,689	0.167	1,451	2,901	4,352

13.8.2.6.4 Puffin

435. Norfolk Vanguard East and Norfolk Vanguard West are located beyond the mean maximum foraging range of any puffin breeding colonies. Outside the breeding season, puffins disperse from their breeding sites. Large numbers are found

throughout the North Sea in the nonbreeding season (defined as August to February). It was during this period that numbers peaked on the Norfolk Vanguard site with a mean maximum of 112 individuals. The totals at risk on other North Sea wind farms are presented in Table 13.69.

Table 13.69. Cumulative puffin numbers on wind farms in the North Sea (taken from EATL 2016). Note these include the preliminary estimates for Hornsea Project Three and Thanet Extension.

Project	Breeding season	Non-breeding season
Aberdeen	42	82
Beatrice	2858	2435
Blyth Demonstration	235	123
Dogger Bank Creyke Beck A	37	295
Dogger Bank Creyke Beck B	102	743
Dogger Bank Teesside A	34	273
Dogger Bank Teesside B	35	329
Dudgeon	1	3
East Anglia ONE	16	32
East Anglia THREE	181	307
Galloper	0	1
Greater Gabbard	0	1
Hornsea Project One	1070	1257
Hornsea Project Two	468	2039
Hornsea Project Three	*252*	*11*
Humber Gateway	15	10
Inch Cape	2956	2688
Lincs and LID6	3	6
London Array I & II	0	1
Moray	2795	656
Neart na Gaoithe	2562	2103
Race Bank	1	10

Project	Breeding season	Non-breeding season
Seagreen A	4254	N/A
Seagreen B	8262	N/A
Sheringham Shoal	4	26
Teesside	35	18
Thanet	0	0
Thanet Extension	*0*	*0*
Triton Knoll	23	71
Westermost Rough	61	35
Seasonal Total (Ex. NV)	**26050**	**13541.8**
Annual Total (Ex. NV)		**39591.8**
Norfolk Vanguard East	0	112
Norfolk Vanguard West	0	0
Seasonal Total (Inc. NV)	**26050**	**13653.8**
Annual Total (Inc. NV)		**39703.8**

436. Natural England does not consider a single combination of displacement and mortality in their assessment of impact, instead advising presentation of the ranges from 0 to 100% as provided in this note. However, evidence in support of the use of a precautionary displacement rate of 70% with a 1% mortality rate for puffin has been presented here. For the current assessments presented in Tables 5 to 7, application of this level of impact indicates that the baseline mortality rate for the relevant populations (North Sea BDMPS) would increase by less than 1% (Table 13.70).

Table 13.70. Puffin cumulative displacement matrix. Levels of mortality which would increase the baseline mortality by percentage thresholds indicated by shading: green <1%; orange >1% and <2%; pink >2% and <3%; clear >3%:

		Mortality (%)																			
		1	2	3	4	5	6	7	8	9	10	20	25	30	40	50	60	70	80	90	100
Displacement (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	8	16	24	32	40	48	56	64	72	80	160	200	240	320	400	480	560	639	719	799
	4	16	32	48	64	80	96	112	128	144	160	320	400	480	639	799	959	1119	1279	1439	1599
	6	24	48	72	96	120	144	168	192	216	240	480	600	719	959	1199	1439	1679	1918	2158	2398
	8	32	64	96	128	160	192	224	256	288	320	639	799	959	1279	1599	1918	2238	2558	2878	3197
	10	40	80	120	160	200	240	280	320	360	400	799	999	1199	1599	1998	2398	2798	3197	3597	3997
	12	48	96	144	192	240	288	336	384	432	480	959	1199	1439	1918	2398	2878	3357	3837	4316	4796
	14	56	112	168	224	280	336	392	448	504	560	1119	1399	1679	2238	2798	3357	3917	4476	5036	5595
	16	64	128	192	256	320	384	448	512	576	639	1279	1599	1918	2558	3197	3837	4476	5116	5755	6395
	18	72	144	216	288	360	432	504	576	647	719	1439	1799	2158	2878	3597	4316	5036	5755	6475	7194
	20	80	160	240	320	400	480	560	639	719	799	1599	1998	2398	3197	3997	4796	5595	6395	7194	7993
	25	100	200	300	400	500	600	699	799	899	999	1998	2498	2998	3997	4996	5995	6994	7993	8993	9992
	30	120	240	360	480	600	719	839	959	1079	1199	2398	2998	3597	4796	5995	7194	8393	9592	10791	11990
	40	160	320	480	639	799	959	1119	1279	1439	1599	3197	3997	4796	6395	7993	9592	11191	12789	14388	15987
	50	200	400	600	799	999	1199	1399	1599	1799	1998	3997	4996	5995	7993	9992	11990	13988	15987	17985	19983
	60	240	480	719	959	1199	1439	1679	1918	2158	2398	4796	5995	7194	9592	11990	14388	16786	19184	21582	23980
	70	280	560	839	1119	1399	1679	1958	2238	2518	2798	5595	6994	8393	11191	13988	16786	19584	22381	25179	27977
	80	320	639	959	1279	1599	1918	2238	2558	2878	3197	6395	7993	9592	12789	15987	19184	22381	25579	28776	31973
	90	360	719	1079	1439	1799	2158	2518	2878	3237	3597	7194	8993	10791	14388	17985	21582	25179	28776	32373	35970
	100	400	799	1199	1599	1998	2398	2798	3197	3597	3997	7993	9992	11990	15987	19983	23980	27977	31973	35970	39967

437. Consequently, the potential cumulative annual displacement mortality for puffin 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 to minor adverse**.

13.8.2.6.5 Razorbill

438. Norfolk Vanguard East and Norfolk Vanguard West are located beyond the mean maximum foraging range of any razorbill breeding colonies. Outside the breeding season, razorbills migrate from their breeding sites. Large numbers are found throughout the North Sea in the nonbreeding seasons (covering the period from August to March). The annual total of razorbills at risk of displacement on the Norfolk Vanguard site (combined across the breeding season and all the nonbreeding seasons) was a mean maximum of 3,296 individuals. The totals at risk on other North Sea wind farms are presented in Table 13.71.

Table 13.71. Cumulative razorbill numbers on wind farms in the North Sea (from EATL 2016). Note these include the preliminary estimates for Hornsea Project Three and Thanet Extension.

Project	Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season
Aberdeen	161	64	7	26
Beatrice	873	833	555	833
Blyth Demonstration	121	91	61	91
Dogger Bank Creyke Beck A	1250	1576	1728	4149
Dogger Bank Creyke Beck B	1538	2097	2143	5119
Dogger Bank Teesside A	834	310	959	1919
Dogger Bank Teesside B	1153	592	1426	2953
Dudgeon	256	346	745	346
East Anglia ONE	16	26	155	336
East Anglia THREE	1807	1122	1499	1524
Galloper	44	43	106	394
Greater Gabbard	0	0	387	84
Hornsea Project One	1109	4812	1518	1803
Hornsea Project Two	2511	4221	720	1668

Project	Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season
Hornsea Project Three	*577*	*398*	*3782*	*576*
Humber Gateway	27	20	13	20
Inch Cape	1436	2870	651	
Lincs and LID6	45	34	22	34
London Array I & II	14	20	14	20
Moray	2423	1103	30	168
Neart na Gaoithe	331	5492	508	
Race Bank	28	42	28	42
Seagreen A	3208	N/A	N/A	N/A
Seagreen B	886	N/A	N/A	N/A
Sheringham Shoal	106	1343	211	30
Teesside	16	61	2	20
Thanet	3	0	14	21
Thanet Extension			*61*	
Triton Knoll	40	254	855	117
Westermost Rough	91	121	152	91
Seasonal Total (Ex. NV)	**20904**	**27892.21**	**18288.59**	**22444.13**
Annual Total (Ex. NV)				**89528.93**
Norfolk Vanguard East	**599**	**491**	**279**	**752**
Norfolk Vanguard West	**280**	**375**	**348**	**172**
Seasonal Total (Inc. NV)	**21783**	**28758.21**	**18915.59**	**23368.13**
Annual Total (Inc. NV)				**92824.93**

439. Natural England does not consider a single combination of displacement and mortality in their assessment of impact, instead advising presentation of the ranges from 0 to 100% as provided in this note. However, evidence in support of the use of a precautionary displacement rate of 70% with a 1% mortality rate for razorbill has

been presented here. For the current cumulative assessment presented in Table 13.72, application of this level of impact indicates that the baseline mortality rate for the relevant populations (North Sea BDMPS) would increase by less than 1% (Table 13.72).

440. Consequently, the potential cumulative annual displacement mortality for razorbill would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

Table 13.72. Razorbill cumulative displacement matrix. Levels of mortality which would increase the baseline mortality by percentage thresholds indicated by shading: green <1%; orange >1% and <2%; pink >2% and <3%; clear >3%:

		Mortality (%)																			
		1	2	3	4	5	6	7	8	9	10	20	25	30	40	50	60	70	80	90	100
Displacement (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	19	37	56	74	93	111	130	149	167	186	371	464	557	743	928	1114	1300	1485	1671	1856
	4	37	74	111	149	186	223	260	297	334	371	743	928	1114	1485	1856	2228	2599	2970	3342	3713
	6	56	111	167	223	278	334	390	446	501	557	1114	1392	1671	2228	2785	3342	3899	4456	5013	5569
	8	74	149	223	297	371	446	520	594	668	743	1485	1856	2228	2970	3713	4456	5198	5941	6683	7426
	10	93	186	278	371	464	557	650	743	835	928	1856	2321	2785	3713	4641	5569	6498	7426	8354	9282
	12	111	223	334	446	557	668	780	891	1003	1114	2228	2785	3342	4456	5569	6683	7797	8911	10025	11139
	14	130	260	390	520	650	780	910	1040	1170	1300	2599	3249	3899	5198	6498	7797	9097	10396	11696	12995
	16	149	297	446	594	743	891	1040	1188	1337	1485	2970	3713	4456	5941	7426	8911	10396	11882	13367	14852
	18	167	334	501	668	835	1003	1170	1337	1504	1671	3342	4177	5013	6683	8354	10025	11696	13367	15038	16708
	20	186	371	557	743	928	1114	1300	1485	1671	1856	3713	4641	5569	7426	9282	11139	12995	14852	16708	18565
	25	232	464	696	928	1160	1392	1624	1856	2089	2321	4641	5802	6962	9282	11603	13924	16244	18565	20886	23206
	30	278	557	835	1114	1392	1671	1949	2228	2506	2785	5569	6962	8354	11139	13924	16708	19493	22278	25063	27847
	40	371	743	1114	1485	1856	2228	2599	2970	3342	3713	7426	9282	11139	14852	18565	22278	25991	29704	33417	37130
	50	464	928	1392	1856	2321	2785	3249	3713	4177	4641	9282	11603	13924	18565	23206	27847	32489	37130	41771	46412
	60	557	1114	1671	2228	2785	3342	3899	4456	5013	5569	11139	13924	16708	22278	27847	33417	38986	44556	50125	55695
	70	650	1300	1949	2599	3249	3899	4548	5198	5848	6498	12995	16244	19493	25991	32489	38986	45484	51982	58480	64977
	80	743	1485	2228	2970	3713	4456	5198	5941	6683	7426	14852	18565	22278	29704	37130	44556	51982	59408	66834	74260
	90	835	1671	2506	3342	4177	5013	5848	6683	7519	8354	16708	20886	25063	33417	41771	50125	58480	66834	75188	83542
	100	928	1856	2785	3713	4641	5569	6498	7426	8354	9282	18565	23206	27847	37130	46412	55695	64977	74260	83542	92825

13.8.2.6.6 Guillemot

441. Norfolk Vanguard East and Norfolk Vanguard West are located beyond the mean maximum foraging range of any guillemot breeding colonies. Outside the breeding season, guillemots disperse from their breeding sites. Large numbers are found throughout the North Sea in the nonbreeding season (defined as August to February). It was during this period that numbers peaked on the Norfolk Vanguard site with a mean maximum of 4,776 individuals (Table 13.73).

Table 13.73. Cumulative guillemot numbers on North Sea wind farms (from EATL 2016). Note these include the preliminary estimates for Hornsea Project Three and Thanet Extension.

Project	Breeding season	Non-breeding season
Aberdeen	547	225
Beatrice	13610	2755
Blyth Demonstration	1220	1321
Dogger Bank Creyke Beck A	5407	6142
Dogger Bank Creyke Beck B	9479	10621
Dogger Bank Teesside A	3283	2268
Dogger Bank Teesside B	5211	3701
Dudgeon	334	542
East Anglia ONE	274	640
East Anglia THREE	1744	2859
Galloper	305	593
Greater Gabbard	345	548
Hornsea Project One	9836	8097
Hornsea Project Two	7735	13164
Hornsea Project Three	*12140*	*13795*
Humber Gateway	99	138
Inch Cape	4371	3177
Lincs and LID6	582	814
London Array I & II	192	377

Project	Breeding season	Non-breeding season
Moray	9820	547
Neart na Gaoithe	1755	3761
Race Bank	361	708
Seagreen A	16500	N/A
Seagreen B	16054	N/A
Sheringham Shoal	390	715
Teesside	267	901
Thanet	18	124
Thanet Extension		*113*
Triton Knoll	425	746
Westermost Rough	347	486
Seasonal Total (Ex. NV)	122651	79878
Annual Total (Ex. NV)		**202529**
Norfolk Vanguard East	**2931**	**2197**
Norfolk Vanguard West	**1389**	**2579**
Seasonal Total (Inc. NV)	**126971**	**84654**
Annual Total (Inc. NV)		**211625**

Table 13.74 Guillemot cumulative displacement matrix. Levels of mortality which would increase the baseline mortality by percentage thresholds indicated by shading: green <1%; orange >1% and <2%; pink >2% and <3%; clear >3%:

		Mortality (%)																			
		1	2	3	4	5	6	7	8	9	10	20	25	30	40	50	60	70	80	90	100
Displacement (%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	42	85	127	169	212	254	296	339	381	423	847	1058	1270	1693	2116	2540	2963	3386	3809	4233
	4	85	169	254	339	423	508	593	677	762	847	1693	2116	2540	3386	4233	5079	5926	6772	7619	8465
	6	127	254	381	508	635	762	889	1016	1143	1270	2540	3174	3809	5079	6349	7619	8888	10158	11428	12698
	8	169	339	508	677	847	1016	1185	1354	1524	1693	3386	4233	5079	6772	8465	10158	11851	13544	15237	16930
	10	212	423	635	847	1058	1270	1481	1693	1905	2116	4233	5291	6349	8465	10581	12698	14814	16930	19046	21163
	12	254	508	762	1016	1270	1524	1778	2032	2286	2540	5079	6349	7619	10158	12698	15237	17777	20316	22856	25395
	14	296	593	889	1185	1481	1778	2074	2370	2666	2963	5926	7407	8888	11851	14814	17777	20739	23702	26665	29628
	16	339	677	1016	1354	1693	2032	2370	2709	3047	3386	6772	8465	10158	13544	16930	20316	23702	27088	30474	33860
	18	381	762	1143	1524	1905	2286	2666	3047	3428	3809	7619	9523	11428	15237	19046	22856	26665	30474	34283	38093
	20	423	847	1270	1693	2116	2540	2963	3386	3809	4233	8465	10581	12698	16930	21163	25395	29628	33860	38093	42325
	25	529	1058	1587	2116	2645	3174	3703	4233	4762	5291	10581	13227	15872	21163	26453	31744	37034	42325	47616	52906
	30	635	1270	1905	2540	3174	3809	4444	5079	5714	6349	12698	15872	19046	25395	31744	38093	44441	50790	57139	63488
	40	847	1693	2540	3386	4233	5079	5926	6772	7619	8465	16930	21163	25395	33860	42325	50790	59255	67720	76185	84650
	50	1058	2116	3174	4233	5291	6349	7407	8465	9523	10581	21163	26453	31744	42325	52906	63488	74069	84650	95231	105813
	60	1270	2540	3809	5079	6349	7619	8888	10158	11428	12698	25395	31744	38093	50790	63488	76185	88883	101580	114278	126975

	Mortality (%)																			
	1	2	3	4	5	6	7	8	9	10	20	25	30	40	50	60	70	80	90	100
70	1481	2963	4444	5926	7407	8888	10370	11851	13332	14814	29628	37034	44441	59255	74069	88883	103696	118510	133324	148138
80	1693	3386	5079	6772	8465	10158	11851	13544	15237	16930	33860	42325	50790	67720	84650	101580	118510	135440	152370	169300
90	1905	3809	5714	7619	9523	11428	13332	15237	17142	19046	38093	47616	57139	76185	95231	114278	133324	152370	171416	190463
100	2116	4233	6349	8465	10581	12698	14814	16930	19046	21163	42325	52906	63488	84650	105813	126975	148138	169300	190463	211625

442. Natural England does not consider a single combination of displacement and mortality in their assessment of impact, instead advising presentation of the ranges from 0 to 100% as provided in this note. However, evidence in support of the use of a precautionary displacement rate of 70% with a 1% mortality rate for guillemot has been presented here. For the current cumulative assessment presented in Table 13.72, application of this level of impact indicates that the baseline mortality rate for the relevant populations (North Sea BDMPS) would increase by less than 1% (Table 13.74**Error! Reference source not found.**).

443. Consequently, the potential cumulative annual displacement mortality for razorbill would not materially alter the background mortality of the population and would be undetectable. Therefore, the magnitude of effect is assessed as negligible. As the species is of medium sensitivity to disturbance, the impact significance is **minor adverse**.

13.8.2.7 Cumulative assessment of collision risk

13.8.2.7.1 Gannet

444. The cumulative gannet collision risk prediction is set out in the form of a ‘tiered approach’ in Table 13.75. This collates collision predictions from other wind farms which may contribute to the cumulative total. This table takes the recently submitted wind farm assessment for East Anglia THREE as its starting point and adds the Norfolk Vanguard predictions. It also includes the preliminary estimates for the Hornsea Project Three and Thanet Extension wind farms.

445. The cumulative totals of collision mortality in each season, and summed across seasons, are presented in Table 13.75. Assessments at other wind farms have been conducted using a range of avoidance rates and alternative collision model Options. In order to simplify interpretation of the data across sites and also to bring these assessments up to date with the current Natural England Advice, the values in Table 13.75 are those estimated using the Band model Option 1 (or 2, if that was the one presented) standardised at an avoidance rate of 98.9%. The worst case scenario for Norfolk Vanguard East has been included along with the revised cumulative total.

Table 13.75 Cumulative Collision Risk Assessment for gannet

Tier	Wind farm	Breeding		Autumn		Spring		Annual	
		CRM	Total	CRM	Total	CRM	Total	CRM	Total
1	Beatrice Demonstrator	0.6	0.6	0.9	0.9	0.7	0.7	2.2	2.2
1	Greater Gabbard	14.0	14.5	8.8	9.7	4.8	5.5	27.5	29.7

Tier	Wind farm	Breeding		Autumn		Spring		Annual	
		CRM	Total	CR M	Total	CRM	Total	CRM	Total
1	Gunfleet Sands	0.0	14.5	0.0	9.7	0.0	5.5	0.0	29.7
1	Kentish Flats	1.4	15.9	0.8	10.5	1.1	6.6	3.3	33.0
1	Lincs	2.1	18.0	1.3	11.8	1.7	8.3	5.0	38.0
1	London Array	2.3	20.3	1.4	13.2	1.8	10.1	5.5	43.5
1	Lynn and Inner Dowsing	0.2	20.5	0.1	13.3	0.2	10.3	0.5	44.1
1	Scroby Sands	0.0	20.5	0.0	13.3	0.0	10.3	0.0	44.1
1	Sheringham Shoal	14.1	34.6	3.5	16.8	0.0	10.3	17.6	61.7
1	Teesside	4.9	39.5	1.7	18.5	0.0	10.3	6.7	68.3
1	Thanet	1.1	40.6	0.0	18.5	0.0	10.3	1.1	69.4
1	Humber Gateway	1.9	42.5	1.1	19.7	1.5	11.8	4.5	73.9
1	Westermost Rough	0.2	42.7	0.1	19.8	0.2	12.0	0.5	74.4
2	Beatrice	37.4	80.1	48.8	68.6	9.5	21.5	95.7	170.1
2	Dudgeon	22.3	102.4	38.9	107.5	19.1	40.5	80.3	250.4
2	Galloper	18.1	120.5	30.9	138.4	12.6	53.2	61.6	312.0
2	Race Bank	33.7	154.2	11.7	150.1	4.1	57.2	49.5	361.5
2	Rampion	36.2	190.3	63.5	213.6	2.1	59.3	101. 8	463.3
2	Hornsea Project One	11.5	201.8	32.0	245.6	22.5	81.8	66.0	529.3
3	Blyth Demonstration Project	3.5	205.4	2.1	247.7	2.8	84.6	8.4	537.8
3	Dogger Bank Creyke Beck Projects A and B	5.6	210.9	6.6	254.3	4.3	89.0	16.5	554.3
3	East Anglia ONE	2.3	213.2	89.1	343.4	4.3	93.3	95.7	650.0
3	European Offshore Wind Deployment Centre	4.2	217.4	5.1	348.6	0.1	93.3	9.3	659.3

Tier	Wind farm	Breeding		Autumn		Spring		Annual	
		CRM	Total	CRM	Total	CRM	Total	CRM	Total
3	Firth of Forth Alpha and Bravo	800.8	1018.2	49.3	397.9	65.8	159.1	915.9	1575.2
3	Inch Cape	336.9	1355.1	29.2	427.1	5.2	164.3	371.3	1946.5
3	Moray Firth (EDA)	80.6	1435.7	35.4	462.5	8.9	173.2	124.9	2071.4
3	Neart na Gaoithe	143.0	1578.7	47.0	509.5	23.0	196.2	213.0	2284.4
3	Dogger Bank Teesside Projects A and B	14.8	1593.4	10.1	519.6	10.8	207.1	35.7	2320.1
3	Triton Knoll	26.8	1620.2	64.1	583.7	30.1	237.1	121.0	2441.1
3	Hornsea Project Two	7.0	1627.2	14.0	597.7	6.0	243.1	27.0	2468.1
4	East Anglia THREE	6.1	1633.3	33.3	631.0	9.6	252.8	49.0	2517.0
5	*Hornsea Project Three*	*13.9*	*1647.2*	*6.2*	*637.2*	*12.8*	*265.5*	*32.8*	*2549.9*
5	*Thanet Extension*	*0.0*	*1647.2*		*637.2*	*10.8*	*276.3*	*10.8*	*2560.6*
	Total		**1647.2**		**637.2**		**276.3**		**2560.6**
5	**NV (WCS)**	18.4	**1665.6**	62.3	**699.5**	29.9	**306.2**	110.6	**2671.2**

446. On the basis of the worst case Norfolk Vanguard collision estimates the annual cumulative total is 2,671. Note, however that many of the collision estimates for other wind farms were calculated on the basis of designs with higher total rotor swept areas than have been installed (or are planned), which is a key factor in collision risk. For example, the Beatrice wind farm, which is currently under construction, was consented on the basis of up to 125 x 7MW turbines but only 84 (of the same model) will be installed, leading to a reduction in mortality risk of 33%. A method for updating collision estimates for changes in wind farm design such as this was presented in EATL (2016). Updating the collision estimates for the Beatrice wind farm using this approach reduces the predicted annual mortality from 96 to 64. Applying the same method to the other wind farms in Table 13.75 can achieve a reduction in the cumulative annual mortality of around 400. Therefore, the values

presented in Table 13.75, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 13% due to the reduced collision risks for projects which undergo design revisions post-consent.

447. Previous gannet collision assessments for the wind farms listed in Table 13.75 have been made on the basis of Band model Option 1 and a range of avoidance rates between 95% and 99%. The current rate of 98.9% dates from November 2014 (JNCC *et al.,* 2014) and followed the review conducted by Cook *et al.* (2014). Therefore, the decisions for some of the projects consented prior to this date were on the basis of estimated cumulative collision mortality numbers which were higher than the values presented in Table 13.75. However, given the variation in rates presented in different assessments and the rates used in reaching consent decisions, it is difficult to confidently determine the avoidance rate used for each wind farm consent decision. Nonetheless, it can be stated with a good degree of certainty that none of the previous wind farms have been consented on the basis of an avoidance rate higher than 99%, and many will have been based on assessment at 98%. It therefore follows that the cumulative total including Norfolk Vanguard (2,671) is almost certainly lower than those on which some recent consent decisions have been granted.

448. Work conducted at the Greater Gabbard wind farm (APEM, 2014) has also found that gannet avoidance of wind farms during the autumn migration period may be even higher than the current estimate of 98.9%. Of 336 gannets observed during this study, only 8 were recorded within the wind farm, indicating a high degree of wind farm (macro) avoidance. Analysis of their data indicated a macro-avoidance rate in excess of 95% compared with the current guidance value of 64%. 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.

449. A review of nocturnal activity in gannets (Furness, subm.) 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 4.3% during the breeding season and 2.3% during the nonbreeding season. These rates were used in the Norfolk Vanguard collision modelling; however, they will also apply to the estimates for other wind farms calculated using the old rate of 25%.

450. It is straightforward to adjust existing mortality estimates using the new and old nocturnal activity rates and the monthly number of daytime and nighttime 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 wind farm 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.

451. 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%.

452. The study concluded that, using the density independent model, on average population growth 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 13.75. 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).

453. It is important to note that the gannet model presented in WWT (2012) was based on the whole British population, so collisions at wind farms on the west coast (e.g. Irish Sea) also need to be added 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 wind farms 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.

454. 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.

455. 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 Norfolk Vanguard project to this cumulative total is small. Gannet are considered to be of low to medium sensitivity to collision mortality and the impact significance is therefore **minor adverse**.

13.8.2.7.2 Kittiwake

456. The cumulative kittiwake collision risk prediction is set out in the form of a 'tiered approach' in Table 13.76. This collates collision predictions from other wind farms which may contribute to the cumulative total. This table takes the recently submitted wind farm assessment for East Anglia THREE as its starting point and adds the Norfolk Vanguard predictions. It also includes the preliminary estimates for the Hornsea Project Three and Thanet Extension wind farms.

457. The cumulative totals of collision mortality in each season, and summed across seasons, are presented in Table 13.76. Assessments at other wind farms have been conducted using a range of avoidance rates and alternative collision model Options. In order to simplify interpretation of the data across sites and also to bring these assessments up to date with the current Natural England Advice, the values in Table 13.76 are those estimated using the Band model Option 1 (or 2, if that was the one presented) standardised at an avoidance rate of 98.9%. The worst case scenario for Norfolk Vanguard East has been included along with the revised cumulative total.

Table 13.76 Cumulative Collision Risk Assessment for kittiwake

Tier	Wind farm	Breeding		Autumn		Spring		Annual	
		CRM	Total	CRM	Total	CRM	Total	CRM	Total
1	Beatrice Demonstrator	0.0	0.0	2.1	2.1	1.7	1.7	3.8	3.8
1	Greater Gabbard	1.1	1.1	15.0	17.1	11.4	13.1	27.5	31.3
1	Gunfleet Sands	0.0	1.1	0.0	17.1	0.0	13.1	0.0	31.3
1	Kentish Flats	0.0	1.1	0.9	18.0	0.7	13.8	1.6	32.9
1	Lincs	0.7	1.8	1.2	19.2	0.7	14.5	2.6	35.5
1	London Array	1.4	3.2	2.3	21.5	1.8	16.3	5.5	41.0
1	Lynn and Inner Dowsing	0.0	3.2	0.0	21.5	0.0	16.3	0.0	41.0
1	Scroby Sands	0.0	3.2	0.0	21.5	0.0	16.3	0.0	41.0
1	Sheringham Shoal	0.0	3.2	0.0	21.5	0.0	16.3	0.0	41.0
1	Teesside	38.4	41.6	24.0	45.5	2.5	18.8	64.9	105.9
1	Thanet	0.3	41.9	0.5	46.0	0.4	19.2	1.2	107.1
1	Humber Gateway	1.9	43.8	3.2	49.2	1.9	21.1	7.0	114.0

Tier	Wind farm	Breeding		Autumn		Spring		Annual	
		CRM	Total	CRM	Total	CRM	Total	CRM	Total
1	Westermost Rough	0.1	43.9	0.2	49.4	0.1	21.2	0.5	114.5
2	Beatrice	94.7	138.6	10.7	60.1	39.8	61.0	145.2	259.7
2	Dudgeon	0.0	138.6	0.0	60.1	0.0	61.0	0.0	259.7
2	Galloper	6.3	144.9	27.8	87.9	31.8	92.8	65.9	325.6
2	Race Bank	1.9	146.8	23.9	111.8	5.6	98.4	31.4	357.0
2	Rampion	54.4	201.2	37.4	149.2	29.7	128.1	121.5	478.5
2	Hornsea Project One	44.0	245.2	55.9	205.1	20.9	149.0	120.8	599.3
3	Blyth Demonstration Project	1.4	246.6	2.3	207.4	1.4	150.4	5.1	604.4
3	Dogger Bank Creyke Beck Projects A and B	288.0	534.6	135.0	342.4	295.0	445.4	718.0	1322.4
3	East Anglia ONE	0.9	535.5	108.4	450.8	31.5	476.9	140.8	1463.2
3	European Offshore Wind Deployment Centre	11.8	547.3	5.8	456.6	1.1	478.0	18.7	1481.9
3	Firth of Forth Alpha and Bravo	153.1	700.4	313.1	769.7	247.6	725.6	713.8	2195.7
3	Inch Cape	13.1	713.5	224.8	994.5	63.5	789.1	301.4	2497.1
3	Moray Firth (EDA)	43.6	757.1	2.0	996.5	19.3	808.4	64.9	2562.0
3	Neart na Gaoithe	32.9	790.0	56.1	1052.6	4.4	812.8	93.4	2655.4
3	Dogger Bank Teesside Projects A and B	136.9	926.9	90.7	1143.3	216.9	1029.7	444.5	3099.9
3	Triton Knoll	24.6	951.5	139.0	1282.3	45.4	1075.1	209.0	3308.9
3	Hornsea Project Two	16.0	967.5	9.0	1291.3	3.0	1078.1	28.0	3336.9
4	East Anglia THREE	6.1	973.6	69.0	1360.3	37.6	1115.7	112.7	3449.6
5	*Hornsea Project Three*	*230.1*	*1203.7*	*93.9*	*1454.2*	*17.2*	*1132.9*	*341.2*	*3790.8*
5	*Thanet Extension*	*0.3*	*1204.0*	*0.9*	*1455.1*	*4.8*	*1137.7*	*6.0*	*3796.8*

Tier	Wind farm	Breeding		Autumn		Spring		Annual	
		CRM	Total	CRM	Total	CRM	Total	CRM	Total
	Total		**1204.0**		**1455.1**		**1137.7**		**3796.8**
5	**NV (WCS)**	20.8	**1224.9**	61.3	**1516.4**	76.3	**1214.0**	158.4	**3955.3**

458. On the basis of the worst case Norfolk Vanguard collision estimates the annual cumulative total is 3,955. Note, however that many of the collision estimates for other wind farms were calculated on the basis of designs with higher total rotor swept areas than have been installed (or are planned), which is a key factor in collision risk. For example, the Beatrice wind farm, which is currently under construction, was consented on the basis of up to 125 x 7MW turbines but only 84 (of the same model) will be installed, leading to a reduction in mortality risk of 33%. A method for updating collision estimates for changes in wind farm design was presented in EATL (2016). Updating the collision estimates for the Beatrice wind farm using this approach reduces the predicted annual mortality from 145 to 97. Applying the same method to the other wind farms in Table 13.76 can achieve a reduction in the cumulative annual mortality of around 550. Therefore, the values presented in Table 13.76, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 14% due to the reduced collision risks for projects which undergo design revisions post consent.

459. A review of nocturnal activity in kittiwakes (Furness, in prep.) has found that the value previously used for this parameter (50%) to estimate flight activity at night is a considerable overestimate and has identified evidence-based rates of 20% during the breeding season and 17% during the nonbreeding season. These rates were used in the Norfolk Vanguard collision modelling; however, they will also apply to the estimates for other wind farms calculated using the old rate of 50%.

460. It is straightforward to adjust mortality estimates using the new and old nocturnal activity rates and the monthly number of daytime and nighttime 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 wind farm 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.

461. For the assessment of the adjacent East Anglia THREE wind farm a kittiwake population model was developed to assess the potential effects of cumulative mortality 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, while the more precautionary density independent model predicted equivalent declines of 10.3% to 10.9%. To place these predicted magnitudes of change in context, over three approximate 15 year periods (between censuses) the British kittiwake population changed by +24% (1969 to 1985), -25% (1985 to 1998) and -61% (2000 to 2013) (http://jncc.defra.gov.uk/page-3201 accessed 26th August 2015). Changes of between 3% and 10% across a longer (25 year) period against a background of natural changes an order of magnitude larger will almost certainly be undetectable.

462. Natural England advised that the results from density independent models should be used '*where there is no information on population regulation for the focal population*' (NE (2017).

463. Evidence for density dependent regulation of the North Sea kittiwake population was summarised in EATL (2016b). While Natural England accepted there was strong evidence for the presence of density dependence operating in the population they maintained that because its mode of operation was less clear the results of the density independent PVA models should be used in preference to the density dependent ones (acknowledging that the results were the worst case). However, 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. Kittiwake is considered to be of low to medium sensitivity, low to medium conservation value and the magnitude of effect described above is considered to be low. Consequently, the worst case cumulative collision mortality is considered to be of low magnitude, resulting in impacts of **minor adverse** significance. However, when the various sources of precaution are taken in to account (precautionary avoidance rate estimates, reduction in wind farm sizes, over-estimated nocturnal activity) the cumulative collision risk impact magnitude is almost certainly smaller still.

13.8.2.7.3 *Lesser black-backed gull*

464. The cumulative lesser black-backed gull collision risk prediction is set out in the form of a 'tiered approach' in Table 13.77. This collates collision predictions from other wind farms which may contribute to the cumulative total. This table takes the recently submitted wind farm assessment for East Anglia THREE as its starting point and adds the Norfolk Vanguard predictions. It also includes the preliminary estimates for the Hornsea Project Three and Thanet Extension wind farms.

465. The collision values presented in Table 13.77 include totals for breeding, nonbreeding and annual periods. However, not all projects provide a seasonal breakdown of collision impacts, therefore it is not possible to extract data from these periods for cumulative assessment. Natural England has previously noted that an 80:20 split between the nonbreeding and breeding seasons is appropriate for lesser black-backed gull in terms of collision estimates (Natural England, 2013). Therefore, for those sites where a seasonal split was not presented the annual numbers in Table 13.77 have been multiplied by 0.8 to estimate the nonbreeding component and 0.2 to estimate the breeding component.

466. Assessments for other wind farms have been conducted using a range of avoidance rates and alternative collision model Options. In order to simplify interpretation of the data across sites and also to bring these assessments up to date with the current Natural England advice, the values in Table 13.77 are those estimated using the Band model Option 1 (or 2, if that was the one presented) at an avoidance rate of 99.5%. (Note that estimates for the Dogger Bank projects have only been presented using Band model Option 3. Therefore, these values in Table 13.77 have been converted to the Natural England advised rate for this model of 98.9%). Each project scenario for Norfolk Vanguard has been included along with its cumulative total.

Table 13.77 Cumulative Collision Risk Assessment for lesser black-backed gull

Tier	Wind farm	Breeding		Non-breeding		Annual	
		CRM	Total	CRM	Total	CRM	Total
1	Beatrice Demonstrator	0.0	0.0	0.0	0.0	0.0	0.0
1	Greater Gabbard	12.4	12.4	49.6	49.6	62.0	62.0
1	Gunfleet Sands	1.0	13.4	0.0	49.6	1.0	63.0
1	Kentish Flats	0.3	13.7	1.3	50.9	1.6	64.6
1	Lincs	1.7	15.4	6.8	57.7	8.5	73.1
1	London Array	0.0	15.4	0.0	57.7	0.0	73.1

Tier	Wind farm	Breeding		Non-breeding		Annual	
		CRM	Total	CRM	Total	CRM	Total
1	Lynn and Inner Dowsing	0.0	15.4	0.0	57.7	0.0	73.1
1	Scroby Sands	0.0	15.4	0.0	57.7	0.0	73.1
1	Sheringham Shoal	1.7	17.1	6.6	64.3	8.3	81.3
1	Teesside	0.0	17.1	0.0	64.3	0.0	81.3
1	Thanet	3.2	20.3	12.8	77.1	16.0	97.3
1	Humber Gateway	0.3	20.5	1.1	78.2	1.3	98.7
1	Westermost Rough	0.1	20.6	0.3	78.4	0.3	99.0
2	Beatrice	0.0	20.6	0.0	78.4	0.0	99.0
2	Dudgeon	7.7	107.7	30.6	264.9	38.3	372.6
2	Galloper	27.8	113.8	111.0	296.3	138.8	410.1
2	Race Bank	43.2	99.2	10.8	230.8	54.0	330.0
2	Rampion	1.6	114.1	6.3	297.5	7.9	411.6
2	Hornsea Project One	4.4	113.8	17.4	296.3	21.8	410.1
3	Blyth Demonstration Project	0.0	105.1	0.0	254.5	0.0	359.6
3	Dogger Bank Creyke Beck Projects A and B	2.6	107.7	10.4	264.9	13.0	372.6
3	East Anglia ONE	4.0	111.7	23.0	287.9	27.0	399.6
3	European Offshore Wind Deployment Centre	0.0	111.7	0.0	287.9	0.0	399.6
3	Firth of Forth Alpha and Bravo	2.1	113.8	8.4	296.3	10.5	410.1
3	Inch Cape	0.0	113.8	0.0	296.3	0.0	410.1
3	Moray Firth (EDA)	0.0	113.8	0.0	296.3	0.0	410.1
3	Neart na Gaoithe	0.3	114.1	1.2	297.5	1.5	411.6
3	Dogger Bank Teesside Projects A and B	2.4	116.5	9.6	307.1	12.0	423.6
3	Triton Knoll	7.4	123.9	29.6	336.7	37.0	460.6

Tier	Wind farm	Breeding		Non-breeding		Annual	
		CRM	Total	CRM	Total	CRM	Total
3	Hornsea Project Two	2.0	125.9	2.0	338.7	4.0	464.6
4	East Anglia THREE	1.8	127.7	8.2	346.9	10.0	474.6
5	*Hornsea Project Three*	*21.6*	*149.3*	*0.9*	*347.8*	*22.5*	*497.1*
5	*Thanet Extension*	*1.9*	*151.2*	*3.6*	*351.4*	*5.5*	*502.6*
	Total		151.2		351.4	0.0	502.6
5	**NV (WCS)**	23.3	174.5	4.07	355.4	27.37	530.0

467. On the basis of the worst case Norfolk Vanguard collision estimates the annual cumulative total is 530. Note, however that many of the collision estimates for other wind farms were calculated on the basis of designs with higher total rotor swept areas than have been installed (or are planned), which is a key factor in collision risk. For example, the Galloper wind farm, which is currently under construction, was consented on the basis of 140 turbines but only 56 have been installed. A method for updating collision estimates for changes in wind farm design was presented in EATL (2016). Updating the collision estimates for the Galloper wind farm using this approach reduces the predicted annual mortality from 139 to 60. Applying the same method to the other wind farms in Table 13.77 can achieve a reduction in the cumulative annual mortality of around 200. Therefore, the values presented in Table 13.77, as well as being based on precautionary calculation methods, can be seen to overestimate the total risk by around 35% due to the reduced collision risks for projects which undergo design revisions post consent.

468. Lesser black-backed gull collision assessments undertaken prior to 2014 were made on the basis of Band model Option 1 and an avoidance rate of 98%, with the change to 99.5% dating from November 2014 (JNCC *et al.,* 2014). Therefore, projects consented prior to this date were on the basis of a cumulative collision mortality 4 times that presented in Table 13.77. Accounting for projects up to Triton Knoll consented after November 2014 (Hornsea Project 1, 22 annual collisions at 99.5%; Dogger Bank Creyke Beck A&B, 13 annual collisions at 98.9% Option 3; Dogger Bank Teesside A&B, 12 annual collisions at 98.9% Option 3) the previous cumulative collision total (at 98%) excluding these three projects would have been 1,656 (461 – (22+13+12) x 4). The current worst case cumulative total of 530, including all consented and still to be consented projects, is therefore much lower than this previously accepted cumulative total. Indeed, even if all of the previous consents had been granted on the basis of an avoidance rate of 99% this would still be around

828, 1.5 times the current cumulative prediction. The same approach can be applied to the seasonal estimates, which are all lower than the cumulative totals for the projects granted consent in 2014.

469. A review of nocturnal activity in seabirds (EATL, 2015) has indicated that the value currently used for this parameter (50%) to estimate collision risk at night for lesser black-backed gull is almost certainly an overestimate, possibly by as much as a factor of two (i.e. study data suggest that 25% is more appropriate). Reducing the nocturnal activity factor to 25% reduced collision estimates by around 15%. Natural England have recognised this aspect of precaution and advised recent projects to undertake collision modelling with nocturnal activity set to both 25% and 50%. This was included in the Norfolk Vanguard collision modelling (by setting the nocturnal factor in simulated model runs to be randomly selected as one of these two values). However, this adjustment to nocturnal activity is also applicable to the other cumulative collision estimates. A correction applied to the other wind farms similar to that used for Norfolk Vanguard along these lines would reduce the overall collision estimate for all wind farms 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.

470. In conclusion, the current cumulative total is considerably lower than previously consented cumulative totals (between 1.5 and 3 times lower), and yet this total still includes several sources of precaution (e.g. consented vs. built impacts and overestimated nocturnal activity). Therefore, the cumulative impact on the lesser black-backed gull population due to collisions both year round and within individual seasons is considered to be of low magnitude and lesser black-backed gull are considered to be of low sensitivity, therefore the impact significance is **minor adverse**.

13.8.2.7.4 Great black-backed gull

471. The cumulative great black-backed gull collision risk prediction is set out in the form of a 'tiered approach' in Table 13.78. This collates collision predictions from other wind farms which may contribute to the cumulative total. This table takes the recently submitted wind farm assessment for East Anglia THREE as its starting point and adds the Norfolk Vanguard predictions. It also includes the preliminary estimates for the Hornsea Project Three and Thanet Extension wind farms.

472. The collision values presented in Table 13.78 include breeding, nonbreeding and annual collision totals. However, not all projects provide a seasonal breakdown of collision impacts, therefore it is not possible to extract data from these periods for cumulative assessment. Natural England has previously noted that an 80:20 split

between the nonbreeding and breeding seasons is appropriate for lesser black-backed gull in terms of collision estimates (Natural England, 2013). This ratio is considered to also be appropriate for great black-backed gull, therefore for those sites where a seasonal split was not presented the annual numbers in Table 13.78 have been multiplied by 0.8 to estimate the nonbreeding component and 0.2 to estimate the breeding component.

473. Assessments for other wind farms have been conducted using a range of avoidance rates and alternative collision model Options. In order to simplify interpretation of the data across sites and also to bring these assessments up to date with the current Natural England advice, the values in Table 13.78 are those estimated using the Band model Option 1 (or 2, if that was the one presented) at an avoidance rate of 99.5%. (Note that estimates for the Dogger Bank projects have only been presented using Band model Option 3. Therefore, these values in Table 13.78 have been converted to the Natural England advised rate for this model of 98.9%). Each project scenario for Norfolk Vanguard has been included along with its cumulative total.

Table 13.78 Cumulative Collision Risk Assessment for great black-backed gull

Tier	Wind farm	Breeding		Non-breeding		Annual	
		CRM	Total	CRM	Total	CRM	Total
1	Beatrice Demonstrator	0.0	0.0	0.0	0.0	0.0	0.0
1	Greater Gabbard	15.0	15.0	60.0	60.0	75.0	75.0
1	Gunfleet Sands	0.0	15.0	0.0	60.0	0.0	75.0
1	Kentish Flats	0.1	15.1	0.2	60.2	0.3	75.3
1	Lincs	0.0	15.1	0.0	60.2	0.0	75.3
1	London Array	0.0	15.1	0.0	60.2	0.0	75.3
1	Lynn and Inner Dowsing	0.0	15.1	0.0	60.2	0.0	75.3
1	Scroby Sands	0.0	15.1	0.0	60.2	0.0	75.3
1	Sheringham Shoal	0.0	15.1	0.0	60.2	0.0	75.3
1	Teesside	8.7	23.8	34.8	95.1	43.6	118.8
1	Thanet	0.1	23.9	0.4	95.5	0.5	119.3
1	Humber Gateway	1.3	25.1	5.1	100.5	6.3	125.7
1	Westermost Rough	0.0	25.1	0.0	100.6	0.1	125.7

Tier	Wind farm	Breeding		Non-breeding		Annual	
		CRM	Total	CRM	Total	CRM	Total
2	Beatrice	30.2	55.3	120.8	221.4	151.0	276.7
2	Dudgeon	0.0	89.3	0.0	357.2	0.0	446.5
2	Galloper	4.5	103.2	18.0	445.0	22.5	548.2
2	Race Bank	0.0	59.8	0.0	239.4	0.0	299.2
2	Rampion	5.2	113.6	20.8	510.8	26.0	624.5
2	Hornsea Project One	17.2	103.2	68.6	445.0	85.8	548.2
3	Blyth Demonstration Project	1.3	83.5	5.1	333.8	6.3	417.3
3	Dogger Bank Creyke Beck Projects A and B	5.8	89.3	23.3	357.2	29.1	446.5
3	East Anglia ONE	0.0	89.3	32.0	389.2	32.0	478.5
3	European Offshore Wind Deployment Centre	0.6	89.9	2.4	391.6	3.0	481.5
3	Firth of Forth Alpha and Bravo	13.4	103.2	53.4	445.0	66.8	548.2
3	Inch Cape	0.0	103.2	36.8	481.7	36.8	585.0
3	Moray Firth (EDA)	9.5	112.7	25.5	507.2	35.0	620.0
3	Neart na Gaoithe	0.9	113.6	3.6	510.8	4.5	624.5
3	Dogger Bank Teesside Projects A and B	6.4	120.0	25.5	536.3	31.9	656.4
3	Triton Knoll	24.4	144.4	97.6	633.9	122.0	778.4
3	Hornsea Project Two	3.0	147.4	20.0	653.9	23.0	801.4
4	East Anglia THREE	4.6	152.1	34.4	688.3	39.0	840.4
5	*Hornsea Project Three*	*9.3*	*161.4*	*49.6*	*737.9*	*58.9*	*899.3*
5	*Thanet Extension*	*1.3*	*162.7*	*17.7*	*755.6*	*19.0*	*918.3*
	Total		**162.7**		**755.6**		**918.3**
5	**NV (WCS)**	0	**162.7**	22.2	**777.8**	22.2	**940.5**

474. On the basis of the worst case Norfolk Vanguard collision estimates the annual cumulative total is 940. Note, however that many of the collision estimates for other wind farms were calculated on the basis of designs with higher total rotor swept areas than have been installed (or are planned), which is a key factor in collision risk. For example, the Beatrice wind farm, which is currently under construction, was consented on the basis of 125 turbines but only 84 are being installed. A method for updating collision estimates for changes in wind farm design was presented in EATL (2016). Updating the collision estimates for the Beatrice wind farm using this approach reduces the predicted annual mortality from 151 to 101. Applying the same method to the other wind farms in Table 13.76 can achieve a reduction in the cumulative annual mortality of around 260. Therefore, the values presented in Table 13.78, as well as being based on precautionary calculations, can be seen to overestimate the total risk by around 30% due to the reduced collision risks for projects which undergo design revisions post consent.

475. Great black-backed gull collision assessments undertaken prior to 2014 were made on the basis of Band model Option 1 and an avoidance rate of 98%, with the change to 99.5% dating from November 2014 (JNCC *et al.,* 2014). Therefore, projects consented prior to this date were on the basis of a cumulative collision mortality 4 times that presented in Table 13.78. Accounting for projects up to Triton Knoll consented after November 2014 (Hornsea Project 1, 86 annual collisions at 99.5%; Dogger Bank Creyke Beck A&B, 29 annual collisions at 98.9% Option 3; Dogger Bank Teesside A&B, 32 annual collisions at 98.9% Option 3) the previous cumulative collision total (at 98%) excluding these three projects would have been 2,524 (778 - (86 + 29 + 32) x 4. The current worst case cumulative total of 940, including all consented and still to be consented projects, is therefore much lower than the previously accepted cumulative total. Indeed, even if all of the previous consents had been granted on the basis of an avoidance rate of 99% this would still be around 1.3 times the current cumulative prediction. The same approach can be applied to the seasonal estimates, which are all lower than the cumulative totals for the projects granted consent in 2014.

476. A review of nocturnal activity in seabirds (EATL, 2015) has indicated that the value currently used for this parameter (50%) to estimate collision risk at night for great black-backed gull is almost certainly an overestimate, possibly by as much as a factor of two (i.e. study data suggest that 25% is more appropriate). Reducing the nocturnal activity factor to 25% reduced collision estimates by around 15%. Natural England have recognised this aspect of precaution and advised recent projects to undertake collision modelling with nocturnal activity set to both 25% and 50%. This was included in the Norfolk Vanguard collision modelling (by setting the nocturnal factor in simulated model runs to be randomly selected as one of these two values).

However, this adjustment to nocturnal activity is also applicable to the other cumulative collision estimates. A correction applied to the other wind farms similar to that used for Norfolk Vanguard along these lines would reduce the overall collision estimate for all wind farms 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.

477. In the decision for the Rampion wind farm (Planning Inspectorate, 2014a; DECC, 2014), the cumulative collision mortality for great black-backed gull was considered. In their recommendations to the Secretary of State (Planning Inspectorate, 2014), the Examining Authority reported the cumulative mortality for this species as either 1,803 individuals per year (Applicant's estimate) or 3,025 (Natural England's estimate). The difference in these two values remained unresolved between the applicant and Natural England, however the Examining Authority (Planning Inspectorate, 2014) concluded:

'that the addition of Rampion OWF does not tip the balance in terms of exceeding a threshold that would not otherwise be exceeded.'

(note that the threshold referred to in the above quote was the PBR value for this species, although PBR is no longer considered an appropriate tool for assessing wind farm impacts).

478. The current cumulative mortality of 940 (Table 13.78) is much lower than either of the cumulative totals reported for Rampion (1,803 and 3,025). The increase in the avoidance rate for this species has resulted in a large reduction in predicted cumulative totals to the extent that the current estimate is much lower than those on which it has been concluded there will be no effect on the population in the long term (DECC, 2014).

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

480. Using the density dependent model, application of an additional annual mortality of 900 to the great black-backed gull BDMPS resulted in impacted populations after 25

years which were 6.1% to 7.7% smaller than in the absence of impact. The equivalent density independent predictions generated population reductions of 21.3% to 21.5%. On the basis of the results from the modelling Natural England concluded that whilst a significant cumulative effect could not be ruled out, the project's (East Anglia THREE) individual contribution was so small that it would not materially affect the overall cumulative impact magnitude. The final East Anglia THREE annual collision impact for great black-backed gull was 39, which is almost twice that for Norfolk Vanguard (22).

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

13.9 Transboundary Impacts

482. Consultation with other EU Member States (MS) surrounding the North Sea basin resulted in one response that raised a potential concern over transboundary impacts on ornithology receptors. This was the response from Rijkswaterstaat (RWS) in the Netherlands, which noted that non-UK wind farms in the southern North Sea had not been included in the cumulative assessment. This response also noted that this would require an international cumulative approach, which has not been developed to date. Furthermore, owing to the different approaches to impact assessment adopted by each MS it is not currently clear how this could be undertaken quantitatively.

483. With regards to the potential for transboundary cumulative impacts, there is clearly potential for collisions and displacement at wind farms outside UK territorial waters. However, the operational offshore wind farms in Belgium, the Netherlands and Germany are comparatively small (in combination these projects are of a similar size to no more than one to two of the more recent UK wind farms, such as East Anglia ONE). Since the spatial scale and hence seabird populations sizes for a transboundary assessment would be much larger, it is apparent that the scale of wind farm development would be relatively much smaller. Therefore, the inclusion of non-UK wind farms is considered very unlikely to alter the conclusions of the existing cumulative assessment.

13.10 Inter-relationships

484. The construction, operation and decommissioning phases of the proposed Norfolk Vanguard wind farm would cause a range of effects on offshore ornithological interests. The magnitude of these effects has been assessed individually above in section 13.7 using expert judgement, drawing from a wide science base that includes

project-specific surveys and previously acquired knowledge of the bird ecology of the North Sea.

485. These effects have the potential to form an inter-relationship and directly impact the terrestrial and seabird receptors and have the potential to manifest as sources for impacts upon receptors other than those considered within the context of offshore ornithology.

486. As none of the offshore impacts to birds were assessed individually to have any greater than a minor adverse impact it is considered unlikely that they would inter-relate to form an overall significant impact on Offshore Ornithology.

487. In terms of how impacts to offshore ornithological interests may form inter-relationships with other receptor groups, assessments of significance are provided in the chapters listed in the second column of Table 13.79. In addition, the table shows where other chapters have been used to inform the offshore ornithology inter-relationships assessment.

Table 13.79 Chapter topic inter-relationships

Topic and description	Related Chapter	Where addressed in this Chapter	Rationale
Indirect impacts through effects on habitats and prey during construction	10 – Benthic Ecology 11 – Fish and Shellfish Ecology	Section 13.7.4.2	Potential impacts on benthic ecology and fish and shellfish during construction could affect the prey resource for ornithology
Indirect impacts through effects on habitats and prey during operation	10 – Benthic Ecology 11 – Fish and Shellfish Ecology	Section 13.7.5.2	Potential impacts on benthic ecology and fish and shellfish during operation could affect the prey resource for ornithology
Indirect impacts through effects on habitats and prey during decommissioning	10 – Benthic Ecology 11 – Fish and Shellfish Ecology	Section 13.7.6.2	Potential impacts on benthic ecology and fish and shellfish during decommissioning could affect the prey resource for ornithology

13.11 Interactions

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

conservative and robust. For clarity the areas of interaction between impacts are presented in Table 13.81.

Table 13.80 Chapter topic inter-relationships

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 seabed	
1 Disturbance and displacement from increased vessel activity	-		Yes, but small (possible longer 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 seabed	Yes, but small (possible longer term effects on birds, but spatial magnitude very small)		-	
Operation				
	1 Disturbance and displacement from offshore infrastructure	2 Indirect impacts through effects on habitats and prey species	3 Collision risk	4 Barrier effects
1 Disturbance and displacement from offshore infrastructure	-	No (direct displacement of birds overrides prey effects)	No (mutually exclusive)	No (similar response)
2 Indirect impacts through effects on habitats and prey species	No (direct displacement of birds overrides prey effects)	-	No	No
3 Collision risk	No (mutually exclusive)	No	-	No (mutually exclusive)
4 Barrier effects	No (similar response)	No	No (mutually exclusive)	-
Decommissioning				
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.				

13.12 Summary

489. This chapter 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 13.1) and assesses the potential impacts on birds.

490. Detailed consultation and iteration of the overall approach to the impact assessment on ornithology receptors has informed this assessment through the EPP for the proposed Norfolk Vanguard project. An Ornithology Expert Technical Group was convened which involved Natural England and the Royal Society for the Protection of Birds (RSPB) for the offshore ornithology discussions. A Schedule of Agreement and Non-agreement has been produced as part of the minutes to the Ornithology Expert Technical Group of the Evidence Plan which is included in an appendix to this submission.

491. A standard survey area, covering Norfolk Vanguard East and West and 4km buffers placed around them, was surveyed using high resolution aerial survey methods over periods of 24 months (NV West) and 32 months (NV East). The results of these surveys have been used to estimate the abundance and assemblage of birds using or passing across the area.

492. Birds were screened in for assessment taking into account their abundance on the wind farm site and their potential sensitivity to wind farm projects.

493. The impacts that could potentially arise during the construction, operation and decommissioning of the proposed Norfolk Vanguard 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:

494. In the Construction Phase

- Impact 1: Disturbance / displacement; and
- Impact 2: Indirect impacts through effects on habitats and prey species.

495. In the Operational Phase

- Impact 3: Disturbance / displacement;
- Impact 4: Indirect impacts through effects on habitats and prey species;
- Impact 5: Collision risk; and
- Impact 6: Barrier effect.

496. In the Decommissioning Phase

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

497. 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. Similarly, no species is subject to an impact of greater than minor adverse significance from the potential effects of the proposed project during operational lifetime.

498. Displacement effects on red-throated divers, gannets, puffins, razorbills and guillemots would not create impacts of more than minor adverse significance during any biological season.

499. The risk to birds from collisions with wind turbines from the proposed Norfolk Vanguard project alone is assessed as no greater than minor adverse significance for all species when considered for all biological seasons against the most appropriate population scale.

500. Potential plans and projects have been considered for how they might act cumulatively with the proposed project and a screening process carried out.

501. The cumulative assessment identified that most impacts would be temporary, small scale and localised. Given the distances to other activities in the region (e.g. other offshore wind farms and aggregate extraction) and the highly localised nature of the impacts above it concluded that there is no pathway for interaction between most impacts cumulatively, which were screened out.

502. In the offshore environment only other wind farms that were operational, under construction, consented but not constructed, subject to current applications or subject to consultation were screened in. This list of wind farms with their status is provided in Table 13.66.

503. The cumulative collision risk impact and displacement impact assessment follows the tiered approach in its presentation of mortality predictions for the identified projects. The risk to birds from cumulative collisions with wind turbines across all wind farms considered is assessed as no greater than minor adverse significance for all species.

504. The identified potential impacts are summarised in Table 13.81.

Table 13.81 Potential impacts identified for offshore ornithology

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Construction						
Disturbance and displacement from	Common scoter	High	Negligible	Minor adverse	N/A	**Minor adverse**

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
increased vessel traffic during export cable installation	Red-throated diver	High	Negligible	Minor adverse	N/A	**Minor adverse**
Disturbance and displacement due to construction activity on wind farm site	Red-throated diver	High	Negligible	Minor adverse	N/A	**Minor adverse**
	Puffin	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
	Razorbill	Medium	Negligible	Minor adverse	N/A	**Minor adverse**
	Guillemot	Medium	Negligible	Minor adverse	N/A	**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**
Operation						
Disturbance and displacement	Red-throated diver	High	Negligible	Minor	NA	**Minor adverse**
	Gannet	Low to medium	Negligible	Negligible to minor	NA	**Negligible to minor**
	Puffin	Low to medium	Negligible to minor	Minor	NA	**Negligible to minor adverse**
	Razorbill	Medium	Negligible	Minor	NA	**Minor adverse**
	Guillemot	Medium	Negligible	Minor	NA	**Minor adverse**
Indirect effects due to impacts on habitats and prey species displacement	All species	Low to high	Negligible	Negligible to minor	NA	**Negligible to minor**
Collision Risk - seabirds	Gannet	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
	Kittiwake	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
	Lesser black-backed gull	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
	Great black-backed gull	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
Collision risk – migrant seabirds	Arctic skua	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
	Great skua	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
	Arctic tern	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
	Common tern	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
Collision risk – non-seabird migrants	All species	Low to high	Negligible	Negligible	N/A	**Negligible**
Barrier effects	All species	Low to high	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 impacts through effects on habitats and prey	All species	Low to high	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
Cumulative						
Operational disturbance and displacement	Red-throated diver	High	Negligible	Minor adverse	N/A	**Minor adverse**
	Gannet	Low	Negligible	Negligible	N/A	**Negligible**
	Puffin	Low to medium	Negligible	Negligible to minor adverse	N/A	**Negligible to minor adverse**
	Razorbill	Medium	Negligible	Minor adverse	N/A	**Minor adverse**
	Guillemot	Medium	Negligible	Minor adverse	N/A	**Minor adverse**

Potential Impact	Receptor	Value/ Sensitivity	Magnitude	Significance	Mitigation	Residual Impact
Collision Risk - seabirds	Gannet	Low to medium	Low	Minor adverse	N/A	**Minor adverse**
	Kittiwake	Low to medium	Low	Minor adverse	N/A	**Minor adverse**
	Lesser black-backed gull	Low to medium	Low	Minor adverse	N/A	**Minor adverse**
	Great black-backed gull	Low to medium	Low	Minor adverse	N/A	**Minor adverse**

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