Sheringham Shoal and Dudgeon Offshore Wind Farm Extension Projects

Environmental Statement

Volume 1

Chapter 11 - Offshore Ornithology

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Glossary of Acronyms

BACI	Before After Control Impact
BAG	Before After Gradient
BDMPS	Biologically Defined Minimum Population Size
BEIS	Department for Business, Energy & Industrial Strategy
BoCC	Birds of Conservation Concern
BTO	British Trust for Ornithology
CGR	Counterfactual of Growth Rate
CEH	Centre for Ecology and Hydrology
CIA	Cumulative Impact Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
CPS	Counterfactual of Population Size
CRM	Collision Risk Modelling
DAS	Discretionary Advice Service
DCO	Development Consent Order
DECC	Department for Energy and Climate Change
DEP	Dudgeon Offshore Wind Farm Extension Project
DEP-N	DEP North Array Area
DEP-S	DEP South Array Area
DOW	Dudgeon Offshore Wind Farm
DSM	Density Surface Model
EEA	European Economic Area
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
EOWDC	European Offshore Wind Deployment Centre
EPP	Evidence Plan Process
ES	Environmental Statement
ESAS	European Seabirds at Sea
ETG	Expert Topic Group
GIS	Geographic Information System
GPS	Global Positioning System
HAT	Highest Astronomical Tide

HRA	Habitats Regulations Assessment
IPMP	In-Principle Monitoring Plan
JNCC	Joint Nature Conservation Committee
LID	Lynn and Inner Dowsing Offshore Wind Farms
MA	Macroavoidance
MERP	Marine Ecosystems Research Programme
MMO	Marine Management Organisation
NNC	North Norfolk Council
NPS	National Policy Statement
OMP	Operational Monitoring Programme
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PCH	Potential Collision Height
PEIR	Preliminary Environmental Information Report
PEMP	Project Environmental Management Plan
pSPA	proposed Special Protection Area
PVA	Population Viability Analysis
RIAA	Report to Inform Appropriate Assessment
RSPB	Royal Society for the Protection of Birds
SEAMAST	Seabird Mapping and Sensitivity Tool
SD(s)	Standard Deviation(s)
SEANSE	Strategic Environmental Assessment North Seas Energy
SEP	Sheringham Shoal Offshore Wind Farm Extension Project
SNCB	Statutory Nature Conservation Bodies
SOSS	Strategic Ornithological Support Services
SOSSMAT	Strategic Ornithological Support Services Migration Assessment Tool
SOW	Sheringham Shoal Offshore Wind Farm
SPA	Special Protection Area
UK	United Kingdom
WWT	Wildfowl and Wetlands Trust
ZoI	Zone of Influence

Glossary of Terms

The Applicant	Equinor New Energy Limited
DEP offshore site	The Dudgeon Offshore Wind Farm Extension consisting of the DEP wind farm site, interlink cable corridors and offshore export cable corridor (up to mean high water springs).
Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension onshore and offshore sites including all onshore and offshore infrastructure.
The Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.
DEP North array area	The wind farm site area of the DEP offshore site located to the north of the existing Dudgeon Offshore Wind Farm
DEP South array area	The wind farm site area of the DEP offshore site located to the south of the existing Dudgeon Offshore Wind Farm
DEP wind farm site	The offshore area of DEP within which wind turbines, infield cables and offshore substation platform/s will be located and the adjacent Offshore Temporary Works Area. This is also the collective term for the DEP North and South array areas.
Grid option	Mechanism by which SEP and DEP will connect to the existing electricity network. This may either be an integrated grid option providing transmission infrastructure which serves both of the wind farms, or a separated grid option, which allows SEP and DEP to transmit electricity entirely separately.
Infield cables	Cables which link the wind turbine generators to the offshore substation platform(s).
Interlink cable corridor	This is the area which will contain the interlink cables between offshore substation platform/s and the adjacent Offshore Temporary Works Area.
Interlink cables	Cables linking two separate project areas. This can be cables linking: 1) DEP South array area and DEP North array area 2) DEP South array area and SEP 3) DEP North array area and SEP

	1 is relevant if DEP is constructed in isolation or first in a phased development. 2 and 3 are relevant where both SEP and DEP are built.
Landfall	The point on the coastline at which the offshore export cables are brought onshore and connected to the onshore export cables.
Offshore cable corridors	This is the area which will contain the offshore export cables or interlink cables, including the adjacent Offshore Temporary Works Area.
Offshore export cable corridor	This is the area which will contain the offshore export cables between offshore substation platform/s and landfall, including the adjacent Offshore Temporary Works Area.
Offshore export cables	The cables which would bring electricity from the offshore substation platform(s) to the landfall. 220 – 230kV
Offshore substation platform	A fixed structure located within the wind farm area, containing electrical equipment to aggregate the power generated by the wind turbines and increase the voltage before transmitting the power to shore
Offshore Temporary Works Area	An Offshore Temporary Works Area within the DCO boundary in which vessels are permitted to carry out activities during construction, operation and decommissioning encompassing a 200m buffer around the wind farm sites and a 750m buffer around the offshore cable corridors. No permanent infrastructure would be installed within the Offshore Temporary Works Area.
PEIR boundary	The area subject to survey and preliminary impact assessment to inform the PEIR, including all permanent and temporary works for SEP and DEP. The PEIR boundary will be refined down to the final DCO boundary ahead of the application for development consent.
Sheringham Shoal Offshore Wind Farm Extension site	Sheringham Shoal Offshore Wind Farm Extension lease area.
The Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Shoal Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.
Study area	Area where potential impacts from the project could occur, as defined for each individual EIA topic.

Sheringham Shoal Offshore Wind Farm Extension Project (SEP) offshore site	Sheringham Shoal Offshore Wind Farm Extension consisting of the SEP wind farm site and offshore export cable corridor (up to mean high water springs).
SEP wind farm site	The offshore area of SEP within which wind turbines, infield cables and offshore substation platform/s will be located and the adjacent Offshore Temporary Works Area.

11 OFFSHORE ORNITHOLOGY

11.1 Introduction

1. This chapter of the Environmental Statement (ES) describes the potential impacts of the proposed Sheringham Shoal Offshore Wind Farm Extension Project (SEP) and Dudgeon Offshore Wind Farm Extension Project (DEP) on offshore ornithology. The chapter provides an overview of the existing environment for the proposed SEP and DEP offshore sites, followed by an assessment of the potential impacts and associated mitigation for the construction, operation, and decommissioning phases of SEP and DEP.

2. This assessment has been undertaken with specific reference to the relevant legislation and guidance, of which the primary sources are the National Policy Statements (NPS). Details of these and the methodology used for the Environmental Impact Assessment (EIA) and Cumulative Impact Assessment (CIA) are presented in **Chapter 5 EIA Methodology** and **Section 11.4**.

3. An assessment of the ornithological receptors present at the export cable landfall and onshore development area is included in **Chapter 20 Onshore Ecology and Ornithology**.

4. The assessment should be read in conjunction with the linked chapters: **Chapter 8 Benthic Ecology** and **Chapter 9 Fish and Shellfish Ecology**, as well as the **Report to Inform Appropriate Assessment (RIAA)** (document reference 5.4)

5. Additional information to support the offshore ornithology assessment is presented in **Appendix 11.1 Offshore Ornithology Technical Report** and **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.

11.2 Consultation

6. Consultation with regard to offshore ornithology has been undertaken in line with the general process described in **Chapter 5 EIA Methodology** and the **Consultation Report** (document reference 5.1), which has been submitted as part of the DCO application. The key elements to date have included scoping, the ongoing Evidence Plan Process (EPP) via the offshore ornithology Expert Topic Group (ETG), with meetings held in January 2020, June 2020, December 2020, August 2021 and February 2022, and the Preliminary Environmental Information Report (PEIR), which was published in April 2021.

7. The feedback received throughout this process has been considered in preparing the ES. This chapter has been updated following consultation in order to produce the final assessment submitted within the Development Consent Order (DCO) application. **Table 11-1** provides a summary of the consultation responses received to date relevant to this topic, and details of how the Project team has had regard to the comments and how these have been addressed within this chapter. The table has been edited to minimise repetition. In addition, stakeholder comments relevant to the **RIAA** (document reference 5.4) are included within this ES chapter given the cross over between the two assessments and to avoid the complexity in attempting to separate comments specific to each assessment.

Table 11-1: Consultation Responses

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Meeting 29/04/19	Regarding the Sandwich tern tagging programme being undertaken at the Dudgeon Offshore Wind Farm (DOW), Natural England queried whether this is focused solely on Scolt Head, which was confirmed. There are potential implications for the observed foraging patterns should the colony switch to Blakeney Point. Natural England would need to take a view on how representative data will be if birds were to switch to Blakeney. The visual, boat based, tracking data from the SOW Operational Monitoring Programme (OMP) (Harwood *et al*., 2018) may be useful in investigating this further. There should be sufficient data available to quantify this.	Information regarding how the at-sea distribution of foraging Sandwich terns might change following a switch in breeding site, whether it can be quantified, and the implications for potential effects on this receptor is presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Meeting 29/04/19	Natural England stated that in the absence of site-specific flight height data, Collision Risk Modelling (CRM) would need to use published flight height distributions ("Corrigendum," 2014; Johnston *et al*., 2014) and Option 2 of the Band model. An alternative option to explore would be to use flight height data from Sheringham Shoal post-construction.	The collision risk assessment (**Section 11.6.2.2.2**) uses published flight height distributions ("Corrigendum," 2014; Johnston *et al*., 2014) that have been used in other offshore wind farm (OWF) assessments. For Sandwich tern, flight height distributions from an additional data source are also used (Harwood, 2021), which was collected during the Sheringham Shoal post-construction monitoring programme.
Natural England	Meeting 29/04/19	It was noted that confidence intervals for the draft 2018 Sandwich tern density estimates are large. With respect to the 10% coverage achieved by the survey programme. Natural England suggested that a power analysis (or similar investigation) might be useful in determining whether there would be benefit in analysing data from the additional pair of cameras. Natural England advised that CRM will need to be presented on the upper and lower CIs and so anything that can reduce the range will help to reduce uncertainty in the assessment, even if just for key species (i.e. Sandwich tern) and for the key months (i.e. April to August).	An investigation found that doubling the camera coverage for the surveys will reduce the variability about mean design-based density estimates by a moderate extent only. CRM has been presented for the mean density estimate for each month, as well as upper and lower 95% confidence intervals (**Section 11.6.2.2.2**).

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Meeting 29/04/19	Natural England requested further detail on age class and species identification rates, noting that it would be useful to review and discuss these aspects further prior to the draft assessments being completed.	Age class and species and identification rates are referred to within the assessment where relevant.
Natural England	Meeting 29/04/19	The Department for Energy and Climate Change (DECC) (2012) Appropriate Assessment predicted a level of Sandwich tern mortality that Natural England were not comfortable with. As a result, Natural England advised there is a high risk of a conclusion of adverse effect on integrity with respect to that species due to the development of SEP and DEP. To assist with this, Natural England suggested that a case should be able to be made to use as-built data for operational wind farms so long as it can be demonstrated that more turbines could not be legally built out. Natural England would also wish to see CRMs for existing projects rerun to reflect as built designs, as opposed to applying correction factors to the existing CRM estimates. It was also noted that CRMs for some of the older projects were not based on the more recent Band (2012) model but instead used alternative models.	The assessment has investigated collision risk for Sandwich tern at other OWFs in the Greater Wash area, as per discussions with Natural England. The CIA for collision mortality uses CRM outputs based on consented parameters, but also makes reference to corrections to mortality totals based on more realistic parameters (**Section 11.6.2.2**, **Appendix 11.1 Offshore Ornithology Technical Report** and **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**).
Natural England	Meeting 29/04/19	Natural England noted that the original Population Viability Analysis (PVA) model for Sandwich tern (ViaPop) used to inform the DECC (2012) Appropriate Assessment of Sandwich Terns at the North Norfolk Coast Special Protection Area (SPA) will need to be updated for the SEP and DEP assessment.	An updated PVA has been prepared using the Natural England PVA tool (Searle *et al*., 2019). Details are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Scoping Opinion (06/11/19)	Account may also need to be taken of the possibility for DEP/SEP to interact with migratory species – which may not be recorded at all during snapshot surveys, even over two years. The work of the SOSS programme provides a means to identify which bird species are likely to have a migratory pathway that encompasses the SEP and DEP footprints (Wright *et al*., 2012) and so merits inclusion in the assessment.	Migratory CRM according to the specified methodology has been carried out and is presented in **Section 11.6.2.2.3**.
Natural England	Scoping Opinion (06/11/19)	Distant SPAs screened in should not be limited to those determined solely by the breeding season/foraging ranges of their ornithological features, but also account for the potential for SEP and DEP to interact with birds from	Apportioning of seabirds outside the breeding season has been carried out according to the information presented in

Consultee	Date, document and/or meeting	Comment	Project response
		much more distant SPAs during the migration and non-breeding seasons as a proportion of the birds using the SEP and DEP areas may originate from even more distant SPAs. Furness (2015) provides information for many species of seabird on the suite of colonies that may have connectivity with the southern North Sea outside the breeding season.	Furness (2015). Where the potential exists for 1% or more of a given SPA population to be present at SEP and DEP at any time of year, the SPA has been screened into **RIAA** (document reference 5.4).
Natural England	Scoping Opinion (06/11/19)	Natural England welcomes acknowledgment of the scale of OWF development not just in United Kingdom (UK) waters but in those of other European countries. This does indeed create the potential for transboundary impacts – and therefore also the need for all such developments (regardless of location) to be included within CIA for populations of many species whose mobility results in their potential interaction with OWFs in a wide range of national waters. It does not, however, follow that as the magnitude of the spatial scale of developments included within transboundary assessments increases that the size of the seabird reference populations increases too. The scope for there to be transboundary effects of developments needs to be considered against each population scale that is relevant – and that will often need to include individual colony SPAs because individuals from any one colony may well interact with developments across various national waters.	For the species included within the CIA, estimates for the size of appropriate background populations are available (Furness, 2015). For transboundary assessments, entire North Sea population estimates of the relevant species are required to place predicted impacts into context, which at the time of writing were not available. No transboundary sites have been screened into the **RIAA** (document reference 5.4).
Natural England	Scoping Opinion (06/11/19)	Natural England does not agree that barrier effects due to the presence of turbines can be scoped out during the construction and decommissioning phases. Barrier effects may begin as soon as the first few turbines are erected (which may be well before the end of the construction period) and may not end until the last few turbines are decommissioned.	It is agreed that there will be a transition between the construction and the operational period impacts, and likewise for operational and decommissioning impacts. At such time as the first wind turbines (and other infrastructure) are installed onto foundations, the impact of barrier effects (and displacement) in relation to turbines would increase incrementally to the same levels as operational impacts. The operational phase assessment for barrier effects (and displacement) is considered a worst-case proxy for the part of the

Consultee	Date, document and/or meeting	Comment	Project response
			construction period where turbines are being installed, and the part of the decommissioning period where turbines are removed This advice has been incorporated into the assessment (**Section 11.6**).
Natural England	Scoping Opinion (06/11/19)	Natural England is not convinced that a 4km buffer around the survey area is sufficient to ensure that characterisation data are going to be gathered across the full extent of the sea area over which the zone of influence of DEP and in particular SEP may extend – particularly in regard to the red-throated diver interest feature of the Greater Wash SPA. For this species there is increasing evidence of the zone of influence of operational windfarms exceeding 10km and perhaps reaching 20km. These distances would see the zone of influence around SEP overlapping with the Greater Wash SPA. Without survey information from these wider areas the ability to reach sound conclusions regarding the magnitude and significance of these developments on the Greater Wash SPA in particular may be compromised. Ideally, the survey design would have been informed by quantitative analyses of existing survey data from the general area of the SEP and DEP developments to arrive at a design that optimised the trade-off between increasing accuracy and precision of population abundance estimates and survey effort. But we acknowledge that there was a project requirement to start ornithological surveys ahead of the evidence plan process.	During later consultation with the Ornithology ETG it was agreed that a robust assessment could be carried out using existing data, which has been referred to as appropriate for offshore ornithology receptors.
Natural England	Scoping Opinion (06/11/19)	As far as Natural England is aware digital aerial imagery cannot be used to discriminate different sexes of seabirds. Also, as far as Natural England is aware, the robustness of all approaches to estimating flight heights from aerial survey platforms has yet to be satisfactorily validated.	Digital aerial survey data were not used by the assessment to either discriminate sex or measure flight height of birds recorded during baseline surveys.
Natural England	Scoping Opinion (06/11/19)	Natural England is not convinced that the area covered by digital aerial survey, even covering as it does a 4km buffer, will provide any real insight into the importance of "the site" relative to a wider area. The entire aerial	The approach taken for collecting baseline data was similar to that employed at other OWFs. The

Consultee	Date, document and/or meeting	Comment	Project response
		survey area is small and will provide no real insights into the abundance and distribution of any species in the general area of the Greater Wash – this being the scale at which year to year variation is most likely to be manifest.	assessment also makes use of a wide range of other data sources and is considered to be robust.
Natural England	Scoping Opinion (06/11/19)	Rather than Natural England being involved in further liaison with the Applicant to agree the specific assessment methodology “following the identification of the preferred offshore development area”, Natural England would welcome inclusion in the identification of the preferred offshore development area with the Applicant.	Any modification of the offshore sites as the development of SEP and DEP progresses will be discussed with Natural England.
Natural England	Scoping Opinion (06/11/19)	Natural England’s position on the issue of generating and using updated collision mortality estimates based on as-built project parameters has been most recently set out in our advice given in response to the PEIR submitted for Hornsea Project 4. This was as follows: Our position on as-built layouts is that for revised collision figures based on design or build changes to be accepted, it is necessary to: Provide documentary proof that the design envelope used to calculate new collision figures is 1) legally secured with no further change possible (i.e. written confirmation from the appropriate Regulator provided); 2) the worst-case scenario design envelope for collisions for each species considered for projects that are not yet built; Agree with Natural England the updated CRM figures – including bird parameters used in the CRM, which CRM model/option to be used, etc; Re-run CRMs to generate updated collision figures against any agreed changes to turbine design layouts. Where this is not possible for a project because original bird density data cannot be obtained, we would need to agree whether correction ratios can be calculated (for example following an approach such as MacArthur Green (2017)) and see the full calculation details for these correction factors.	Noted. For species other than Sandwich tern, assessments of cumulative and in-combination collision risk have used predicted collision mortalities based on consented OWF designs, though reference is made to potential overestimation of collision risk using this approach where this is considered to be relevant. For the cumulative and in-combination collision risk assessment for Sandwich tern (**Section 11.7.3.2.5**), three scenarios in addition to consented and as-built OWF designs have been considered. The first assumes that any unbuilt capacity at the consented OWFs is built out using turbines of the same specification as the consented design. The second assumes that any unbuilt capacity at the consented OWFs is built out using turbines of the same specification as those actually used at

Consultee	Date, document and/or meeting	Comment	Project response
			the OWF. The final set of CRM outputs is the same as the latter scenario, but with the assumption that the as-built layout of DOW is legally secured. Further details describing the mechanism for securing the as-built layout of DOW are provided in **Chapter 4 Project Description**, the **Explanotory Memorandum** (document reference 3.2) and the **Draft DCO** (document reference 3.1).
Natural England	Scoping Opinion (06/11/19)	Natural England notes the reference to the conclusions of The Crown Estate's Offshore Wind Extensions Plan Habitat Regulations Assessment (HRA). Natural England advises the Applicant that in its advice to The Crown Estate on the revised Report to Inform Appropriate Assessment (RIAA) (submitted to the Crown Estate by Natural England on 15th July 2019) that "Natural England is not able to agree with the overall conclusions of the RIAA in relation to bird features of SPA."	Natural England's comments on this document have been obtained from The Crown Estate and are noted.
Natural England	Scoping Opinion (06/11/19)	In assessing the sensitivity of each species, Natural England advises the Applicant of the value of consulting the information contained within its Advice on Operations for the features of each Marine Protected Area.	This advice was noted, and these documents are referred to where relevant.
Natural England	Scoping Opinion (06/11/19)	In addition to the list of alternative sources of information provided regarding the distribution of seabirds at sea, Natural England advises the Applicant to make use of the information arising from the work on mapping the distributions of birds and marine mammals around the whole of the UK as part of the Marine Ecosystems Research Programme (MERP). Natural England also advises that in the near future a review of breeding seabird foraging ranges is likely to be completed (part of The Crown Estate front-loading projects for Round 4) and of seabird behaviour at sea under different environmental conditions (ongoing project funded by Marine Scotland). There may be other ongoing projects whose findings may be relevant to the assessments made by the Applicant in due course.	Outputs from the MERP report (Waggitt *et al*., 2019) have been used when considering the relative importance of SEP and DEP for offshore ornithology receptors. Woodward *et al*. (2019) is a key source of many of the breeding season foraging ranges referred to by the assessment.

Consultee	Date, document and/or meeting	Comment	Project response
Royal Society for the Protection of Birds (RSPB)	First ETG Meeting (09/01/20)	The timing of the baseline survey flights was requested, in order to understand whether diurnal foraging peaks are likely to have been recorded.	Some information on this subject was presented at the third ETG meeting in December 2020. Further details are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England and RSPB	First ETG Meeting (09/01/20)	Both Natural England and RSPB stated that it is important to agree on the definition of biologically relevant seasons early in the process.	Biologically relevant seasons are discussed and presented for each offshore ornithology receptor in **Section 11.5.1.2**. These were presented during the ETG process and agreed with stakeholders, particularly the use of full breeding seasons, as opposed to migration-free breeding seasons.
Natural England and RSPB	First ETG Meeting (09/01/20)	Natural England queried the preference of the project team for using design-based density estimates for the assessment, since the data collected outside the extension arrays is valuable. Natural England stated that a model-based approach was worth exploring given the large confidence intervals presented in draft Sandwich tern density estimates, and because the Lincs OWF post-consent work (Hi Def Aerial Surveying, 2017) suggests successful use of a model-based approach. The ETG agreed that discussing a model-based approach with HiDef would be useful. The ETG agreed that a list of species to be investigated using modelled estimates should be produced (should a model-based approach be pursued), which may be determined by the number of observations.	After extensive further consideration (including a minuted meeting with the Applicant and HiDef Aerial Surveys Ltd on 25th March 2020), it was concluded that a model-based approach (e.g. using MRSea) is unlikely to be appropriate for this assessment. Design-based approaches to density estimation have therefore been employed by the assessment for all offshore ornithology receptors. Following further requests from Natural England in its section 42 response, model-based density estimation has since been undertaken for Sandwich tern only, and is presented in **Appendix 11.1 Offshore Ornithology Technical Report**. The impact assessment for Sandwich tern uses both design-based

Consultee	Date, document and/or meeting	Comment	Project response
			and model-based density estimates throughout, to enable comparisons to be made between the outputs.
Natural England and RSPB	First ETG Meeting (09/01/20)	For Sandwich tern the key months during the breeding season are April and May. The DEP April 2019 data shows large abundance difference between the two surveys in that month. It was noted that unusual events such as a flock/feeding aggregation have a large effect on density estimates, and this needs to be considered. Natural England stated that two surveys per month is beneficial but given the high variability within and between months, more thought is needed how variability in numbers is reflected. It is important that variability reflects reality and is not a result of survey design and analysis.	Doubling the survey effort to two per month during the 2019 breeding season has captured a wider range of variability in densities than may have otherwise been the case. The variability in numbers is reflected in the assessment by the inclusion of 95% confidence intervals in collision risk modelling, which will be wider given the higher variability.
RSPB	First ETG Meeting (09/01/20)	RSPB asked if project team had looked at the outputs from the more recent report on the Flamborough kittiwake tracking in 2017. RSPB stated that there is a more recent report that will be available shortly, including 2019 data. Later studies cover more of the breeding season – a new tagging method has been used where tags are retained for longer (up to 1 month) compared to a few days in Cleasby *et al*. (2018).	The 2017 census data (Aitken *et al*., 2017) are used to set breeding season reference populations for this species. A range of published data sources are used to consider connectivity between SEP and DEP, and the Flamborough and Filey Coast SPA.
RSPB	First ETG Meeting (09/01/20)	Wakefield *et al*. (2013) shows gannet utilisation distribution from the Flamborough Head and Bempton Cliffs SPA and suggested the extension areas may be on the edge of the distribution. RSPB indicated that better data is required. RSPB was uncertain if the Wakefield paper included all of the tracking data from Langston (2013).	The assessment takes a precautionary view that during the breeding season, 100% of gannets present are breeding adults that originate from the Flamborough and Filey Coast SPA.
RSPB	First ETG Meeting (09/01/20)	Regarding the Sandwich tern tracking for DOW OMP, RSPB asked what sort of tags were used since, although flight height information is not an objective of the monitoring, Global Positioning System (GPS) data may include information that can be used to interpret flight heights (distribution rather than exact spot heights).	It was confirmed by email from Bureau Waardenburg, who are carrying out the DOW OMP Sandwich tern tracking, that no flight height data were recorded in previous years with the tags. For that project it was decided to use all power in

Consultee	Date, document and/or meeting	Comment	Project response
			the batteries for x/y positioning at a small sampling interval rather than adding the energetically costly z positioning.
Natural England and RSPB	First ETG Meeting (09/01/20)	The ETG agreed that it will probably be necessary to re-run Sandwich tern CRMs in the Greater Wash for all OWFs where feasible. RSPB asked whether Natural England has a position on whether the stochastic or deterministic model should be used. Natural England's reply was that they have been encouraging developers to use the stochastic model. Natural England noted a reservation due to discrepancies between the stochastic and deterministic outputs. RSPB replied that they believed that recent work has resolved these discrepancies. It was stated by Natural England that they will formally provide its position as to whether the stochastic or deterministic model should be used.	Deterministic CRM has been used throughout the assessment following advice from Natural England received through DAS on 7 August 2020 (see below). This includes the rerunning of Sandwich tern CRM for other OWFs in the Greater Wash area.
Natural England and RSPB	First ETG Meeting (09/01/20)	Natural England recommended that the CRM assessments be re-run rather than building on the existing assessment. Natural England advised that the project team should try to obtain the advice provided to the Crown Estate on its Plan-level HRA. Natural England also stated that for Sandwich tern, confidence in the acceptable annual mortality level without an adverse effect on site integrity of 94 birds (beyond which an adverse effect on North Norfolk Coast SPA site integrity would occur, as calculated by DECC (2012) Appropriate Assessment) is not high because there has not been sufficient evidence from post-construction monitoring.	The advice provided by Natural England to The Crown Estate advice was obtained and noted. The position of Natural England on thresholds is noted. However, the approach of setting threshold levels for impacts is not considered to represent a robust approach (Green *et al*., 2016), so it is unclear why it was referred to.
Natural England and RSPB	First ETG Meeting (09/01/20)	Regarding Sandwich tern avoidance rate, it is still Natural England's official position that 0.980 should be used as stated in UK SNCBs (2014). However, Natural England recognises that this should be reviewed and is in the process of commissioning work to do so. It is hoped that this work will report in time to be used in the assessment – expected around 2020. However, this work has yet to be commissioned.	This position was noted. The assessment conclusions are based on models incorporating an avoidance rate of 0.980 for Sandwich tern, though considers alternative avoidance rates, and the potential for macro-avoidance

Consultee	Date, document and/or meeting	Comment	Project response
		RSPB advised caution when using predictors from the Folkerts model, and that avoidance rate is model specific and not same for Folkerts and Band models. The ETG was undecided whether the same avoidance rates will be used in stochastic and deterministic CRMs. The Joint Nature Conservation Committee (JNCC) are commissioning work on five species which the ETG noted will be useful. It will recommend different avoidance rates for deterministic and stochastic models.	not accounted for in the avoidance rate of 0.980.
Natural England and RSPB	First ETG Meeting (09/01/20)	RSPB asked what the frequency of GPS fixes was in the Fijn and Gyimesi (2018) Sandwich tern flight speed study. RSPB noted that flight speed is used in the Band model twice; in the flux and probability of collision variables. Both are unvalidated. RSPB advised the ETG would need to decide whether account for different behaviours in the model flight speed parameters. Natural England stated that they would welcome further discussion on use of flight speeds.	Flight speeds recorded using the method of Fijn and Gyimesi (2018) are instantaneous. In their DAS advice (7th August 2020), Natural England recommended that CRM utilising this latest evidence on Sandwich tern flight speed was not pursued, and that previously used values should be retained. GPS-derived flight speeds are included in the assessment since they are considered to represent the best available evidence. Detail is available in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England and RSPB	First ETG Meeting (09/01/20)	The ETG broadly agreed that the Sandwich tern PVA parameters should be updated from the 2012 assessment. Natural England asked if the parameters for Sandwich tern in the PVA tool are national or specific to the North Norfolk Coast, noting that local / site specific information should be used where possible. RSPB agreed on this point.	This point was agreed.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England and RSPB	First ETG Meeting (09/01/20)	Natural England stated that the impact of a switch of Sandwich tern breeding location from Scolt Head to Blakeney Point should be assessed because this would bring the Sandwich tern breeding population closer to the SOW and DOW, as well as SEP and DEP. Whilst foraging activity from Blakeney Point appears to be more restricted to the area close the colony than for Scolt Head according to some data (Wilson *et al*., 2014), Natural England stated that it may be necessary to consider transit routes to and from foraging areas from different home colonies.	A discussion of how the potential for a switching of breeding location has been incorporated into the assessment is provided in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England and RSPB	First ETG Meeting (09/01/20)	Natural England asked whether the air gap between rotors and sea level has been considered in the design envelope, as increasing air gap is an obvious mitigation option which would result in a considerable reduction in collision risk. Natural England added that it would be useful to consider the impact of different scenarios.	It was confirmed that this has been taken into account. Since the production of the PEIR, the air gap of SEP and DEP has been increased from 26m to 30m to reduce the collision risk of offshore ornithology receptors. Further details are provided in **Chapter 4 Project Description**.
Natural England and RSPB	Second ETG Meeting (04/06/20)	Regarding the selection of design-based density estimation methods for the assessment, Royal HaskoningDHV stated that this decision was based on a review of MRSea and advice from HiDef (who have undertaken a model-based approach at another site which bears several similarities to SEP and DEP). RSPB stated that it would be helpful to get more detail on the advice provided by HiDef. Natural England stated that discussions with the wider team would be required before providing formal feedback, noting that there are concerns around confidence in density data due to large confidence intervals. RSPB agreed and stated that more time was required to process the information. RSPB stated that in the MRSea package there is the possibility to review procedures, efficiency of different model approaches	This position was noted.

Consultee	Date, document and/or meeting	Comment	Project response
		and scenarios including patchy distributions, limited covariate data and low numbers.	
Natural England and RSPB	Second ETG Meeting (04/06/20)	Natural England stated that it would be good to know the final sample size in terms of records for the full aerial survey now complete.	The spreadsheet containing the raw data has not been presented within the assessment. However, distribution maps of raw counts have been produced, and are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Second ETG Meeting (04/06/20)	Natural England questioned why there are separate reporting regions for DEP (north and south).	The Applicant stated that lease areas provide flexibility in terms of turbine location. For example there is one scenario where all turbines could be located in the DEP North array area (DEP-N) only and therefore the DEP South array area (DEP-S) would not be developed.
Natural England	Second ETG Meeting (04/06/20)	Royal HaskoningDHV presented findings of the assessment of use of the data from second pair of cameras. Doubling the camera coverage results in a reduction in the variability about the mean estimates by a quarter to a third, but sometimes by less. The level of variability associated with the mean density estimates for Sandwich tern remains relatively high. This therefore does not solve the problem of having high levels of variability about the mean abundance estimates. Natural England suggested exploring if this could be beneficial for surveys with more bird records.	The assessment relies on design-based density estimates calculated with data from the second pair of cameras for surveys carried out between March and September each year, without data from the second pair of cameras for surveys carried out between October and February each year.
Natural England and RSPB	Second ETG Meeting (04/06/20)	The Ornithology ETG generally supports use of flight speed data from Fijn and Gyimesi (2018). RSPB questioned how behaviour will be classified, and if HiDef data can be classified accordingly.	Classifying behaviour of birds recorded by the baseline surveys has not been undertaken. However, as well as the findings of Fijn and Gyimesi (2018), the DOW OMP tracking data have been used to provide site-specific flight speed

Consultee	Date, document and/or meeting	Comment	Project response
			estimates. The mean flight speeds are used in CRM.
RSPB	Second ETG Meeting (04/06/20)	RSPB stressed that anything that can be done to increase air gap before DCO submission would be appreciated. Equinor replied that collision risk is being considered, but pointed out that raising the air gap significantly increases foundation size and project cost. RSPB acknowledged this but restated the value of agreeing air gap pre-examination. RSPB stated that data gathered by HiDef can be used to pick up birds in transit, and potentially birds foraging. RSPB suggested that it would be good to do a behaviour-based collision risk modelling, as risks are different depending on bird behaviour.	A minimum air gap of 30m has been incorporated into the project design (further details are provided in **Chapter 4 Project Description**). This has been increased from the 26m that was included in the PEIR project design, to reduce potential collision risk to offshore ornithology receptors. Behaviour-based collision risk modelling is not considered possible, on the basis that the baseline data collected does not permit the allocation of behaviour to the majority of birds observed.
Natural England and RSPB	Second ETG Meeting (04/06/20)	Natural England stated that for CRM, a consistent and agreed industry approach to modelling (i.e. "buy in" from other developers), including the commitments required to no further expansion beyond 'as built' to allow as built parameters to be used in the assessment, will be required. Natural England will require that the Project reaches an agreement with other developers so that there is an agreed approach to the cumulative impact assessment. Natural England stated that with respect to presenting consented and as-built collision estimates, this would constitute a change in how cumulative impacts are assessed, and that given post construction monitoring for DOW is incomplete this would not be sufficient. Natural England stated that all CRMs need to be repeated with cross industry agreement on the approach that will be carried forward and applied to any future extension projects, and agreed with the Crown Estate. RSPB supported this approach.	The Applicant replied that a strategic approach would be considered. The assessment conclusions are based on CRMs using consented parameters for existing OWFs, though CRMs for as-built layouts are considered as appropriate. The Applicant requested that Natural England and the RSPB provide clarification on the request for a strategic approach in writing to avoid any confusion about what is being requested.

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		Natural England and RSPB could not advise the best way to undertake such an approach, other than to say a wider discussion is required.	
Natural England and RSPB	Second ETG Meeting (04/06/20)	Natural England asked to see a table of Sandwich tern productivity rates for the North Norfolk Coast SPA to understand any variation over the years. RSPB agreed to approach site managers at Scolt Head and Blakeney Point, and request productivity data.	Breeding success for Sandwich tern, which was taken from JNCC (2022), is presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	DAS Letter, 07/08/20	During the Second ETG meeting Natural England advised that assessing displacement effects for red-throated diver should be at least out to 10km. However, Natural England has recently advised East Anglia One North and East Anglia Two that this is now extended to 12km. This change is based on empirical data from OWFs and therefore we advise SEP and DEP to do similar. However, it is acceptable to use pre-existing survey data to predict the possible impacts. Consideration should be given to the redistribution and changes in density of birds since the Lawson *et al*. (2016) data. Digital survey data collected for the Lincs post consent monitoring (Hi Def Aerial Surveying, 2017) demonstrates this (albeit over a sub-section of the SPA). Natural England advises that this should be taken into account when assessing the effect of displacement on red-throated diver in the Greater Wash SPA and suggests presenting some worse case scenarios based on current understanding of distribution and likely density.	Operational displacement effects on red-throated diver have been assessed out to 4km from SEP and DEP using baseline data, and out to 12km from SEP and DEP using other data sources (Bradbury *et al*., 2014; Lawson *et al*., 2016). The assessment is presented in **Section 11.6.2.1.3**.
Natural England	DAS Letter, 07/08/20	Natural England notes that the approach to excluding dawn and dusk when conducting digital aerial surveys while necessary methodologically, is likely to lead to some level of bias in sampling seabird activity, and will differ depending on the species and time of year. Whilst this bias may be methodologically unavoidable, it would be appropriate to present survey timings and review the evidence on focal species daily activity patterns, so that the limitations of the data can be discussed.	The survey timings are presented in **Appendix 11.1 Offshore Ornithology Technical Report**. As stated by Natural England, some bias in the survey methodology is unavoidable. There is little scope to vary the time of day at which surveys occur, due to factors such as aircraft logistics,

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			transit to and from the study area, the timing of windows for suitable light and weather, commencement of surveys sufficiently early to complete in a single day, and leaving time for survey completion in the event of any issues during the survey. It should be noted that this is not an issue restricted to SEP and DEP, it is a potential issue at all OWFs.
Natural England	DAS Letter, 07/08/20	Further sources of potentially useful information are Environmental Statements (ESs) and post consent monitoring reports from of all OWFs in the Wash (e.g. SOW, Dudgeon, Race Bank, Lincs, Lynn and Inner Dowsing (LID), Triton Knoll), and reports related to DECC (2012), including population modelling work.	These sources of information have been consulted where they were available, and when it was considered to improve the assessment. They are referenced in the text as they are referred to, and are all listed in the references section at the end of the chapter.
Natural England	DAS Letter, 07/08/20	For the purposes of EIA then Furness et. al. (2015) (or Cramp and Simmons) are appropriate noting that Natural England use the FULL breeding seasons (not the migration free breeding season) and follow the recommendations from Furness *et al*. (2015) around appropriate non-breeding seasons (e.g. guillemot has a breeding and non-breeding season only).	The full breeding season has been used for all species for which this biologically defined season is relevant. These are presented in **Section 11.5.1.2**.
Natural England	DAS Letter, 07/08/20	We advise that colony specific evidence is used to inform seasons at an HRA level.	The assessment uses biologically relevant seasons as defined by Furness (2015). This includes the use of full breeding seasons throughout, as opposed to migration free breeding seasons.
Natural England	DAS Letter, 07/08/20	Natural England agrees with the use of relevant seabird research, foraging ranges, distribution and age classes, but note that age class data is limited in its use for many species and some assumptions will need to be made and agreed upon.	This position was noted.

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Natural England	DAS Letter, 07/08/20	Natural England notes that a proposed approach to apportioning has not been submitted, and that apportioning is not addressed in the draft HRA screening. Natural England suggests that the approach is submitted for feedback. Natural England would further note that we had substantial issues with the apportioning approach submitted as part of Hornsea Project Three, and would therefore advise against basing any approach on that submission.	The assumptions used with regard to apportioning are considered by the Applicant to be precautionary. These are set out in **Section 11.5.1**.
Natural England	DAS Letter, 07/08/20	We do not find the Matrix Impact assessment to be particularly informative or intuitive. How is the conservation value captured in the matrix methodology?	This is explained in **Section 11.4.3.2**.
Natural England	DAS Letter, 07/08/20	Natural England queries point 105 that notes; 'In the case of projects which were in construction or operation during baseline surveys for SEP and DEP, these are considered as part of the baseline for the EIA in line with Advice Note seventeen (Planning Inspectorate, 2019). ' Natural England does not consider projects to be 'part of the baseline' in terms of cumulative or in-combination effects, unless the data under-pinning the assessment (e.g. distribution, population size, survival rate) were all collected subsequent to the construction or operation of projects. Please note that there will be up and coming advice as part of the East Anglia One North and East Anglia Two examination on consideration of cumulative impacts to red-throated diver.	This position was noted. During cumulative and in-combination assessment, existing or planned OWFs are not treated as part of the baseline. Natural England's guidance on red-throated diver has been considered and followed during the preparation of the assessment (**Section 11.6.1.1.2**, **Section 11.6.2.1.3**, and **RIAA**).
Natural England	DAS Letter, 07/08/20	Natural England urgently advises that there has been a change in our advice on the use of the stochastic collision risk model (McGregor *et al.*, 2018). Due to technical issues with the sCRM that are undermining the confidence that can be placed in the outputs, Natural England advises that deterministic, rather than stochastic, collision models are run. Statutory Nature Conservation Bodies (SNCBs) are working on new guidance, but until such a time that we have established clarity on some of the issues and established advice on key input parameters including avoidance rates that will ensure consistency in outputs, then we currently recommend running deterministic models. However, due to the	Deterministic CRM has been used throughout the assessment, and parameters varied according to this advice (**Section 11.6.2.2.2**). The Band spreadsheets have been used, and have been included in an Annex to **Appendix 11.1 Offshore Ornithology Technical Report**.

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		considerable uncertainty/variability in the input parameter values used in the CRM, and in the model itself, to allow a robust assessment of potential collision impacts on populations it is important to take account of this uncertainty where possible and to indicate the range of confidence around the collision estimate. Therefore, we advise that for the key input parameters below, uncertainty around the parameter estimates should be considered on an individual parameter basis. • monthly bird density • flight height • avoidance rate • nocturnal activity factor This can be done using the Band (2012) spreadsheet or by running the sCRM model developed by McGregor *et al*. (2018) by having no variability (i.e. standard deviations) set for any input parameter and undertaking multiple runs of the model to account for individual variation in each relevant input parameter. This gives an indication of which parameters might have the most influence on the prediction of collision risk, recognising that individually these will not reflect the effect of uncertainty across all parameters. We can provide more detailed advice on incorporating parameter uncertainty in due course.	
Natural England	DAS Letter, 07/08/20	With regards to updating Sandwich tern avoidance rate, the contract has been awarded to the BTO, a start-up meeting is taking place in the second week of August. The timelines are for a report by the end of the year.	The avoidance rate review was published in August 2021 (Cook, 2021). In October 2021, Natural England informed the Applicant that it is not appropriate to use the recommended rates in the British Trust for Ornithology (BTO) report. This followed a review of the data underpinning the report by MacArthur Green. The assessment has complied with this request.

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Natural England	DAS Letter, 07/08/20	With regards to Sandwich tern, we acknowledge that the Fijn and Gyimesi (2018) paper is an important data source for Sandwich tern flight speed, but note that the difference in mean flight speed between the reference speeds used in Cook *et al*. (2014) of 10m/s, Christensen *et al*. (2004) of 10.5m/s and reported in Fijn and Gyimesi (2018) of 10.25m sec are not big. We will be raising the issue of Sandwich tern flight speed with the BTO as part of the avoidance rate review, and will hope to incorporate new information on flight speed into the review. We further welcome the suggestion that equivalent information from the post-construction monitoring work at Dudgeon OWF may be obtained.	GPS-derived flight speeds are included in the CRM for Sandwich tern, since they are considered to represent the best available evidence. Detail is available in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	DAS Letter, 07/08/20	Natural England request that site specific data from both SOW and DOW OWF are also presented from ESs and any post consent work available), but do not expect them to be included in CRM.	A full review of all available Sandwich tern flight height data is provided in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	DAS Letter, 07/08/20	It is currently challenging, if not impossible, to account for a decommissioning schedule within the PVA tool at present, as this requires a variable harvest rate over time. We welcome further discussion on this topic. Natural England suggests that preliminary population modelling is conducted by SEP and DEP and that the details of which (including the run logs) are shared with Natural England. Natural England is also undertaking an informal, in-house project to model Sandwich tern population impacts in the Wash. Whilst this is currently delayed due to covid-related staff resource issues, we hope to progress this in September.	Decommissioning of existing OWFs has not been included in the PVAs included in the assessment. Instead, the precautionary assumption that all existing OWFs will remain operational for the entire duration of the operational phase of SEP and DEP has been made. The approach to PVA is explained and discussed in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Third ETG Meeting (09/12/20)	Natural England noted that for kittiwake, distribution maps for the whole survey area would be useful given the complex nature of the reporting regions.	Maps of raw observations for kittiwake and other offshore receptors are included in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Third ETG Meeting (09/12/20)	Natural England queried why the DEP-N site is the shape that it is.	A number of constraints resulted in the boundaries being selected as they are, including shallow water depths in the

Consultee	Date, document and/or meeting	Comment	Project response
			western area and oil and gas activity. See the **Offshore Design Statement** (document reference 9.26) for further details.
Natural England	Third ETG Meeting (09/12/20)	Natural England noted that the conservation objectives for the Greater Wash SPA include disturbance in its own right.	This has been taken into account in the **RIAA** (document reference 5.4).
RSPB	Third ETG Meeting (09/12/20)	RSPB asked if Equinor has looked at how red-throated diver distributions in the wider area have changed post OWF construction.	All available information has been considered in the preparation of the assessment.
Natural England	Third ETG Meeting (09/12/20)	Natural England noted that they are planning updated Greater Wash SPA surveys in the future.	Noted.
Natural England	Third ETG Meeting (09/12/20)	Evidence is that terns switched from sandeel to herring later in the year and that the Dudgeon OMP data should provide useful insight into these patterns. It is suggested that Cefas/MMO are asked whether there is any fisheries data available to help underpin the tern distribution patterns.	Since the DOW OMP only covers a small part of the breeding season, it was concluded the data is unlikely to be useful for this purpose.
Natural England	Section 42 Consultation Response (10/06/21)	Due to the consultation timeframes and size of documentation Natural England has limited PEIR comments to focus on priority areas within the offshore ornithology impact assessment, with a view to ensuring that the DCO application is submitted with the most complete and robust data sets and analyses required to inform both the EIA and HRA assessments of SEP and DEP, and the focal species and colonies (in particular those that present the most significant consenting risk to the projects) are assessed in the most appropriate way.	Noted. The Applicant also notes that Natural England have not reviewed elements of the assessment prior to submission of the DCO application. Notably, Natural England did not comment on the conclusions of the draft Information to Inform Habitats Regulations Assessment.
Natural England	Section 42 Consultation Response (10/06/21)	Natural England are making no comment on the conclusions drawn regarding ornithological impact as part of either EIA or HRA; however, we draw the Applicant’s attention to recent advice Natural England has provided to OWFs in Examination (EA1N Appendix A19 - NE Comments and Conclusions on EIA Scale Impacts Deadline 8.pdf), in regards to impacts at both HRA and EIA scales.	Noted. The information from the supplied reference has been drawn upon when producing this assessment.

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Natural England	Section 42 Consultation Response (10/06/21)	Natural England have prioritised reviewing the key HRA sections on: • Greater Wash SPA (red-throated diver and sandwich tern via NNC SPA review) • North Norfolk Coast SPA (sandwich tern) • Flamborough and Filey Coast SPA (all qualifying species)	Noted.
Natural England	Section 42 Consultation Response (10/06/21)	The following sections of Chapter 13 and the HRA report, have NOT been reviewed: • Interpretation of impacts (at HRA or EIA scale) • Impacts on non-focal species • Impacts that are generally lower-consenting risk (e.g. indirect effects) Instead, Appendix 13.1 and Appendix 13.2, have been reviewed as these contain crucial information on the underlying data.	Noted. This means that Natural England have not reviewed elements of the assessment prior to submission of the DCO Application.
Natural England	Section 42 Consultation Response (10/06/21)	Project parameters are clearly defined, but it is not clear whether worst-case scenarios have been.	The assessment makes use of the template for presenting the worst-case scenario that Natural England have prepared. The information is presented in **Section 11.3.2**.
Natural England	Section 42 Consultation Response (10/06/21)	Natural England continue to be concerned by the limited number of transects within the individual reporting regions and the use of design-based, rather than a model-based analysis approach. It is important to note that employing a design-based approach requires that the survey design (transect orientation, spacing etc.) has been carefully considered, particularly when study regions are non-rectangular (Thomas *et al*, 2010).	As requested by Natural England, model-based density estimation has been considered for Sandwich tern only, and is presented in **Appendix 11.1 Offshore Ornithology Technical Report**. The impact assessment uses both design-based and model-based density estimates throughout, to enable comparisons to be made between the outputs. Thomas *et al*. (2010) makes reference to the use of sawtooth and zigzag transect

Consultee	Date, document and/or meeting	Comment	Project response
			designs when dealing with non-rectangular study regions. However, since the aerial survey study area (and hence SEP and DEP) themselves rely on a parallel transect design, this point is not applicable.
Natural England	Section 42 Consultation Response (10/06/21)	We request that more information is provided regarding the survey data and survey design that has been used to calculate the abundances/densities. Some of the reasons given as to why a model-based approach would not be appropriate centre around spatial coverage and sample size. We request that a clear figure of survey design and information on transect length per reporting region and % coverage per reporting region is provided, and that the number of observations per reporting region (for focal species at least) are provided.	The transect design has been provided on **Figure 11.1**. The approximate transect lengths and approximate percentage coverage achieved by the study design in each reporting region is presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Section 42 Consultation Response (10/06/21)	In regards spatial coverage, we note a minimum target of 10% coverage was set. However, no detailed information has been provided on how the survey design was arrived at. Surveys need to have been designed to collect a representative sample on bird density across the survey area. Independent samples are typically considered to be individual transects or survey grids. Too little coverage and/or too few independent samples may lead to density estimates lacking in accuracy and/or precision. This can result in inaccurate estimates of abundance and distribution, potentially with wider confidence intervals than would be attained with more comprehensive sampling. This in turn can lead to a wider range of estimates of potential impacts and reduce the future ability to detect changes in bird abundance and distribution. The Applicant has commissioned digital aerial surveys conducted using 4 video cameras but has only analysed and presented data from 2 cameras. On Natural England's request the Applicant conducted a preliminary assessment of whether the analysis of 4 cameras (vs 2) improved the precision of the abundance/density estimates. Following presentation of	Noted. In response to Natural England's concerns, coverage for all surveys between March and September has been increased to 20%, for all species recorded during these surveys. This has been achieved through the analysis of additional camera data collected during baseline surveys carried out between March and September. This time period was selected as it encompasses the breeding season for all key species considered by the assessment. The coefficient of variation values for each density estimate have been presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

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		these findings at an Evidence Plan Topic Group, Natural England advised that the analysis of 4 cameras should be considered for focal species in key months, as the preliminary findings suggested there was greater benefit when abundance/density was higher. We note that if all data collected had been analysed (i.e. from all 4 cameras) for each monthly survey to generate density and population estimates for species there would have been coverage of approximately 20% of the survey area for each survey. The level of coverage that can be considered sufficient for baseline characterisation will depend on the nature of the area being surveyed and the abundance and distribution of receptors across the area. If a narrower transect width is used for surveys (e.g. a 250m transect width for 2 cameras, rather than a 500m width for all 4 cameras) then it is likely that a larger number of transects will be needed to achieve the same level of precision as would be derived from a sample of wider transects (Buckland *et al*., 2012; Thaxter and Burton, 2009). We also request that an associated measure of the level of precision (e.g. % coefficient of variation) is presented for density/abundance figures of focal species.	
Natural England	Section 42 Consultation Response (10/06/21)	We would expect that evidence from a power analysis of existing data sets to be used, in order to demonstrate that the survey coverage and design selected would provide an adequate baseline characterisation. If at the Examination stage the survey design and/or percentage coverage are questioned by the Examining Authority, SEP and DEP would need robust evidence to justify the approach taken.	It is unclear why power analysis would be expected. The Applicant is not aware of this technique informing study design for other OWFs. The survey design employed for SEP and DEP is comparable to baseline survey programmes employed at other OWFs which have received consent. With respect to the size of the study area relative to the OWFs, and survey coverage, the study design of SEP and DEP substantially exceeds what has been carried out by many other OWFs.

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Natural England	Section 42 Consultation Response (10/06/21)	Natural England advises that best practice is to use the Natural England PVA tool to create up to date, robust and consistent population models for all species that require population modelling, rather than depending on past population models presented in previous applications. Natural England requests that up to date population models are presented for gannet, guillemot, razorbill, and kittiwake, using the Natural England PVA tool, and providing the associated log file for each model built. This ensures transparency and consistency. We would be pleased to have further discussions with the Applicant on this process, prior to submission of the DCO application.	PVAs for North Norfolk Coast SPA Sandwich tern, and Flamborough and Filey Coast SPA gannet, guillemot, kittiwake and razorbill have been prepared and included within the assessment. Details are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Section 42 Consultation Response (10/06/21)	We note that for Sandwich tern, the in-combination assessment should include all OWFs within the relevant BDMPS outside the breeding season, in this case the UK North Sea and channel BDMPS.	The cumulative and in-combination assessment includes all data that could be located for impacts on North Norfolk Coast SPA Sandwich terns during the non-breeding season. The sources are referenced in the text as they are referred to, and are all listed in the references section at the end of the chapter.
Natural England	Section 42 Consultation Response (10/06/21)	We would like to request the following additional information is provided, in order to allow Natural England to assess the robustness of the underpinning analyses: 1. PVA log files 2. Band spreadsheets for all CRM presented 3. All data presented according to Natural England template (as attached) 4. Survey information as per above (including number of observations per survey per species, survey effort per reporting region, distribution maps of key species)	All of the requested data have been supplied as part of the assessment and can be found in **Appendix 11.1 Offshore Ornithology Technical Report**.

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Natural England	Section 42 Consultation Response (10/06/21)	*'...the area of sea within the boundary of the Greater Wash SPA, as defined by its other features, holds one of the largest known wintering populations of little gull in the UK and therefore merited classification as an SPA according to the UK SPA selection guidelines. However, birds outside the boundary of the SPA are not considered to be part of the qualifying feature. The birds present at SEP and DEP are therefore not part of the qualifying feature, which is screened out as no impacts on it are predicted.'* This doesn't seem to be consistent with the reasoning presented for the screening in of Sandwich tern at Greater Wash SPA. These birds remain qualifying features of the Greater Wash SPA when outside the boundary of the site (para 1225). Please clarify why different approaches have been taken.	Following discussions on this point, little gull has been screened into the **RIAA** (document reference 5.4).
Natural England	Section 42 Consultation Response (10/06/21)	Natural England is not only concerned about the additional displacement from SEP turbines on the distribution of red-throated divers within the Greater Wash SPA, but also from associated activities. Please see our advice for the EA1N examination as there are similar issues albeit to a different SPA. We advise that as a minimum the best practice protocol for mitigating vessel disturbance on red-throated diver should be adopted for any transiting vessels associated with the works i.e. • Avoiding transiting the site between 1st November and 1st March (inclusive) • selecting routes that avoid known aggregations of birds; • restricting (to the extent possible) vessel movements to existing navigation routes (where the densities of divers are typically relatively low);• maintaining direct transit routes (to minimise transit distances through areas used by divers); • avoidance of over-revving of engines (to minimise noise disturbance); and, • briefing of vessel crew on the purpose and implications of these vessel	The Applicant has committed through the **Outline Project Environmental Management Plan (PEMP)** (document reference 9.10) to implement a best practice protocol for minimising disturbance to red-throated divers. Measures are included in **Table 11-4**.

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		management practices (through, for example, tool-box talks). However, we note that there is a potential for cable installation and O&M reburial work to be undertaken for ~ 6 months (~110 - 180 days) within the footprint the Greater Wash SPA. Therefore, red-throated diver in the vicinity of the export cable could be displaced for the full over wintering period for this species. Natural England is increasingly becoming concerned in relation to disturbance and/or displacement of red-throated divers from the more persistent presence of OWF-related vessels. In this context of increasing vessel activity, we consider that a 'worst-case scenario' of ~ 180 days of cable burial during the period that red-throated diver are likely to be most sensitive (1st November to 1st March inclusive) could make a meaningful contribution to in-combination effects on the SPA. This gives further weight to the need for a seasonal restriction for cable installation/remediation works. As a result of this we advise that there is a likely significant effect from the proposals alone and in-combination which should be considered in the HRA.	
Natural England	Section 42 Consultation Response (10/06/21)	Greater Wash SPA Sandwich tern: Please refer to comments below in relation to Sandwich tern at the North Norfolk Coast SPA, most comments also relate to the assessment conducted for Greater Wash SPA.	This information is noted and the advice applied to assessments of both SPAs.
Natural England	Section 42 Consultation Response (10/06/21)	Regarding the 2km buffer around cable laying vessels used for displacement calculations, mortality figures presented in text are not referenced to a table/appendix. Also, it is not clear where these are from. Present method/matrix used to quantify/assess displacement effects during construction.	The matrices that underpin the assessment of disturbance and displacement in the construction phase of SEP and DEP are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

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Natural England	Section 42 Consultation Response (10/06/21)	Paragraph 1298 states 'no AEoI due to in-combination effects of export cable corridor', but this section refers to operational phase.	This section of the **RIAA** (document reference 5.4) has been checked and amended.
Natural England	Section 42 Consultation Response (10/06/21)	*"Numbers have decreased at many of the SPA sites, but have increased at some, including the North Norfolk Coast SPA and Ramsar site, such that the overall population change since designation is small."* Note this means that the North Norfolk Coast SPA is a key site in regards the UK SPA network. Natural England advise this should be taken into account when considering impacts to this population.	The current status of the North Norfolk Coast SPA and the wider suite of SPAs supporting breeding Sandwich terns have been considered during the preparation of the assessment.
Natural England	Section 42 Consultation Response (10/06/21)	There are some discrepancies between the figures presented here (Table 9.11) and those supplied to us by RSPB. Please note, there are some small discrepancies between the numbers presented here and those supplied to by Natural England and RSPB. Please double check.	Sandwich tern counts at the North Norfolk Coast SPA referred to throughout this assessment have been taken from the JNCC Seabird Monitoring Programme Database (JNCC, 2022).
Natural England	Section 42 Consultation Response (10/06/21)	*"The selection of a preferred breeding location generally shifts every few years and is thought to be due to a number of reasons. These include the presence of black-headed (positive factor) and large gulls (negative factor) at the start of the breeding season, the presence of non-avian predators (e.g. foxes), and the state of vegetation. Sandwich terns are highly vulnerable to mammal predators and declines at colonies are most often related to an increase in predator access, especially to foxes, but also rats, stoats and American mink."* Are these comments colony specific (and if so informed by who/what?) or from Mitchell *et al*. (2004)?	These comments were taken from discussions held with Bureau Waardenburg, made with the benefit of several years of experience of tagging Sandwich terns at Scolt Head.
Natural England	Section 42 Consultation Response (10/06/21)	Natural England note the reference to the latest mean peak count or equivalent in the abundance attribute, and welcome engagement around the most suitable parameterisation of the Sandwich tern PVA	The Applicant agreed that additional consultation regarding PVA would be

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			beneficial. A workshop was therefore held in November 2021.
Natural England	Section 42 Consultation Response (10/06/21)	*"Displacement rates of 30% to 50%, and a maximum mortality rates of 1% to 5% of displaced birds, are considered as the potential range of displacement effects."* Please provide an explanation (or reference to where the explanation is provided) as to why these rates have been selected.	Additional work carried out since PEIR has resulted in displacement rates for Sandwich tern being set at 0.000 to 0.500, and mortality rates of displaced birds at 1%. The evidence and reasoning supporting this is presented in **Section 11.6.2.1.3.5**.
Natural England	Section 42 Consultation Response (10/06/21)	*"Due to data availability, only birds in flight are included in the totals for OWFs other than SEP and DEP."* It would be good to present the implications of only using birds in flight data, by presenting the % of birds in flight vs all birds for SEP and DEP in this section (Natural England note this is presented in para 24 appendix 13.2).	No changes to the assessment have been made in light of this comment. Of the 1,710 Sandwich tern observations made during the SEP and DEP baseline surveys, 1,676 (98%) were of birds in flight. The inclusion of the extra birds would not materially affect the assessment as the predicted displacement mortalities would be unchanged, and the outcome or conclusions of the assessment would be the same.
Natural England	Section 42 Consultation Response (10/06/21)	*"When combined, this would increase the baseline mortality of the SPA breeding population (989 adult birds per year based on an adult population of 9,700 individuals and the adult mortality rate of 10.2%)"* This is the 2018 population size. Please clarify why this has been selected?	In the years during the collection of the majority of baseline data (2018 and 2019), the mean Sandwich tern population of the North Norfolk Coast SPA was 9,443 individuals. The baseline annual mortality of this population, assuming an adult mortality rate of 10.2% (Horswill and Robinson, 2015), is 963 birds. This population and baseline mortality are used as the basis of the increase in mortality calculations.

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			For population modelling, the mean count between 2010 and 2019 of 8,369 individuals was used as the starting population. The baseline annual mortality of the 2010 to 2019 mean population, assuming an adult mortality rate of 10.2% (Horswill and Robinson, 2015), is 854 birds.
Natural England	Section 42 Consultation Response (10/06/21)	*"The context of a population that has experienced a mean annual growth of 8.5% between 2010 and 2020 (Section 9.3.2.1)."* Natural England advise the 2020 figure should be excluded from calculations at this point, as: i) It is likely that the increase in population size was actually due to an influx of birds from a failed Dutch colony that moved to North Norfolk later in the spring. This has been evidenced via both ringing and colour ringing observations (T. Bolderstone, NE senior reserve manager, pers comm. 2021) ii) The survey data collected to inform SEP and DEP covers the 2018-2019 breeding seasons (with the exception of April 2020).	The Applicant agrees. The ES and **RIAA** (document reference 5.4) do not use 2020 count data for the North Norfolk Coast SPA in quantitative assessment.
Natural England	Section 42 Consultation Response (10/06/21)	*"Table 9-19: In-combination collision risk for Sandwich terns of the North Norfolk Coast SPA and Ramsar site using consented OWF parameters, avoidance rate 0.9883."* Please clarify why the in-combination total for all Greater Wash OWF (excluding SEP and DEP) is so much lower than the original DECC AA. Presumably this is due to a number of differences in regards CRM selection, flight height, etc. Clarity on this critical issue is needed.	A formal sensitivity analysis has not been carried out, but it is suspected that the use of the Option 2 flight height distribution in PEIR ("Corrigendum," 2014; Johnston *et al*., 2014) is the main contributory factor to this observation. The use of the Harwood (2021) flight height distribution returns CRM outputs to levels similar to those reported in DECC (2012).

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Natural England	Section 42 Consultation Response (10/06/21)	Where is the information on as built wind farm parameters presented? On the question of as-built parameters, please see Natural England Response to EA1 Non Material Change Application regarding the appropriateness of using as-built values.	This information is presented in **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.
Natural England	Section 42 Consultation Response (10/06/21)	*"Table 9-25: Predicted in combination seasonal and annual collision and displacement mortality for Sandwich tern apportioned to the North Norfolk Coast SPA."* These figures appear to be the 'as-built' CRM figures, please make this clear in the legend. As Natural England have previously advised, consented figures should be used unless the 'as built' parameters have been legally secured.	The assessment generally utilises the consented OWF design CRMs when drawing conclusions, but reference to more realistic OWF designs is made to ensure that an appropriate level of precaution is used and understood within the assessment.
Natural England	Section 42 Consultation Response (10/06/21)	PVA time span should represent windfarm life span - 35 years. Please correct.	All PVAs have been altered to run for 40 years (the lifetime of SEP and DEP). It has been assumed that all other OWFs considered within the cumulative and in-combination will also continue to operate throughout this period. This, along with the use of consented OWF parameters, mean that there is a considerable risk that impacts are overestimated.
Natural England	Section 42 Consultation Response (10/06/21)	*"It is nevertheless assumed on a precautionary basis that all gannets subject to impacts of collision and displacement at SEP and DEP during the breeding season are breeding adults from the SPA."* It would be useful to state the breeding season months here and confirm that the breeding season is considered to be March – September, in line with what Natural England advise (Furness, 2012).	The text has been amended to incorporate the breeding season months. This also applies to similar text for other species.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Section 42 Consultation Response (10/06/21)	*"Seasonal and annual population estimates of gannets at SEP and DEP, within the extension sites and a 2km buffer, are given in Table 9-37. This table also includes seasonal and annual population estimates for all OWFs included in the in-combination assessment (for the development and a 2km buffer where available, although the buffer zones for in-combination sites included in this assessment varied between 0km and 4km depending on the data available."* It would be useful if there was a table presented or the figures highlighted in the raw data in PEIR Appendix 11.1 Offshore Ornithology Technical Report, Royal Haskoning DHV (2021) to show exactly which data from the survey have been used to calculate the figures in Table 9-37.	Whilst this request was considered, it was deemed challenging to achieve whilst retaining the existing presentation of the baseline data. It has therefore not been included for gannet, or other species.
Natural England	Section 42 Consultation Response (10/06/21)	*"Seasonal and annual population estimates of gannets at DEP, SEP and other OWFs included in the in-combination assessment, apportioned to Flamborough and Filey Coast SPA."* Please inform us of the source for the figures provided for Hornsea Project Four in Table 9-37. At present Natural England advise using the Hornsea Project 4 PEIR figures as the most recently published figures.	Natural England's Relevant Representations for the Hornsea Project Four DCO Examination (Natural England, 2021) make it clear that a range of aspects of the assessment methodology have not been carried out to their suggested methodologies. For this reason, the estimated impacts due to Hornsea Project Four for all species are taken from the PEIR.
Natural England	Section 42 Consultation Response (10/06/21)	*"At displacement rates of 60% to 80% and a maximum mortality rate of 1% for displaced birds, a maximum of three SPA breeding adults would be predicted to die each year (Table 9-38). This would increase the baseline mortality of the SPA breeding population by a maximum of 0.15%."* Please provide matrices for Upper Confidence Limits and Lower Confidence Limits.	The matrices that underpin the assessment of disturbance and displacement in the operational phase of SEP and DEP for all relevant species are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Section 42 Consultation Response (10/06/21)	*"Breeding season apportionment of collisions to Flamborough and Filey Coast SPA is as per MacArthur Green and Royal HaskoningDHV (2021b)."* Provision of reference only is insufficient. Define in text. It is not clear what breeding population has been used for FFC SPA. Has the most recent SPA population been used, as for the calculation of baseline adult mortality (1509)?	Apportioning methods have been explained in the **RIAA** (document reference 5.4) text. For apportioning, the data in Furness (2015) has been used, and not the most up to date colony counts.
Natural England	Section 42 Consultation Response (10/06/21)	*"Mean peak abundance estimates (with range of recorded peak values) recorded for species recorded in the aerial survey study area during the baseline surveys, by biologically relevant season. Part seasons covered by the aerial survey programme have been included as full seasons by the mean peak calculations. Dashed cell indicate where a season does not apply to a given species for the purposes of the assessment."* This appears to be peak abundance across the entire survey area (this covers SEP and DEP regions and a large area in between. Is this useful? Mean peak is relevant to displacement, but not used in CRM.	The mean peak abundances of the wider aerial survey study area presented do not feed directly into quantitative elements of the assessment. However, it is considered to be useful background information as it demonstrates the peak numbers of marine ornithology receptors present in the wider area during different seasons and has therefore been provided for context.
Natural England	Section 42 Consultation Response (10/06/21)	*"Average annual survival rates of offshore ornithology receptors across age classes, along with productivity and average mortality rate for entire population calculated using age-specific demographic rates and age class proportions average mortality rate for entire population calculated using age-specific demographic rates and age class proportions"* This should be referenced, there is reference to data sources in text, but table should make data source clear.	The references have been added to the **Table 11-17** caption.
Natural England	Section 42 Consultation Response (10/06/21)	Section 13.6.2.2.2.1 - Note that Band Option 2 used for all species recorded in flight to screen. No specific information or justification on lower limits used to screen out species at this stage. Define screening parameters. It may be more appropriate to use something other than CRM to screen species out.	The approach to screening is based on the assessment methodology described in **Section 11.6.2.2.2.3**. Any species where the combined annual collision rate was greater than one was screened into further assessment. Some species which did not meet this threshold but are

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			considered to possess high sensitivity to collision were also screened in.
Natural England	Section 42 Consultation Response (10/06/21)	It is probably not useful to include birds that were absent from both sites. Remove absent birds.	Birds absent from both SEP and DEP have been removed from the table.
Natural England	Section 42 Consultation Response (10/06/21)	Have used upper figure of the Natural England advice, which is to apply the following ranges of nocturnal activity levels in CRM: Gannet: 1-2 (equating to 0-25% nocturnal activity), Kittiwake: 2-3 (equating to 25-50% nocturnal activity), Large gulls (LBBG, herring gull, GBBG): 2-3 (equating to 25-50% nocturnal activity). This is an acceptable method as worst-case is used, but please be aware that Natural England has advised other projects that it would be appropriate to calculate CRM for a range of nocturnal activity to present range of predicted impacts.	As well as the upper figure of Natural England's advice on nocturnal activity factors (**Table 11-102**), CRMs using evidence-based rates are presented for species for which they were available.
Natural England	Section 42 Consultation Response (10/06/21)	Biometric parameters only presented in Appendix 13.1, in which the date presented in Table 13-3 is not referenced. Please state the origin of tern biometric and behaviour parameters and confirm sources of data in the appendix table by referencing.	The references have been added to the relevant table in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Section 42 Consultation Response (10/06/21)	Table legend is unclear. Update table legend to clarify that figures presented are % of time operational.	The **Table 11-3** caption has been updated.

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Natural England	Section 42 Consultation Response (10/06/21)	Natural England advise that CRM should be presented as monthly figures.	The CRM outputs are presented as monthly figures in the tables, with seasonal figures referred to in the accompanying text. Monthly figures for offshore ornithology receptors screened out of the assessment are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Section 42 Consultation Response (10/06/21)	*"The lower, mean, and upper collision estimate for each scenario is presented, based on the results obtained from including the appropriate variation about mean values for density (95% lower and upper confidence intervals), flight height (95% lower and upper confidence intervals) and avoidance rate (two standard deviations). Presented within the same table are percentage increases in background mortality rates of seasonal and annual populations (Table 13-16)."* This is the correct approach but does not appear to be the case in the following tables, please amend if needed.	The CRM outputs are presented separately for each parameter variation in the tables, with comment on this provided in the text.
Natural England	Section 42 Consultation Response (10/06/21)	Please provide this figure.	All figures are provided in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Section 42 Consultation Response (10/06/21)	*"…along with the total length of transects used in subsequent analysis."* These are the total transect lengths in the entire aerial survey area. Include the transect lengths and a clear figure that shows the transects for the SEP and DEP areas (with buffers indicated).	The transect design has been provided on **Figure 11.1**. The approximate transect lengths and approximate percentage coverage achieved by the study design in each reporting region is presented in **Appendix 11.1 Offshore Ornithology Technical Report**. These figures are approximate as exact survey effort differed slightly between surveys due to minor differences in start and stop

Consultee	Date, document and/or meeting	Comment	Project response
			times for transects and minor deviations of the aircraft from the transect line.
Natural England	Section 42 Consultation Response (10/06/21)	It is worth noting that surveys are all conducted between 9 and 3. We recommend you include discussion of the bias (if any) this might introduce.	Some bias in the survey methodology is unavoidable. There is little scope to vary the time of day at which surveys occur, due to factors such as aircraft logistics, transit to and from the study area, the timing of windows for suitable light and weather, commencement of surveys sufficiently early to complete in a single day, and leaving time for survey completion in the event of any issues during the survey. It should be noted that this is not an issue restricted to SEP and DEP, it is a potential issue at all OWFs.
Natural England	Section 42 Consultation Response (10/06/21)	Where is the additional survey information presented/used? Please consider.	With regard to age classification, 92% of all birds were recorded as either “blank” or “unknown”. The recorded age classes of gannet and kittiwake are used in the **RIAA** (document reference 5.4) to refine the breeding season apportioning predictions of breeding adults from the Flamborough and Filey Coast SPA. Due to concerns around the small numbers of birds assigned a sex or behaviour, unknown reliability of the observations made, and the unknown potential for biases in this information,

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			sex and behavioural observations are not used by the assessment.
Natural England	Section 42 Consultation Response (10/06/21)	Natural England have concerns over the reporting regions. Please clarify whether DEP North and DEP South are treated as independent reporting regions for the purpose of this analysis.	DEP-N and DEP-S are treated as a combined reporting region in the design-based density estimates. Assessment of the baseline survey data indicates that for many species, there was very little difference in encounter rate between DEP-N and DEP-S. The model-based density estimates produced for Sandwich tern enable the scenario where all turbines might be installed in DEP-N to be examined quantitatively (with respect to collision) for Sandwich tern only (**Section 11.6.2.2.2.4**). The mean density estimates within DEP-N are larger than DEP as a whole, but there is considerable overlap of the 95% CIs, indicating that differences are not likely to be statistically significant.
Natural England	Section 42 Consultation Response (10/06/21)	Natural England note that we advised the use of published flight heights and Option 2, as the survey methodology (digital aerial surveying) did not include an adequate method to record flight heights. However, the review presented in para 26 and beyond, and our own analysis of this matter, suggests that in this instance (for Sandwich Terns breeding in the Greater Wash area) the published flight height distributions are underestimating the proportion of birds that fly at potential collision height. Natural England advise that we have contracted ECON ecology to re-analyse flight height data collected during the Sheringham Shoal post-consent monitoring (and presented in Harwood *et al*. 2018). This report is	The revised flight height distribution for Sandwich tern was received in September 2021, and along with Option 2 CRM, is used as a source of Sandwich tern flight height information by the assessment.

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		currently in final draft stage and will be made available to the applicant within the next month. It is Natural England's opinion that this data set constitutes the best available evidence to inform CRM for Sandwich Tern in the Greater Wash. Unlike most data collected on flight height, this work has been validated via the use of range-finders and collected at a site adjacent to the project areas subject to current assessment. We will share this report with the applicant as soon as it is finalised.	
Natural England	Section 42 Consultation Response (10/06/21)	*"The upper 95% confidence limit of the Johnston et al. (2014) and "Corrigendum" (2014) dataset overlaps with the percentage of birds recorded at PCH predicted by the SOW and DOW baseline surveys."* It only appears to overlap with the PCH predictions for SOW and with Triton Knoll.	The relevant text in **Appendix 11.1 Offshore Ornithology Technical Report** has been amended.
Natural England	Section 42 Consultation Response (10/06/21)	*"However, a possible explanation for the lower flight height estimates in the Johnston et al. (2014) and "Corrigendum" (2014) dataset is that these data are expected to contain large numbers of birds on passage, or dispersing from colonies outside the breeding season, and that Sandwich terns may tend to fly at lower heights during these times than they do during the breeding season (Perrow et al., 2017)."* This suggests that the Johnston *et al*. (2014) and "Corrigendum" (2014) data should be limited to use outside the breeding season.	This is a reasonable suggestion. The assessment has dealt with this by relying on the flight height distribution of Harwood (2021) in Sandwich tern CRM.
Natural England	Section 42 Consultation Response (10/06/21)	*"These are lower levels of macro-avoidance incorporated into the 0.989 avoidance rate for this species."* What does this mean?	This text refers to the macro-avoidance incorporated into the currently recommended avoidance rate of 0.989. The text in **Appendix 11.1 Offshore Ornithology Technical Report** has been developed to explain this point with greater clarity.
Natural England	Section 42 Consultation Response (10/06/21)	Natural England have concerns about gannet avoidance rate. Please see related points. Note that ORJIP collected no data on gannet collisions.	The gannet avoidance rate of 0.989 that is used throughout the assessment is that recommended by SNCB guidance (UK SNCBs, 2014).

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Natural England	Section 42 Consultation Response (10/06/21)	*"For gannet, a nocturnal activity value of 25% has been used in this assessment, although CRM outputs are also presented using the evidence-based value of 8%."* Please reference tables where these CRM outputs are presented.	CRM outputs for gannet using both nocturnal activity factors are presented in **Table 11-107**.
Natural England	Section 42 Consultation Response (10/06/21)	*"For kittiwakes and other gulls, nocturnal activity values of 50% have been used in the CRMs in this assessment, following the default values given in Band (2012). For kittiwake, a review and analysis of activity data from tracking studies (Furness et al. in prep.) has identified nocturnal activity rates for the breeding and non-breeding seasons, respectively, of 20% and 17% based on empirical evidence. Therefore, the 50% value used here is considered highly precautionary. CRM outputs for kittiwake are also presented using the evidence-based value of 20%."* Please reference tables where these CRM outputs are presented.	CRM outputs for kittiwake using both nocturnal activity factors are presented in **Table 11-110**.
Natural England	Section 42 Consultation Response (10/06/21)	*"Other than differences in the categorisation of flight activity, the methodology employed was identical to the published work of Fijn and Gyimesi (2018)."* Please could this statement be explained? The categorisation of flight activity seems quite significant to rates presented.	Further detail on the differences has been added to **Appendix 11.1 Offshore Ornithology Technical Report** to illustrate the differences in categorisation, along with a summary of the result of these changes on the outputs.
Natural England	Section 42 Consultation Response (10/06/21)	Natural England have concerns about kittiwake and gannet apportioning. Natural England queries why age class data has not been used to refine this apportioning.	This step was omitted in error from the PEIR submission. It is now included.
Natural England	Section 42 Consultation Response (10/06/21)	*"This equates to a latest total population size of 165,469, when calculated as individuals and multiplied up to include subadult birds, based on the adult proportion of 0.53 from Furness (2015)."* It is unclear as to why sub-adults are being accounted for here, when apportioning approaches calculate number of breeding adults. Please could this be clarified.	This calculation is not used in and does not influence the assessment. It has therefore been removed from the document.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Section 42 Consultation Response (10/06/21)	*"This equates to a latest total population size of 15,902, when calculated as individuals and multiplied up to include subadult birds, based on the adult proportion of 0.61 from Furness (2015)."* Natural England query why is this calculation presented and how it has influenced the assessment.	This calculation is not used in and does not influence the assessment. It has therefore been removed from the document.
Natural England	Section 42 Consultation Response (10/06/21)	*"As the population of Sandwich tern at the North Norfolk Coast SPA appears to have increased between 2008 and 2018 (JNCC, 2020), and appears to have been relatively stable since approximately 2013, the population estimate based on the 2018 count (breeding and non-breeding/sub-adult birds) has been used as a reference population."* Interpretation of population trends is, of course, greatly influenced by the time period over which the trend is assessed. For example, examination of the period, 2006 to 2016, would suggest that the population was more or less stable rather than increasing (and 2008 was a low point in the population numbers).	This is noted. Assessment of population trends at a range of temporal scales have been included in the **RIAA** (document reference 5.4), in order to try and present a balanced view of Sandwich tern population trends at the North Norfolk Coast SPA.
Natural England	Section 42 Consultation Response (10/06/21)	*"Since 2015, the majority of Sandwich terns breeding in the North Norfolk Coast SPA have been located at Scolt Head, and not Blakeney Point (JNCC, 2020). The selection of a preferred breeding location is due to a number of reasons. These include the presence of black-headed (a positive factor for Sandwich tern colonisation) and large gulls (a negative factor for Sandwich tern colonisation) at the start of the breeding season, the presence of non-avian predators (e.g. foxes), and the state of vegetation."* Please provide references/evidence source.	These comments were taken from discussions held with Bureau Waardenburg, made with the benefit of several years of experience of tagging Sandwich terns at Scolt Head.
Natural England	Section 42 Consultation Response (10/06/21)	*"Considering differential at-sea distributions due to colony switching"* Natural England welcome the review presented within this section and would welcome engagement on how this could be improved to better understand if impacts are likely to differ in years when Sandwich terns favour Blakeney Point over Scolt Head.	Discussion is included within the assessment.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Section 42 Consultation Response (10/06/21)	*"It is proposed to undertake investigations into the differences between the modelled population trend and observed trends at the North Norfolk Coast SPA as part of the final Environmental Statement (ES) submission, particularly with respect to how impacted scenarios might vary when applied to increasing, stable, or decreasing baseline scenarios."* We would welcome engagement as regards PVA scenarios, and the parameterisation of the models.	A PVA workshop was held in November 2021. A summary of the key points discussed is provided later in this table.
Natural England	Section 42 Consultation Response (10/06/21)	MacArthur Green, 2020a - Headroom calculations - It is noted that these are presented, but not used for assessment. Natural England do not advise that the approach presented as a method for altering the collision figures of planned and consented projects. Our advice is that the CRM should be completely re-run for built and refined projects (assuming the developer in question has not already done so), using project-specific bird density data, in order to generate updated collision figures for a legally-secured built or refined project design. Please also see our advice above regarding the legal basis for heagapdroom.	This advice is noted. In the absence of re-run CRM using as-built designs for many of the OWFs in question, these figures have been retained for comparison within the assessment. For the cumulative and in-combination collision risk assessment for Sandwich tern (**Section 11.7.3.2.5**), three scenarios in addition to consented and as-built OWF designs have been considered. The first assumes that any unbuilt capacity at the consented OWFs is built out using turbines of the same specification as the consented design. The second assumes that any unbuilt capacity at the consented OWFs is built out using turbines of the same specification as those actually used at the OWF. The final set of CRM outputs is the same as the latter scenario, but with the assumption that the as-built layout of DOW is legally secured. Further details describing the

Consultee	Date, document and/or meeting	Comment	Project response
			mechanism for securing the as-built layout of DOW are provided in **Chapter 4 Project Description**, the **Explanatory Memorandum** (document reference 3.2) and the **Draft DCO** (document reference 3.1).
Natural England	Fourth ETG Meeting (10/08/21)	Regarding evidence on the robustness of using model-based density estimation vs design-based methods, precision may not differ between the two but it is possible that there could be reasons (e.g. coefficient of variation) to have greater confidence in the data produced using model-based density estimation.	This has been explored during the assessment of the model-based density estimates produced for Sandwich tern in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Fourth ETG Meeting (10/08/21)	For design-based density estimation to work well, survey design is really important. What hasn't been provided to Natural England to date is a clear description of why the survey was designed in the manner that it was.	Information regarding the selection of transect orientation, and the survey methodology, is provided in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Fourth ETG Meeting (10/08/21)	Regarding design-based methods, it seems that there may be a missed opportunity because there is a large survey area which is disregarded for the impact assessment, but which could be included if model-based estimates are used.	As requested by Natural England, model-based density estimation has been undertaken for Sandwich tern only, and is presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Fourth ETG Meeting (10/08/21)	10% survey coverage is an arbitrary figure, no evidence to support that this is appropriate. Would make more sense to work to a certain coefficient of variation for each species so e.g. for some species, for some months, a higher coverage may be appropriate. It's not as clear cut whether 10% or 20% is appropriate. Power analysis has been considered to potentially inform this figure however this isn't a method commonly employed at the present time.	Coverage for all surveys between March and September has been increased to 20% for all species recorded during these surveys. This has been achieved through the analysis of additional data collected during these surveys. March to September was selected as it encompasses the breeding season for all key species considered by the assessment.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Fourth ETG Meeting (10/08/21)	Is there a reason why the coefficients of variation for density estimates can't be made available?	The coefficients of variation for the density estimates have been added to the tables in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	Fourth ETG Meeting (10/08/21)	Do the existing DOW and SOW sites form part of the SEP and DEP buffer zones?	Yes. This can clearly be seen in **Figure 11.1**.
Natural England	Fourth ETG Meeting (10/08/21)	Did you take statistical advice whether it was appropriate to consider the northern and southern polygons of DEP as a single entity?	Yes. The potential for treating the DEP-N and DEP-S individually was examined in conjunction with HiDef Aerial Surveying, but it was considered that the transect lengths within DEP-N and DEP-S were too small for reliable design-based density estimation to be possible.
Natural England	Fourth ETG Meeting (10/08/21)	The BTO avoidance rate review should be finalised and on their website any day now. However, we can share the key findings from that review essentially a tabulated list of the avoidance rates that are recommended. Other stage to that is the SNCB note in response to their review which is not available in the next few days but is being worked on. SNCBs are very likely to adopt these ARs.	This information was noted. The avoidance rate review was published in August 2021 (Cook, 2021). In October 2021, Natural England informed the Applicant that it is not appropriate to use the recommended rates in the BTO report. This followed a review of the data underpinning the report by MacArthur Green. The assessment has complied with this request.
Natural England	Fourth ETG Meeting (10/08/21)	Natural England agree that non-breeding Sandwich tern collision estimates from other windfarms for cumulative/in-combination collision risk assessment can follow approach used previously for kittiwake, gannet and large gulls.	A review of other OWF assessments for which passage Sandwich tern were quantitatively assessed was undertaken, but none were identified.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Fourth ETG Meeting (10/08/21)	One of the parameters that we were looking at when looking at PVAs was considering how to look at the two colonies (Scolt Head and Blakeney Point). You have a problem where low productivity at one site and high at the other and it switches between the two. One way to deal with this would be a weighted mean population and productivity estimate in order to incorporate the two subpopulations as one but weighting the population to allow for that. This needs to be considered in the PVA quite carefully.	This approach was followed during the production of Sandwich tern PVAs.
Natural England	Fourth ETG Meeting (10/08/21)	Re. colony counts, it may be reasonable just to draw the line at 2019. 2020 is unusual (immigration). 2021 therefore difficult to use without using 2020.	This approach was followed during the production of Sandwich tern PVAs.
Natural England	Fourth ETG Meeting (10/08/21)	With respect to the revised Sandwich tern flight height distributions (Harwood, 2021), the “ESAS style” flight height distributions are the most appropriate for use in CRM, and are the most similar to Johnston *et al*. (2014) measurements.	The Harwood (2021) flight height distribution has been used by the assessment to carry out Sandwich tern CRM.
Natural England	Fourth ETG Meeting (10/08/21)	Natural England have concerns around the flight height distributions collected using RIB tracking studies (autocorrelation). This could be dealt with through further analysis and may not be an issue but don't know that until/unless it's looked at.	Noted. The Harwood (2021) flight height distribution used was collected during ‘ESAS style’ boat-based surveys, and not RIB tracking studies.
Natural England	Fourth ETG Meeting (10/08/21)	Regarding Sandwich tern nocturnal activity calculations, Natural England indicated that sunrise/sunset should be measured in a way compatible with the Band model. The question that needs to be answered is how much activity is there at the project areas after sunset and before sunrise and how that compares to activity at the places after sunset and before sunrise.	The approach taken to assessing nocturnal activity of Sandwich tern is presented in **Appendix 11.1 Offshore Ornithology Technical Report**. It attempts to answer the two questions posed here.
RSPB	Fourth ETG Meeting (10/08/21)	Is the "nocturnal activity" genuine, or is it from birds leaving the colony during the day and showing in that area between daylight and darkness?	Detailed assessment of the data by Bureau Waardenburg suggests the nocturnal activity to be genuine, but often restricted spatially to areas adjacent to the colony and coast.

Consultee	Date, document and/or meeting	Comment	Project response
RSPB	Fourth ETG Meeting (10/08/21)	It would be useful to know where the birds recorded in the early morning peak are going. Could that be looked at and taken into consideration?	Bird movements at this time of day were recorded in all directions out to sea from the colony. The majority of activity at these times was nearer to the coast than SEP and DEP.
Natural England	Fourth ETG Meeting (10/08/21)	Caution against putting too much confidence in the tagging data because there aren't too many tagged Sandwich terns. It might be more appropriate to use the early boat-based data.	Noted. The Sandwich tern tagging dataset is discussed in detail in **Appendix 11.1 Offshore Ornithology Technical Report**, and its use to support the assessment has been carefully considered.
Natural England	Fourth ETG Meeting (10/08/21)	Cumulative and in-combination numbers from East Anglia ONE North and TWO are the ones most recently reviewed by Natural England. Check examination submissions for that project as there may be updated submissions.	These are used as the source for the latest cumulative and in-combination numbers as suggested.
Natural England	Fourth ETG Meeting (10/08/21)	As Great Yarmouth is being considered as an option as an operations and maintenance base, which may mean that red-throated diver of the Outer Thames SPA will need to be considered in the assessment.	This has been accounted for in the **RIAA** (document reference 5.4).
Natural England	DAS Letter, 13/09/21	It should be noted that the reliance on 10% survey coverage as an indicator of survey robustness is a long running source of discussion within the OWF industry. The SNCBs are keen to move towards a more informed, intelligent survey design, that considers how to ensure confidence in abundance figures for key species. Using an arbitrary 10% coverage guideline does not do that, as far as we are aware. Furthermore, it should be noted that Natural England have not endorsed 10% coverage in any general guidance, though there may have been instances where a survey design has been considered acceptable with that level of coverage. Power analysis is one way to explore the confidence that can be placed in the data gathered and should be considered as an option.	Noted.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	DAS Letter, 13/09/21	There has been no rationale provided for the survey design, in terms of transect position, direction (in relation to any known density gradients of birds) and spacing, or why for example the decision was taken to survey twice in some months, rather than increasing spatial coverage. This information would help inform our view on whether a design-based density estimation is appropriate. Otherwise it would be necessary for Natural England to assume that the survey design has followed a standard Digital Aerial Survey (DAS) approach and has not specifically considered the reporting regions, or gradients present.	The rationale for the transect orientation and length is provided in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	DAS Letter, 13/09/21	It seems likely that if a model-based approach to density estimation is possible, it would result in a more accurate representation of the density and distribution of birds on site, by utilising data from the full survey area and including covariates. However this approach might not necessarily improve precision. Whether the work required to do this is proportionate, considering the issues that may arise (due to sample sizes, resolution of covariates, birds in flight, etc), is not something that Natural England can advise on.	As requested by Natural England, model-based density estimation has been undertaken for Sandwich tern only and is presented in **Appendix 11.1 Offshore Ornithology Technical Report** .
Natural England	DAS Letter, 13/09/21	Based on the coefficients of variation provided, variability in the data appears to be relatively high. Previously DAS providers have aimed for a coefficient of variation of 16% and suggested that if this is not met for focal species, then analysing the other two cameras could be considered. Low precision reduces the confidence that can be placed in the mean, but gives us no indication as to whether the sample mean is close to the true mean. When considering estimated impacts, low precision will likely lead to Natural England placing greater emphasis on the upper extent of the range of impacts based on upper and lower confidence intervals (CI) in our interpretation. This increases the risk of a conclusion of unacceptable impact to the populations in question.	In response to Natural England's concerns, coverage for all surveys between March and September has been increased to 20%, for all species recorded during these surveys. This has been achieved through the analysis of additional data collected during these surveys. March to September was selected as it encompasses the breeding season for all key species considered by the assessment.
Natural England	DAS Letter, 13/09/21	For at least two species, kittiwake at Flamborough and Filey Coast SPA and Sandwich tern at North Norfolk Coast SPA, Natural England has already advised that the in-combination level of impact is at or close to an adverse effect on integrity (i.e. at or close to a conclusion of AEOI to these sites), In this context it is entirely proportionate to work towards obtaining	Noted.

Consultee	Date, document and/or meeting	Comment	Project response
		abundance and density data that is as accurate and precise as is possible (within the confines of the survey data collected).	
Natural England	DAS Letter, 13/09/21	It is stated by Johnston and Cook (2016) that flight height distributions for use within Extended Band model are not transferable across platforms. For example, densities derived from DAS should not be used with flight height distributions derived from boat-based surveys. Therefore, we do not advise the use of the extended model for Sandwich tern, so neither Option 3 nor 4 are appropriate. For the project alone assessment we advise presenting Option 1 (using Harwood, 2021) and Option 2. For the in-combination assessment, we suggest that: a) for all Greater Wash wind farm projects, Option 1 could be run using Harwood (2021). In the case of non-Greater Wash wind farms (which are unlikely to contribute many Sandwich tern overall), then either project-specific Potential Collision Heights (PCH), Harwood (2021), or Johnston *et al*. (2014) could be used. b) Option 1 could also be run using project specific PCH (as reported in each ES) for all windfarms (where available) and Harwood (2021) for SEP and DEP. c) Option 2 – using Johnston *et al* (2014) could also be run for all projects.	The approach to the project alone assessment is as suggested by Natural England. For the in-combination assessment, approach a) has been selected. The reasoning for this is that Harwood (2021) is thought to represent the best available evidence for Sandwich tern flight heights in the Greater Wash during the breeding season.
Natural England	DAS Letter, 13/09/21	In relation to the Confidence Intervals provided, Natural England notes that the Harwood (2021) report states: *"In all cases, the best fitting distributions were selected based on examination of goodness-of-fit plots and Akaike information criterion AIC*	The 95% confidence intervals of the Harwood (2021) flight height distributions are not used by the assessment.

Consultee	Date, document and/or meeting	Comment	Project response
		scores. Uncertainty in parameter estimates for each fitted distribution was estimated using parametric bootstrapping for the actual rangefinder data and nonparametric bootstrapping for the binned data (n=1,000). This produced median, lower and upper 95% CIs for the fitted distribution parameters. Note that the resultant confidence intervals modify the distribution so that the lower and upper confidence intervals may not always be lower and higher than the median fitted distributions at different flight heights." Thus, the initial analysis only provides a characterisation of the uncertainty in the parameters of the fitted distribution, rather than the required pointwise confidence intervals. Therefore, it is not appropriate to use the confidence intervals provided in the database for the CRM.	
Natural England	DAS Letter, 13/09/21	Natural England retains significant concerns regarding the use of flight speed data from the Scolt Head study (Fijn & Collier, 2020) in the absence of a detailed report on the derivation of the flight speeds from the tracking data. Without such a report, presented in a format that allows for a rigorous examination of the data and subsequent analysis of it, the confidence we can place in that data remains excessively limited and accordingly the dataset would not meet Natural England's evidence standards. Natural England acknowledges that it would be preferable to utilise the site-specific data, which should represent the best available evidence. However, we suggest that it needs to be written up in a detailed, cohesive paper or report that allows a clear assessment of the data, analysis, and any limitations to enable its use. If that is not possible (or maybe, until that is possible) then the flight speeds previously detailed by Fijn and Gyimesi (2018) should be used. Alternatively, it might be instructive to carry out modelling with both (one version using Fijn and Collier (2020), and another using Fijn and Gyimesi (2018)).	Sandwich tern CRMs have been undertaken using both flight speeds. GPS-derived flight speeds are included in the assessment since they are considered to represent the best available evidence. Detail is available in **Appendix 11.1 Offshore Ornithology Technical Report**, which is hoped will provide additional confidence in the data.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	DAS Letter, 13/09/21	In the case of Sandwich tern, the total population size is reasonably stable, and so the use of a mean (over 5 years, as presented in the PEIR, or longer), may be appropriate. However, the fact that North Norfolk Coast SPA comprises of two colonies in most years and that these colonies can differ widely in population size and productivity (both between colony and interannually) indicates that the method and time period over which a mean population is calculated needs to be carefully considered. Furthermore, Natural England recommends the exclusion of the 2020 colony count due to it being an unusual year, with exceptionally high immigration and being later than the surveyed breeding seasons. A five or even ten year mean may be appropriate, but it may be preferable to do this at the scale of the total population (i.e. Scolt Head and Blakeney Point) rather than modelling them as sub-populations.	This advice has been followed. The mean population size of the North Norfolk Coast SPA between 2010 and 2019 (i.e. ten years) was used as the PVA starting population. The population was modelled as a single population.
Natural England	DAS Letter, 13/09/21	If a single population approach is taken then weighting the productivity according to the population sizes of the two colonies should be undertaken. Productivity could be calculated to be the mean of the weighted mean over the same time period selected for the population figure. The Sandwich tern population at the North Norfolk Coast (NNC) Special Protection Area (SPA) does experience ‘catastrophic’ events that can significantly reduce productivity in some years (e.g. 2007 at Scolt Head, 2014/15 at Blakeney Point). These events should not be excluded from the overall productivity figures, as they are part of the population dynamic that has generated a stable-slightly increasing trend in the sandwich tern population over the last 40 years, but neither should they be given undue weight. Hence weighted means for productivity over a relatively long time span (e.g. 10 years) may be an appropriate approach.	This advice has been followed. The weighted mean productivity of Scolt Head and Blakeney Point colonies between 2010 and 2019 (i.e. ten years) was used as the PVA productivity.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	DAS Letter, 13/09/21	It was suggested in the PEIR that there is some degree of double counting between the juvenile survival rates and the productivity rates. Natural England would be interested to know whether there has been any quantification of the scale of this issue. Presumably this would relate to birds that are ringed as nestlings, do not subsequently fledge, but are reported as dead in the ringing recovery scheme and included in the survival estimation process. It would be helpful if it could be clarified whether this is the case. We would also appreciate discussion regarding whether this 'double counting' is likely to significantly impact the survival rate. There is an option within the Natural England PVA tool to model the populations with only the adult survival rate provided. It may be worth exploring this, before modifying the pre-adult survival rates.	This advice was noted and followed. It was not possible to quantify the scale of the potential double counting issues identified. Adult only survival models have been used for Sandwich tern PVAs presented in the assessment.
Natural England	DAS Letter, 13/09/21	Regarding PVAs for Flamborough and Filey Coast SPA species: a) Population sizes should be derived from the latest full colony population counts. A full census was conducted in 2017 and presented in Aitken *et al*. (2017). b) Productivity rates and standard deviations should be calculated using the data provided in the Flamborough and Filey Coast SPA seabird monitoring programme reports from 2009-2019 (Aitken *et al*. 2017, Babcock *et al* 2014, 2015, 2016, 2018 and Lloyd *et al* 2020). 2009 productivity data for razorbill should be excluded due to reduced plot coverage in that year. Annual productivity should be calculated as the mean of each study plot for gannet, guillemot, and razorbill. In the case of kittiwake, Natural England advise the use of 0.58 (SD 0.096) which represents mean productivity across all plots in Flamborough/Bempton and Filey for the period 2012 to 2019. This represents the period when productivity plots were covered in both Flamborough/Bempton and Filey areas of the SPA. c) Survival rates from Horswill and Robinson (2015) are appropriate, in the absence of colony/region specific survival rates. The Natural England PVA tool is prepopulated with survival rates and associated standard deviations	This advice was noted and has been followed during the production of PVAs for Flamborough and Filey Coast SPA species.

Consultee	Date, document and/or meeting	Comment	Project response
		for the species in question. It should be noted that a number of the survival rates presented in Horswill & Robinson (2015) do not have an associated standard deviation. As part of the development work for the NE PVA tool, CEH calculated SDs for these survival rates, and in some instances supplied new data (guillemot years 3-4). Table 1 (not reproduced here) details recommended survival rates and SDs. When using the Natural England PVA tool, please check that the default rates match these.	
Natural England	PVA Meeting, 10/11/21	The 0.980 avoidance rate is a non-empirically derived rate. It doesn't necessarily incorporate meso- or macro-avoidance. Most of these data will be recording flight activity at a number of turbines which would include going between, below and above the turbines. It isn't possible to tell how these may have been different if the turbines were not there. Meso-avoidance is more likely to be incorporated in those rates but would take a fair amount of unpicking to determine which of the studies that informed the rates did not incorporate meso-avoidance as a lot of them would have. Point taken though that meso-avoidance likely to be an important factor for Sandwich terns and for CRM more generally.	For Sandwich tern, a range of macro-avoidance rates have been applied to the breeding season collision rates of SEP and DEP, and other OWFs in the Greater Wash area. The range of displacement rates has been selected following a review of relevant literature, which is presented in **Appendix 11.1 Offshore Ornithology Technical Report**.
Natural England	PVA Meeting, 10/11/21	Many of the Round 2 arrays seem to be set up in simple corridors and lines of sight which may not be the case for SEP and DEP/newer sites which seem to pack turbines at the edges which would then seem to increase the importance of macro-avoidance. Have you looked at the likely layout of the design?	The offshore ornithology assessment has not considered the layout of turbines, since detailed layouts are not yet confirmed and will not be defined until post-consent. **Chapter 13 Shipping and Navigation** sets out layout principles that will be carried through to the final layout design, to be agreed post-consent in consultation with relevant stakeholders (MCA and Trinity House).
Natural England	PVA Meeting, 10/11/21	In PVA, allow a period of five years for the burn-in before the start of the impact.	This advice was noted and has been followed.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	PVA Meeting, 10/11/21	Natural England would advise use of the Centre for Ecology and Hydrology (CEH) rates which fed into the PVA tool. This is in the PVA report user guide. Natural England would prefer to incorporate 10 years of data rather than 5 into the productivity and starting population values.	This advice was noted and has been followed. Both of these points have been incorporated into the revised PVAs.
Natural England	PVA Meeting, 10/11/21	Natural England requested further information on double counting between the juvenile survival rates. Does the death of ringed chicks feed into the productivity estimates? Is that the crux of the double counting effect? No ringing data is currently available from Blakeney Point. The number of Sandwich terns that are ringed in the nest and then don't fledge but still go into the full database could be the reason for this. However it doesn't say in Robinson (2010) whether this was controlled for. At Coquet Island for roseate terns, there may be information collected on the number of ringed birds that died/never fledged. However, it is accepted that it will be difficult to quantify this. It will be reasonable to explore other rates but could just go to an adult only survival model. Juvenile and adult survival rates for other tern species are quite different to Sandwich tern, or there are no rates available. A review beyond UK waters looking at similar species might be worthwhile.	Potential issues surrounding the juvenile survival rates could not be resolved. In addition, no appropriate measurement of variation around the mean survival rates for other immature classes is available for Sandwich tern. For these reasons, adult only survival models have been used.
Natural England	PVA Meeting, 10/11/21	Anything that is an 'as built' OWF design has to be legally secured and then the remaining consented section could be modelled and presented as a worst-case. However, the Natural England position on this advice has not yet been formalised. Further still, a worst-worst-case is all projects being based on the consented design envelopes.	This advice was noted and has been followed in the Sandwich tern cumulative assessment. CRM has been undertaken using five different scenarios of OWF design. These are consented, as-built, and three further as-built scenarios with additional turbines (either consented or as-built type) used to expand the as-built OWF design to consented capacity. Further information is presented in **Section 11.7.3.2.5**.
Natural England	PVA Meeting, 10/11/21	Sheringham Shoal post-construction monitoring showed an increase in 2% of the CRM outputs from what was presented within the project's EIA. How	This has not been incorporated into the assessment. The reason for this is that

Consultee	Date, document and/or meeting	Comment	Project response
		can you present the 'as-built' modelling for this within the SEP and DEP assessment?	all in-combination and cumulative impact assessments for collision risk rely on models using baseline data as an input parameter. This approach has been used across the industry for some time.
Natural England	PVA Meeting, 10/11/21	There is post-construction monitoring data from Race Bank and Lincs. Could be worthwhile to present the results from those within the assessment to show the reality of the impacts.	Information from the available post construction monitoring reports for these two projects has been referred to as appropriate.
Natural England	PVA Meeting, 10/11/21	None of the post-construction monitoring studies at OWFs near SEP and DEP have estimated collisions. Dudgeon tagging data used a methodology that was developed in the Netherlands to calculate an avoidance rate (although not directly relevant to Band) but also produced an attraction / avoidance index which may be useful. There are ways of analysing tracking data. Appreciate that that will not be useable in the Band model directly but might be useful to sense check and contextualise some of these predictions.	Whilst potentially useful, the calculation of revised avoidance rates is beyond the scope of this assessment.
Natural England	PVA Meeting, 10/11/21	Natural England indicated that in their view, it is not worth considering the fact that the operational lifetime of the existing windfarms is unlikely to be for 35 years. This is because there is just as much chance of them being re-powered as being decommissioned.	This advice was noted and has been followed. All existing OWFs are assumed to be operational for the lifetime of SEP and DEP, which is 40 years.
Natural England	PVA Meeting, 10/11/21	From a Natural England perspective it would be reasonable to include catastrophic events within the productivity estimates, and to therefore use ten year means for starting population and productivity. This would reflect the ecological reality that Sandwich terns are particularly prone to these events. Natural England would also be keen that the weighted productivity was over a longer period of time, and suggest potentially just using adult only survival rate models.	This advice was noted and has been followed. Productivity estimates for the Sandwich tern PVAs are based on a weighted mean between Scolt Head and Blakeney Point from 2010 to 2019. Adult only survival models have been used.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Fifth ETG Meeting (09/02/22)	The northwest tip of the DEP north array area is likely to have more Sandwich terns compared to the south and therefore would be very helpful to have these split out with respect to density estimates.	The model-based density estimates produced for Sandwich tern enable the scenario where all turbines might be installed in DEP-N to be examined quantitatively (with respect to collision) for Sandwich tern only (**Section 11.6.2.2.2.4**).
Natural England	Fifth ETG Meeting (09/02/22)	Natural England raised a number of technical points relating to model-based density estimation of Sandwich tern, including inclusion (or otherwise) of particular covariates in the model.	A separate meeting with the author of the model-based density estimates (expert from HiDef Aerial Surveying) was proposed, and the draft report of the work shared with Natural England. Details are summarised later in this table.
Natural England	Fifth ETG Meeting (09/02/22)	Combining the two separate DEP array areas in the design-based density estimation could be driving some of the uncertainty / lack of precision in the Sandwich tern data.	This is possible. However, there was a clear rationale for having to combine them (short transect lengths in both regions potentially leading to low quality density estimates).
Natural England	Fifth ETG Meeting (09/02/22)	The northwest tip of DEP needs to be removed, since that is where the sandbanks/sandeels are, and therefore where the Sandwich terns are more likely to be.	Any changes / additional mitigation would need to be driven by evidence. **Chapter 3 Site Selection and Alternatives** and the **Offshore Design Statement** (document reference 9.26) set out the clear process undertaken to select the wind farm site and array area boundaries, and the main reasons relating to all reasonable alternatives considered during the evolution of the project design.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Fifth ETG Meeting (09/02/22)	Regarding Sandwich tern displacement, the use of a displacement matrix is appropriate. Displacement rates of up to 100%, and mortality rates up to 10% should be presented. Lower end of the mortality range (i.e. 1%) is probably more suitable for Sandwich tern.	This approach has been presented within the assessment. However, displacement rates of 0.000 to 0.500, and a mortality rate of 1% have formed the basis of the assessment conclusions.
Natural England	Fifth ETG Meeting (09/02/22)	It would be useful to see the SeaBORD evidence from Scotland which would take account of both impacts to mortality and productivity. It may well be that it is more likely to be a productivity effect rather than a mortality effect so could check the modelling results for other species as it may help contextualise the rates that we have here, although I do tend to agree that mortality rate is likely to be at the lower end for Sandwich tern.	This has not been explored as part of the assessment since operational phase Sandwich tern displacement is anticipated to be a relatively minor impact as acknowledged by Natural England. Furthermore, SeaBORD is a tool designed to be used on species other than Sandwich tern, in a geographical area that is very different from the wider Wash area in which SEP and DEP are situated.
Natural England	Fifth ETG Meeting (09/02/22)	Could the 30 turbines proposed for DEP occur in DEP-N or DEP-S?	Up to 30 turbines could occur in DEP-N. However if DEP-S is developed then turbines would be spread across both array areas. The position of these turbines within DEP is not yet confirmed. Detailed layouts will come post consent at detailed design.
Natural England	Fifth ETG Meeting (09/02/22)	If there was a need to limit the numbers of turbines in one of DEP-N or DEP-S, is there a way to secure that?	Whilst the DCO could theoretically be amended to secure a limit on turbine numbers in either DEP-N or DEP-S if required, this restriction is not a development scenario or design option considered within the DCO application.

Consultee	Date, document and/or meeting	Comment	Project response
Natural England	Fifth ETG Meeting (09/02/22)	Natural England requested further information on how “theoretical as-built” OWF designs could be used within the assessment.	Theoretical as-built OWF designs are used in the Sandwich tern cumulative assessment (**Section 11.7.3.2.5** and **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**).
Natural England	Fifth ETG Meeting (09/02/22)	Natural England asked whether there is a way for Equinor to legally secure the as-built designs of DOW and SOW.	SOW is built out to maximum capacity. For DOW, this could be done through amending the section 36 consent. A legal mechanism has been included in Article 45 of the **Draft DCO** (document reference 3.1) to secure the release of the headroom from DOW, the principle of which has been discussed with the Department for Business, Energy & Industrial Strategy (BEIS).
Natural England	Fifth ETG Meeting (09/02/22)	On a precautionary note about SEP and DEP, not contributing as much as existing OWFs to Sandwich tern mortality. You may recall that the original Vanguard approach to *de minimus* for kittiwake impacts is no longer going to be accepted. The SoS has made it clear that the *de minimus* route is not an option.	Noted. The Applicant’s **RIAA** (document reference 5.4) concludes that AEoI for the Sandwich tern feature of the Greater Wash SPA and the North Norfolk Coast SPA could not be ruled out and therefore a derogation case including compensatory measures has been put forward for this species (**Habitats Regulations Derogation: Provision of Evidence** (document reference 5.5)). Similarly, the **RIAA** concludes that AEoI for the kittiwake feature of the Flamborough and Filey Coast SPA could not be ruled out and therefore a derogation case including compensatory measures has been put forward for this

Consultee	Date, document and/or meeting	Comment	Project response
			species (**Habitats Regulations Derogation: Provision of Evidence** (document reference 5.5)).
Natural England	Fifth ETG Meeting (09/02/22)	The use of a 10km buffer for potential red-throated diver displacement is in line with latest SNCB guidance.	Noted.
Natural England	Fifth ETG Meeting (09/02/22)	Suggested next step is to look at what EA1N and EA2 have done. Firstly, effect over the total area and a straight line approach assuming a 100% displacement at 0km and 0% at 12km. I would advise against trying to model effects, because their model ended up with displacement values that were below what empirical evidence was suggesting.	The straight line approach has been incorporated into the assessment performed within the **RIAA** (document reference 5.4).
Natural England	Fifth ETG Meeting (09/02/22)	Updated Greater Wash SPA data for Sandwich tern were collected in mid-January and a second survey planned for mid-February. A report will be delivered at some point after the end of March.	Noted.

11.3 Scope

11.3.1 Study Area

8. The study area for offshore ornithology has been defined on the basis of the aerial survey study area, which covers the SEP and DEP wind farm sites, as well as a 4km buffer around them (the 4km is measured from the boundary of the permanent works areas of wind farm sites, rather than the boundary of the offshore temporary works area). Interlink cable corridors are encompassed within the aerial survey study area. The offshore export cable corridor is included within the study area however is only partially encompassed by the aerial survey study area (see **paragraph 52** and **Figure 11.1**). This has been defined on the basis of the types of impacts to be considered by the assessment. For some offshore ornithology receptors (i.e. red-throated diver *Gavia stellata*), impacts could occur at greater distances from SEP and DEP than 4km. For this species, habitats within 6km of the aerial survey study area (i.e. within 10km of the SEP and DEP wind farm sites) are considered. The study area for offshore ornithology is presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

11.3.2 Realistic Worst-case Scenario

11.3.2.1 General Approach

9. The final design of SEP and DEP will be confirmed through detailed engineering design studies that will be undertaken post-consent to enable the commencement of construction. In order to provide a precautionary but robust impact assessment at this stage of the development process, realistic worst-case scenarios have been defined in terms of the potential effects that may arise. This approach to EIA, referred to as the Rochdale Envelope, is common practice for developments of this nature, as set out in Planning Inspectorate Advice Note Nine: Rochdale Envelope (v3, 2018). The Rochdale Envelope for a project outlines the realistic worst-case scenario for each individual impact, so that it can be safely assumed that all lesser options will have less impact. Further details are provided in **Chapter 5 EIA Methodology**.

10. In the response to the Section 42 Consultation (**Table 11-1**), and draft guidance regarding evidence and data standards for OWF assessments (Natural England, 2021a), suggested templates for presenting worst-case scenarios relevant to offshore ornithology in all project phases have been provided. These are presented in **Table 11-2** and are based on the project parameters described in **Chapter 4 Project Description**, which provides further details regarding specific activities and their durations.

11. In addition to the design parameters set out in **Table 11-2**, consideration is also given to:

- How SEP and DEP will be built out as described in **Section 11.3.2.2** to **Section 11.3.2.4** below. This accounts for the fact that whilst SEP and DEP are the subject of one DCO application, it is possible that only one Project could be built out (i.e. build SEP or DEP in isolation) or that both of the Projects could be developed. If both are developed, construction may be undertaken either concurrently or sequentially;
- A number of further development options which either depend on pre-investment or anticipatory investment, or that relate to the final design of the wind farms;
- Whether one Offshore Substation Platform (OSP) or two OSPs are required; and
- The design option of whether to use all of DEP-N and DEP-S, or whether to use DEP-N only.

12. In order to ensure that a robust assessment has been undertaken, all development scenarios and options have been considered to ensure the realistic worst-case scenario for each topic has been assessed. Further details are provided in **Chapter 4 Project Description**.

Table 11-2: Worst-case Scenario Information for SEP and DEP Presented in Format Requested by Natural England

Parameter	Values	
	DEP	SEP
Latitude (decimal degrees)	53.19	53.48
Area of OWF (km^2)	114.75	97.00
Area of OWF + 2km buffer (km^2)	286.89	207.54
Area of OWF + 4km buffer (km^2)	504.30	347.06
Area of OWF + 10km buffer (km^2)[1]	1,235.71	912.69
Maximum width of OWF (km)	10.18	9.62
Length of operational period (years)	40	40
Number of turbines	30	23
Number of blades	3	3
Maximum blade width (m)	7.50	7.50
Average blade pitch at mean predicted wind speed (degrees)[2]	0	0
Rotor radius (m)	117.50	117.50
Average rotation speed at mean predicted wind speed (rpm)[2]	5.66	5.66
Hub height relative to Highest Astronomical Tide (HAT) (m)	147.50	147.50
Tidal offset (m)	2.60	2.60
Notes 1. There is an overlap between the OWF + 10km buffer areas for SEP and DEP. The total combined area of both is 1,885.40km^2.		

Parameter	Values	
	DEP	SEP
2. Uses mean annual wind speed predicted at 151m above mean sea level. Mean rotation speed during generic breeding season months April to August would be 5.20 rpm (12.3% decrease). This rotation speed was not used in the assessment, but would result in collision risk reducing by approximately 1.5% during these months.		

13. The worst-case scenarios for indirect effects (**Sections 11.6.1.2**, **11.6.2.4** and **11.6.3.2**) are as presented for disturbance/habitat loss impacts in **Table 9-2** of **Chapter 9 Fish and Shellfish Ecology**.

11.3.2.2 Construction Phase Scenarios

14. In the event that both SEP and DEP are built, the following principles set out the framework for how SEP and DEP may be constructed:
    - SEP and DEP may be constructed at the same time, or at different times;
    - If built at the same time both SEP and DEP could be constructed in four years;
    - If built at different times, either Project could be built first;
    - If built at different times, each Project would require a four year period of construction;
    - If built at different times, the offset between the start of construction of the first Project, and the start of construction of the second Project may vary from two to four years;
    - Taking the above into account, the total maximum period during which construction could take place is eight years for both Projects; and
    - The earliest construction start date is 2025.
15. The impact assessment for offshore ornithology considers the following development scenarios in determining the worst-case scenario for each topic:
    - Build SEP or build DEP in isolation – one OSP only; and
    - Build SEP and DEP concurrently or sequentially – with either two OSPs, one for SEP and one for DEP, or with one OSP only to serve both SEP and DEP
    - For each of these scenarios it has been considered, within the limitations of the available information, whether the build out of DEP-N and DEP-S, or the build out of the DEP-N only, represents the worst-case for that topic. Any differences between SEP and DEP, or differences that could result from the manner in which the first and the second projects are built (concurrent or sequential and the length of any gap) are identified and discussed where relevant in the impact assessment section of this chapter (**Section 11.6**). For each potential impact, where necessary, only the worst-case construction scenario for two Projects is presented, i.e. either concurrent or sequential. The justification for what constitutes the worst-case is provided, where necessary, in **Section 11.6**.

16. Any differences between the two projects, or differences that could result from the manner in which the first and the second projects are built (concurrent or sequential and the length of any gap) are identified and discussed where relevant in the impact assessment section of this chapter (**Section 11.6**). For each potential impact only the worst-case construction scenario for two projects is presented, i.e. either concurrent or sequential. The justification for what constitutes the worst-case is provided, where necessary, in **Section 11.6**.

11.3.2.3 Operational Phase Scenarios

17. Operation scenarios are described in detail in **Chapter 4 Project Description**. Where necessary, the assessment considers the following three scenarios:

- Only SEP in operation;
- Only DEP in operation; and
- The two Projects operating at the same time, with a gap of two to four years between each Project commencing operation.

18. The operational lifetime of each Project is expected to be 40 years.

19. The approximate percentage of time that turbines are expected to be operational at SEP and DEP (based on the proportion of time that the wind speed is expected to be between 3 and 35 m/s, the cut-in and cut-out speeds) is presented by month in **Table 11-3**. This does not include a further 2% to 3% downtime each month due to planned maintenance, which may occur in both operational and non-operational wind speeds.

Table 11-3: Wind Resource Parameters Used in CRM for SEP and DEP

Month	% time operational	
	DEP	SEP
Jan	95.5	95.8
Feb	97.2	97.0
Mar	93.7	93.2
Apr	92.5	91.9
May	91.7	90.8
Jun	88.7	88.5
Jul	89.8	89.0
Aug	92.1	91.4
Sep	94.1	93.4
Oct	95.8	95.9
Nov	96.8	97.2
Dec	97.2	97.3

11.3.2.4 Decommissioning Phase Scenarios

20. Decommissioning scenarios are described in detail in **Chapter 4 Project Description**. Decommissioning arrangements will be agreed through the submission of a Decommissioning Programme prior to construction, however for the purpose of this assessment it is assumed that decommissioning of SEP and DEP could be conducted separately, or at the same time.

11.3.3 Summary of Mitigation Embedded in the Design

21. This section outlines the embedded mitigation relevant to the offshore ornithology assessment, which has been incorporated into the design of SEP and DEP (**Table 11-4**). Where other mitigation measures are proposed, these are detailed in the impact assessment (**Section 11.6**).

Table 11-4: Embedded Mitigation Measures

Parameter	Mitigation measures embedded into project design
Site selection	Wind farm boundary site selection process: the shallow area to the northwest of the existing Dudgeon OWF was excluded from the DEP-N boundary for technical reasons due to the shallow water depth and bathymetry, which were considered unsuitable for foundation and cable installation. In addition, Natural England advised (meeting held 29th January 2018) that this shallow area was believed to be important for feeding birds and that it would therefore be of benefit to exclude the area from development. Following the advice from Natural England and the bathymetry analysis, this area was removed from the southern boundary of DEP-N.
Air gap	The project designs of SEP and DEP assessed in the PEIR had an air gap of 26m at Highest Astronomical Tide (HAT). This was set at a value greater than the minimum of 22m to reduce the potential collision risk for offshore ornithology receptors. Between PEIR and the production of the ES, air gap has been further increased to 30m above HAT in response to consultation feedback, providing further reduction of potential collision risk for offshore ornithology receptors.
Best practice protocol for minimising disturbance to red-throated diver	Potential impacts on red-throated diver during operation and maintenance works will be mitigated through: • Avoiding and minimising maintenance vessel traffic, where possible, during the most sensitive time period in October to March (inclusive); • Restricting vessel movements where possible to existing navigation routes (where the densities of red-throated divers are typically relatively low); • As far as possible maintaining direct transit routes (to minimise transit distances through areas used by red-throated diver); • Where it is necessary to go outside of established navigational routes, avoid rafting birds either en-route to the wind farm sites from port and/or within the wind farm sites (dependent on location) and where possible avoid disturbance to areas with consistently high diver density; • Avoidance of over-revving of engines (to minimise noise disturbance); and • Briefing of vessel crew on the purpose and implications of these vessel management practices (through, for example, tool-box talks). The Project Team would make maintenance vessel operators aware of the importance of the species and the associated mitigation measures through tool box talks

11.4 Impact Assessment Methodology

11.4.1 Policy, Legislation and Guidance

11.4.1.1 National Policy Statements

22. The assessment of potential impacts upon offshore ornithology has been made with specific reference to the relevant National Policy Statements (NPS). These are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIPs). Those relevant to SEP and DEP are:

- Overarching NPS for Energy (EN-1) (Department of Energy and Climate Change (DECC) (2011a));
- NPS for Renewable Energy Infrastructure (EN-3) (DECC, 2011b); and
- NPS for Electricity Networks Infrastructure (EN-5) (DECC, 2011c).

23. The specific assessment requirements for offshore ornithology, as detailed in the NPS (EN-1) and NPS (EN-3), are summarised in **Table 11-5**.

24. It is noted that the Overarching NPS for Energy (EN-1) and the NPS for Renewable Energy Infrastructure (EN-3) are in the process of being revised. Draft versions were published for consultation in September 2021 (BEIS, 2021a, 2021b). A review of these draft versions has been undertaken in the context of this ES chapter.

25. **Table 11-5** includes a section for the draft version of NPS (EN-3) (BEIS, 2021b) in which relevant additional NPS requirements not presented within the current NPS (EN-3) have been included. A reference to the particular requirement's location within the draft NPS and to where within this ES chapter it has been addressed has also been provided. No updates within NPS (EN-1) (BEIS, 2021a) are considered relevant to the offshore ornithology assessment.

26. Minor wording changes within the draft versions which do not materially influence the NPS requirements have not been reflected in **Table 11-5**.

Table 11-5: NPS Assessment Requirements

NPS requirement	NPS reference	Section reference
NPS for Energy (EN-1)		
Clearly set out any effects on internationally, nationally and locally designated sites of ecological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity	EN-1 – 5.3.3	**Section 11.6**
Show how the proposed project has taken advantage of opportunities to conserve and enhance biodiversity conservation interests.	EN-1 – 5.3.4	**Section 11.6**
Include appropriate mitigation measures as an integral part of the proposed development	EN-1 – 5.3.18	**Section 11.6**
NPS for Renewable Energy Infrastructure (EN-3)		
Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed OWF and in accordance with the appropriate policy for OWF EIAs.	EN-3 – 2.6.64	**Section 11.6**
Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational OWF should be referred to where appropriate	EN-3 – 2.6.66	Evidence from operational OWFs is referred to throughout the assessment
The assessment should include the potential of the scheme to have both positive and	EN-3 – 2.6.67	This is discussed throughout the assessment

NPS requirement	NPS reference	Section reference
negative effects on marine ecology and biodiversity		
The scope, effort and methods required for ornithological surveys should have been discussed with the relevant statutory advisor	EN-3 – 2.6.102	Natural England were appraised of the survey programme prior to the commencement of the Evidence Plan Process
Relevant data from operational OWFs should be referred to in the applicant's assessment	EN-3 – 2.6.103	Evidence from operational OWFs is referred to throughout the assessment
It may be appropriate for assessment to consider collision risk modelling for certain species of birds	EN-3 – 2.6.104	**Section 11.6**
Draft NPS for Renewable Energy Infrastructure (EN-3) (BEIS, 2021b)		
Currently, cumulative impact assessments for ornithology are based on the consented Rochdale Envelope parameters of projects, rather than the 'as-built' parameters, which may pose a lower risk to birds. The Secretary of State will therefore require any consents to include provisions to define the final 'as built' parameters (which may not then be exceeded) so that these parameters can be used in future cumulative impact assessments. In parallel we will look to explore opportunities to reassess ornithological impact assessment of historic consents to reflect their 'as built' parameters. Any ornithological 'headroom' between the effects defined in the 'as built' parameters and Rochdale Envelope parameters can then be released. We will also consider the potential applicability of these principles to other consent parameters.	EN-3 – 2.29.2	Provisions to define and confirm the 'as built' parameters for SEP and DEP following completion of construction so that these can be used in CIAs for future developments are included in the **Draft DCO** (document reference 3.1) and described in the **Explanatory Memorandum** (document reference 3.2). The CIA for Sandwich tern (**Section 11.7.3.2.5**) has assessed a range of designs for the operational and consented projects included in the CIA in an attempt to address the unrealistic nature of CIA assessments based purely on consented designs.
Displacement and population viability assessments must be undertaken for certain species of birds	EN-3 – 2.29.2	Displacement assessments and PVA for the relevant species have been undertaken and are provided in **Section 11.6** and **11.7** and the **RIAA** (document reference 5.4).
Turbine parameters should also be developed to reduce collision risk where the assessment shows there is a significant risk of collision (e.g., altering rotor height).	EN-3 – 2.29.6	The project designs of SEP and DEP assessed in the PEIR had an air gap of 26m HAT. This was set at a value greater than the minimum of 22m MHWS to reduce the potential collision risk for offshore ornithology receptors. Between PEIR and the production of the ES, air gap has been further increased to 30m HAT, providing further reduction of potential collision

NPS requirement	NPS reference	Section reference
		risk for offshore ornithology receptors.

11.4.1.2 Other

27. In addition to the NPS, there are a number of pieces of guidance applicable to the assessment of offshore ornithology. These include:

- The most relevant EIA guidance for offshore ornithology receptors is CIEEM (2018). The EIA methodology described in **Section 11.4** and applied in this chapter is based on this guidance;
- Draft guidance documents for the assessment of OWF impacts on offshore ornithology receptors produced by Natural England (Natural England, 2021a, 2021b, 2021c);
- Headroom in Cumulative Offshore Wind Farm Impacts for Seabirds: Legal Issues and Possible Solutions (The Crown Estate and Womble Bond Dickinson, 2021); and
- A wide range of additional guidance has been referred to throughout the assessment as required.

28. Further detail where relevant is provided in **Chapter 2 Policy and Legislative Context**.

11.4.2 Data and Information Sources

11.4.2.1 Site Specific Surveys

29. In order to provide site specific and up to date information on which to base the impact assessment, site characterisation surveys of the aerial survey study area commenced in May 2018 and concluded in April 2020. These surveys occurred once per month, except between April and August 2019, when two surveys per month were conducted. The methodology employed was a digital aerial survey, using video. Further information on the survey programme is provided in **Appendix 11.1 Offshore Ornithology Technical Report**.

11.4.3 Impact Assessment Methodology

30. **Chapter 5 EIA Methodology** provides a summary of the general impact assessment methodology applied to SEP and DEP. The following sections confirm the methodology used to assess the potential impacts on offshore ornithology.

31. The impact assessment has been undertaken in line with the most recent guidance (CIEEM, 2018), and informed by expert opinion where necessary. Key guidance documents on specific areas of the assessment such as estimating operational phase displacement (UK SNCBs, 2017), collision risk (Band, 2012; McGregor *et al*., 2018; UK SNCBs, 2014; Wright *et al*., 2012), and potential population level effects (Searle *et al*., 2019) have been utilised and referred to where appropriate.

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

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

33. For each effect, the assessment identifies receptors sensitive to that effect and implements a systematic approach to understanding the impact pathways and the level of impacts on given receptors.

11.4.3.1 Receptor Sensitivity

34. The sensitivity of a receptor is an expression of the likelihood of change to it when a pressure (i.e. a predicted impact) is applied. It is defined by the tolerance (or lack thereof) to a particular impact, along with the capacity for recovery of the receptor. Definitions of tolerance are presented in **Table 11-6**, whilst capacity for recovery definitions are presented in **Table 11-7**. A matrix showing how the definitions for tolerance and recovery can be combined to estimate receptor sensitivity is provided in **Table 11-8**. The majority of seabirds have a low capacity for recovery, given that they are long lived species with extensive maturation periods, low natural adult mortality levels and low fecundity. Approximate definitions for overall sensitivity are provided in **Table 11-9** using the example of disturbance due to construction activity.

35. Species assessed for potential impacts are those which were recorded during surveys and which are considered to be at potential risk either due to their abundance, conservation importance and/or potential sensitivity to OWF impacts. However, where appropriate, the assessment considers species which may have been recorded during baseline surveys, but are considered likely to use SEP, DEP, and the habitats surrounding them (e.g. migratory birds).

Table 11-6: Definition of Tolerance for an Offshore Ornithology Receptor

Tolerance	Definition
High	No or minor adverse change (which may not be detectable against existing variation) in key functional and physiological attributes through direct effects, because the receptor can avoid/adapt to/accommodate it.
Medium	Moderate decline in key functional and physiological attributes through direct mortality, reduced reproductive success, or other effects impacting receptor fitness. The receptor is less able to avoid/adapt to/accommodate the pressure.

Tolerance	Definition
Low	Substantial decline in key functional and physiological attributes through direct mortality, reduced reproductive success, or other effects impacting receptor fitness. The receptor is not able to avoid/adapt to/accommodate the pressure.

Table 11-7: Definition of Recovery Levels for an Offshore Ornithology Receptor

Capacity	Definition
High	Short lived receptor (up to five years), first breeding within approximately one year, high natural annual adult mortality (>25%), high annual reproductive output (> five chicks per pair).
Medium	Moderately short lived receptor (approximately five to ten years), first breeding within two to three years, moderate natural annual adult mortality (15-25%), moderate annual reproductive output (two to five chicks per pair).
Low	Long lived receptor (more than ten years), first breeding in excess of three years, low natural annual adult mortality (<15%), low annual reproductive output (< two chicks per pair).

Table 11-8: Tolerance and Capacity Recovery Matrix for Determination of Sensitivity of Ornithological Receptors

	Low tolerance	Medium tolerance	High tolerance
Low recovery	High	Medium	Low
Medium recovery	Medium	Medium	Low
High recovery	Low	Low	Low

Table 11-9: Example Definitions of the Different Sensitivity Levels for an Offshore Ornithology Receptor

Sensitivity	Definition
High	Receptor has very limited tolerance of a potential impact, e.g. strongly displaced by sources of disturbance such as noise, light, vessel movements and the presence of people
Medium	Receptor has limited tolerance of a potential impact, e.g. moderately displaced by sources of disturbance such as noise, light, vessel movements and the presence of people
Low	Receptor has some tolerance of a potential impact, e.g. partially displaced by sources of disturbance such as noise, light, vessel movements and the presence of people
Negligible	Receptor is generally tolerant of a potential impact e.g. not displaced by sources of disturbance such as noise, light, vessel movements and the presence of people

36. The sensitivity of each ornithological receptor to each impact pathway has been estimated by information identified by a literature review. The overall confidence in the information used to define the sensitivity of each seabird receptor has also been qualitatively assessed. This is a method adapted from Pérez-Domínguez *et al*. (2016), and consists of considering three aspects of an evidence base with regard to sensitivities to particular impacts:

- Quality of information: highest quality information from peer reviewed papers (either observation or experimental), or grey literature from reputable sources, with heavier reliance on grey literature and/or expert judgement being considered to represent a lower quality evidence base.

- Applicability of evidence: evidence based on the same impacts, arising from similar activities, on the same species, in the same geographical area, is considered evidence with the highest associated confidence, followed by similar pressures/activities/species in other areas, followed by proxy information.
- Concordance: situations where available evidence is in broad agreement in terms of sensitivity and magnitude of impact results in a higher confidence compared to a situation where evidence is only in partial agreement, or not in agreement at all.

37. Whilst efforts have been made to estimate the sensitivity of all ornithology receptors, if no evidence exists, a receptor has been characterised as “not assessed”. Where insufficient evidence exists to complete the sensitivity assessment, but there are concerns over potential impacts, receptors are classed as “sensitive”.

11.4.3.2 Conservation Value

38. The conservation value of species is used to provide additional context to the impact assessment, and may be used to refine predictions as appropriate. It is not a key input into the impact assessment process, as there is a tendency for overreliance on conservation value to underestimate potential impacts on receptors with a lower conservation value (Box *et al*., 2017). For example, high conservation value and high sensitivity are not necessarily linked for a particular impact. A receptor could be of high conservation value (e.g. a qualifying feature of a SPA) but have a low or negligible physical/ecological sensitivity to an effect.

39. The conservation value of ornithological receptors is based on the population from which individuals are predicted to be drawn, reflected in the current understanding of the movements of bird species. Conservation value for a species can vary through the year depending on the relative sizes of the number of individuals predicted to be at risk of impact and the population from which they are predicted to be drawn. Ranking therefore corresponds to the degree of connectivity which is predicted between SEP, DEP, 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. Population status is also taken account of in the assessment. For example, effects on a declining species may be of more concern than those on an increasing species.

40. Example definitions of the value levels for ornithology receptors are given in **Table 11-10**. These are related to connectivity with populations that are protected as qualifying species of SPAs, proposed SPAs (pSPAs) or Ramsar sites, which are internationally designated sites carrying strong protection for populations of qualifying bird species.

Table 11-10: Example Definitions of the Different Conservation Values for an Offshore Ornithology Receptor

Conservation value	Definition
High	A receptor population for which individuals at risk can be clearly connected to a particular conservation site of international or national importance.

Conservation value	Definition
Medium	A receptor population for which individuals at risk may be drawn from particular conservation site of international or national importance, although other populations may also contribute to individuals at risk.
Low	A receptor population for which individuals at risk have no known connectivity to conservation sites of international or national importance.

11.4.3.3 Impact Magnitude

41. The definitions of the impact magnitude levels for offshore ornithology receptors are set out in **Table 11-11**. Generally, based on findings from population viability analyses for bird species, it would be considered that increases in mortality rates of less than 1% would be undetectable in terms of changes in population size. This has been used as a guide to define impact magnitudes throughout the assessment.

Table 11-11: Definitions of Levels of Impact Magnitude for an Offshore Ornithology Receptor

Impact magnitude	Definition
High	A change that is predicted to irreversibly alter the receptor population in the short to long term, and to alter the long-term viability of the receptor population and/or the integrity of a protected site.
Medium	A change that occurs in the short and long term, but which is not predicted to alter the long-term viability of the receptor population and/or the integrity of a protected site.
Low	A change that is sufficiently small scale or of short duration to cause no long term harm to the receptor population and/or the integrity of a protected site.
Negligible	A very slight change that is sufficiently small scale or of such short duration that it may be undetectable in the context of natural variation.
No change	No positive or negative change is predicted.

11.4.3.4 Impact Significance

42. In basic terms, the potential significance of an impact is a function of the sensitivity of the receptor and the magnitude of the effect (see **Chapter 5 EIA Methodology** for further details). The determination of significance is guided by the use of an impact significance matrix, as shown in **Table 11-12**. Definitions of each level of significance are provided in **Table 11-13**.

43. Potential impacts identified within the assessment as major or moderate are regarded as significant in terms of the EIA regulations. Potential impacts should be described using impact significance, followed by a statement of whether the impact significance is significant in terms of the EIA regulations, e.g. "*minor adverse impact, not significant in EIA terms / moderate adverse impact, significant in EIA terms*". Appropriate mitigation has been identified, where possible, in consultation with the regulatory authorities and relevant stakeholders. The aim of mitigation measures is to avoid or reduce the overall impact in order to determine a residual impact upon a given receptor.

Table 11-12: Impact Significance Matrix

		Adverse magnitude				Beneficial magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	*Major*	*Major*	*Moderate*	*Minor*	*Minor*	*Moderate*	*Major*	*Major*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Minor*	*Minor*	*Moderate*	*Major*
	Low	*Moderate*	*Minor*	*Minor*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

Table 11-13: Definition of Impact Significance

Impact significance	Definition
Major	Very large or large change in receptor condition, both 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
No change	No impact, therefore, no change in receptor condition

11.4.4 Cumulative Impact Assessment Methodology

44. The CIA considers other plans, projects and activities that may impact cumulatively with SEP and DEP. As part of this process, the assessment considers which of the residual impacts assessed for SEP and/or DEP on their own have the potential to contribute to a cumulative impact, the data and information available to inform the cumulative assessment and the resulting confidence in any assessment that is undertaken. **Chapter 5 EIA Methodology** provides further details of the general framework and approach to the CIA.

45. For offshore ornithology these activities include OWFs, marine aggregate extraction areas, oil and gas exploration and extraction, subsea cables and pipelines and commercial shipping.

11.4.5 Transboundary Impact Assessment Methodology

46. The transboundary assessment considers the potential for transboundary effects to occur on offshore ornithology receptors as a result of SEP and DEP; either those that might arise within the Exclusive Economic Zone (EEZ) of European Economic Area (EEA) states or arising on the interests of EEA states e.g. a non UK fishing vessel. **Chapter 5 EIA Methodology** provides further details of the general framework and approach to the assessment of transboundary effects.

47. For offshore ornithology the potential for transboundary effects has been identified in relation to 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).

11.4.6 Assumptions and Limitations

48. The assessment process contains a wide range of sources of uncertainty. These include the process of estimating seabird density and abundance estimates from baseline survey data, estimated values for seabird flight characteristics to be used in displacement modelling (e.g. displacement and mortality rates), CRM (e.g. flight height distributions, avoidance rates, bird size, flight speeds, bird behaviour, and the parameters of the turbines), and demographic rates used in PVA (e.g. environmental and demographic variations in survival and productivity). This is not an exhaustive list.

49. The assumptions and limitations of the assessment are discussed throughout the chapter where they apply.

11.5 Existing Environment

50. The characterisation of the existing or baseline environment has been undertaken based on site-specific baseline surveys (**Section 11.4.2.1** and **Appendix 11.1 Offshore Ornithology Technical Report**), along with a desk study which considers all known and available relevant literature. The following sections summarise the species recorded during surveys, and present information from relevant literature to establish the likely level of importance of the aerial survey study area to the species recorded. Finally, to provide further context, a review of existing pressures on the wider environment is provided.

11.5.1 Offshore Ornithology Receptors Recorded During Baseline Surveys

11.5.1.1 Overview

51. Species recorded by the site-specific baseline surveys (digital video aerial bird surveys of the aerial survey study area, as described in **Appendix 11.1 Offshore Ornithology Technical Report**) are listed in **Table 11-14** along with details of whether they are listed on Annex I of the Birds Directive, and their Birds of Conservation Concern (BoCC) status. No species recorded during the baseline surveys had a change in BoCC status between the 2015 (Eaton *et al*., 2015) and 2021 (Stanbury *et al*., 2021) BoCC studies.

Table 11-14: Species Recorded in the SEP and DEP Aerial Survey Study Area, Along with Information on their Conservation Status

Common name	Scientific name	Conservation status
Arctic skua	*Stercorarius parasiticus*	BoCC Red
Arctic tern	*Sterna paradisaea*	Annex I, BoCC Amber
Black-headed gull	*Chroicocephalus ridibundus*	BoCC Amber
Common gull	*Larus canus*	BoCC Amber
Common scoter	*Melanitta nigra*	BoCC Red
Common tern	*Sterna hirundo*	Annex I, BoCC Amber
Cormorant	*Phalacrocorax carbo*	BoCC Green
Fulmar	*Fulmarus glacialis*	BoCC Amber

Common name	Scientific name	Conservation status
Gannet	*Morus bassanus*	BoCC Amber
Golden plover	*Pluvialis apricaria*	BoCC Green
Great black-backed gull	*Larus marinus*	BoCC Amber
Great crested grebe	*Podiceps cristatus*	BoCC Green
Great skua	*Stercorarius skua*	BoCC Amber
Guillemot	*Uria aalge*	BoCC Amber
Herring gull	*Larus argentatus*	BoCC Red
Kestrel	*Falco tinnunculus*	BoCC Amber
Kittiwake	*Rissa tridactyla*	BoCC Red
Knot	*Calidris canutus*	BoCC Amber
Lapwing	*Vanellus vanellus*	BoCC Red
Lesser black-backed gull	*Larus fuscus*	BoCC Amber
Little gull	*Hydrocoloeus minutus*	BoCC Green
Little tern	*Sternula albifrons*	Annex I, BoCC Amber
Long-tailed duck	*Clangula hyemalis*	BoCC Red
Long-tailed skua	*Stercorarius longicaudus*	BoCC Green
Manx shearwater	*Puffinus puffinus*	BoCC Amber
Oystercatcher	*Haematopus ostralegus*	BoCC Amber
Pomarine skua	*Stercorarius pomarinus*	BoCC Green
Puffin	*Fratercula arctica*	BoCC Red
Razorbill	*Alca torda*	BoCC Amber
Red-throated diver	*Gavia stellata*	Annex I, BoCC Green
Sandwich tern	*Thalasseus sandvicensis*	Annex I, BoCC Amber
Shag	*Phalacrocorax aristotelis*	BoCC Red
Tufted duck	*Aythya fuligula*	BoCC Green
Woodpigeon	*Columba palumbus*	BoCC Green

52. For the offshore cable corridor located beyond the aerial survey study area, it is standard practice not to carry out site-specific baseline ornithology surveys. The assessment for this component of SEP and DEP has been carried out with reference to several existing sources of information (Bradbury *et al*., 2014; Cleasby *et al*., 2018; Lawson *et al*., 2016; Wilson *et al*., 2014).

53. Detail on the seabird species recorded during the baseline surveys (**Table 11-14**) is presented in **Appendix 11.1 Offshore Ornithology Technical Report**. This includes the seasons in which they were present, the abundance at which they were recorded across the aerial survey study area, and the apportioning of seabirds to particular populations, with justification. The latter is essential for the impact assessment presented in **Section 11.6**, which places predicted seasonal mortality into context by comparing it to relevant background populations, and the predicted increase in background mortality which could result.

11.5.1.2 Biologically Relevant Seasons

54. Impacts have been assessed in relation to relevant biological seasons, as defined by Furness (2015). These are presented for relevant offshore ornithology receptors in **Table 11-15**. These seasonal definitions 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). Where the full breeding season overlaps other seasons, impacts are apportioned to the breeding season unless otherwise stated. The use of particular seasons and reference populations varies by species and is discussed below.

11.5.1.3 Calculation of Species Densities and Abundance

55. The methods used to calculate species density and abundance are presented in **Appendix 11.1 Offshore Ornithology Technical Report**. Mean peak abundances within species-specific seasons (**Table 11-15**) recorded within the aerial survey study area are provided in **Table 11-16**. The aerial survey study area is considerably larger than SEP and DEP (**Figure 11.1**), so the mean peak abundances presented do not feed directly into quantitative elements of the assessment. However, this is considered to represent useful background information that demonstrates the peak numbers of offshore ornithology receptors present in the wider area during different seasons.

11.5.1.4 Demographic Data

56. Demographic data for species scoped in for assessment for one or more potential impacts are provided in **Table 11-17**. These data (from Horswill and Robinson (2015)); with the exception of great black-backed gull which is taken from Royal HaskoningDHV (2016)), have been used to calculate average annual mortality rates across age classes. These are used to assess potential mortality from interactions with SEP and DEP in terms of changes to population mortality rates.

Table 11-15: Biologically Relevant Seasons for Offshore Ornithology Receptors at SEP and DEP. Prefixes Indicate Early in Month ("e."), Mid-Month ("m.") and Late in Month ("l.").

Species	Breeding	Migration-free breeding	Autumn migration	Winter	Spring migration	Non-breeding	Source
Arctic skua	May - Jul	Jun - Jul	Aug - Oct	Nov - Mar	Apr - May	Aug - Apr	Furness (2015)
Arctic tern	May - e.Aug	Jun	Jul - e.Sept	Oct - Mar	Apr - May	m.Aug - Apr	Furness (2015)
Black-headed gull	-	Apr - Jul	-	-	-	Aug - Mar	Cramp and Simmons (1983)
Common gull	May - Jul	-	-	-	-	Aug - Apr	Cramp and Simmons (1983)
Common scoter	m.Apr - Aug	-	-	-	-	Sept - e.Apr	Cramp and Simmons (1983)
Common tern	May - Aug	Jun - m.Jul	l.Jul - e.Sept	Oct - Mar	Apr - May	Sept - Apr	Furness (2015)
Cormorant	Apr - Aug	May - Jul	Aug - Oct	Nov - Jan	Feb - Apr	Sept - Mar	Furness (2015)
Fulmar	Jan - Aug	Apr - Aug	Sept - Oct	Nov	Dec - Mar	Sept - Dec	Furness (2015)
Gannet	Mar - Sept	Apr - Aug	Sept - Nov	None	Dec - Mar	Oct - Feb	Furness (2015)
Great black-backed gull	l.Mar - Aug	May - Jul	Aug - Nov	Dec	Jan - Apr	Sept - Mar	Furness (2015)
Great skua	May - Aug	May - Jul	Aug - Oct	Nov - Feb	Mar - Apr	Sept - Apr	Furness (2015)
Guillemot	Mar - Jul	Mar - Jun	Jul - Oct	Nov	Dec - Feb	Aug - Feb	Furness (2015)
Herring gull	Mar - Aug	May - Jul	Aug - Nov	Dec	Jan - Apr	Sept - Feb	Furness (2015)
Kittiwake	Mar - Aug	May - Jul	Aug - Dec	None	Jan - Apr	Sept - Feb	Furness (2015)
Lesser black-backed gull	Apr - Aug	May - Jul	Aug - Oct	Nov - Feb	Mar - Apr	Sept - Mar	Furness (2015)
Little gull	Apr - Jul	May - Jul	-	-	-	Aug - Apr	Cramp and Simmons (1983)
Little tern	May - e.Aug	Jun	l.Jul - e.Sept	-	m.Apr - May	m.Aug - Apr	Furness (2015)

Species	Breeding	Migration-free breeding	Autumn migration	Winter	Spring migration	Non-breeding	Source
Long-tailed skua	-	-	Sept - Oct	-	Apr - May	-	Cramp and Simmons (1983)
Manx shearwater	Apr - Aug	Jun - Jul	Aug – e.Oct	m.Oct – m.Mar	l.Mar - May	Sept - Mar	Furness (2015)
Pomarine skua	-	-	Sept - Oct	-	Apr - May	-	Cramp and Simmons (1983)
Puffin	Apr - e.Aug	May - Jun	l.Jul - Aug	Sept - Feb	Mar - Apr	m.Aug - Mar	Furness (2015)
Razorbill	Apr - Jul	Apr - Jun	Aug - Oct	Nov - Dec	Jan - Mar	Aug - Mar	Furness (2015)
Red-throated diver	Mar - Aug	May - Aug	Sept - Nov	Dec - Jan	Feb - Apr	Sept - Feb	Furness (2015)
Sandwich tern	Apr - Aug	Jun	Jul - Sept	-	Mar - May	Sept - Mar	Furness (2015)
Shag	Feb - Aug	Mar - Jul	Aug - Oct	Nov	Dec - Feb	Sept - Jan	Furness (2015)

Table 11-16: Mean Peak Abundance Estimates (with Range of Recorded Peak Values) Recorded for Species Recorded in the Aerial Survey Study Area during the Baseline Surveys, by Biologically Relevant Season. Part Seasons Covered by the Aerial Survey Programme have been Included as Full Seasons by the Mean Peak Calculations. Dashed Cell Indicate where a Season Does Not Apply to a Given Species

Species	Autumn migration	Winter	Spring migration	Non-breeding	Breeding
Arctic skua	6 (0 - 15)	0	0	-	0
Arctic tern	0	0	47 (19 - 83)	-	26 (7 - 50)
Black-headed gull	-	-	-	150 (56 - 265)	74 (43 - 110)
Common gull	-	-	-	88 (35 - 167)	115 (29 - 276)
Common scoter	-	-	-	56 (0 - 164)	0
Common tern	235 (84 - 428)	0	203 (59 - 383)	-	222 (139 - 318)
Cormorant	8 (0 - 23)	0	0	-	21 (0 - 60)
Fulmar	89 (38 - 150)	0	20 (0 - 49)	-	67 (26 - 124)
Gannet	1,655 (1,237 - 2,093)	0	96 (29 - 178)	-	788 (460 – 1,146)
Great black-backed gull	491 (239 - 800)	185 (78 - 330)	66 (10 - 129)	-	27 (11 - 48)
Great skua	8 (0 - 23)	11 (0 - 34)	0	-	0
Guillemot	-	-	-	33,251 (16,014 - 54,281)	10,686 (7,583 - 14,162)
Herring gull	-	-	-	41 (10 - 83)	52 (11 - 116)
Kittiwake	4,351 (1,721 - 8,077)	0	175 (79 - 293)	-	3,330 (2,124 -4,941)
Lesser black-backed gull	26 (3 - 63)	11 (0 - 30)	0	-	253 (98 - 504)
Little gull	-	-	-	1,599 (864 - 2,557)	11 (0 - 27)
Little tern	0	-	0	-	8 (0 - 23)
Long-tailed skua	0	0	3 (0 - 8)	-	0

Species	Autumn migration	Winter	Spring migration	Non-breeding	Breeding
Manx shearwater	134 (30 - 286)	0	0	-	44 (0 - 132)
Pomarine skua	0	6 (0 - 15)	0	-	0
Puffin	-	-	-	190 (51 - 99)	55 (18 - 322)
Razorbill	9,458 5,188 - 15,239)	3,377 (2,801 - 3,993)	901 (480 - 1,389)	-	3,088 (1,784 - 4,716)
Red-throated diver	180 (67 - 325)	31 (5 - 41)	360 (103 - 796)	-	134 (87 - 190)
Sandwich tern	99 (34 - 199)	0	0	-	1,695 (1,174 - 2,350)
Shag	0	0	0	-	5 (0 - 15)

Table 11-17: Average Annual Survival Rates of Offshore Ornithology Receptors Across Age Classes, Along with Productivity and Average Mortality Rate for Entire Population Calculated using Age-Specific Demographic Rates and Age Class Proportions. Data from Horswill and Robinson (2015) with the Exception of Great Black-Backed Gull, which is Taken from Royal HaskoningDHV (2016). Proportions of Modelled Populations from Furness (2015).

Species	Parameter	Age class						Productivity	Average mortality
		0-1	1-2	2-3	3-4	4-5	Adult		
Arctic tern	Survival	-	-	-	-	-	0.837	0.380	-
	Proportion	0.130	0.080	0.080	0.080	-	0.630		
Arctic skua	Survival	0.346	0.346	0.346	0.346	-	0.910	0.487	0.519
	Proportion	0.150	0.090	0.090	0.090	-	0.580		
Black-headed gull	Survival	-	-	-	-	-	0.825	0.625	0.175
	Proportion	-	-	-	-	-	-		
Common gull	Survival	0.410	0.710	-	-	-	0.828	0.543	0.172
	Proportion	-	-	-	-	-	-		
Common tern	Survival	0.441		0.850		-	0.883	0.764	0.215
	Proportion	0.130	0.080	0.080	0.080		0.63		
Gannet	Survival	0.424	0.829	0.891	0.895	-	0.919	0.700	0.191
	Proportion	0.191	0.081	0.067	0.060	-	0.600		
Great skua	Survival	0.730	-	-	-	-	0.882	0.651	0.157
	Proportion	0.140	-	-	-	-	0.410		
Great black-backed gull	Survival	0.815	0.815	0.815	0.815	-	0.815	1.139	0.185
	Proportion	0.194	0.156	0.126	0.102	-	-		
Guillemot	Survival	0.560	0.792	0.917	0.939	0.939	0.939	0.672	0.140
	Proportion	0.168	0.091	0.069	0.062	0.056	0.552		
Herring gull	Survival	0.798	-	-	-	-	0.834	0.920	0.184
	Proportion	0.220	0.100	0.100	0.100	-	0.480		
Kittiwake	Survival	0.790	0.854	0.854	0.854	-	0.854	0.690	0.156
	Proportion	0.155	0.123	0.105	0.089	-	0.527		
	Survival	0.820	0.885	0.885	0.885	-	0.885	0.530	

Species	Parameter	Age class						Productivity	Average mortality
		0-1	1-2	2-3	3-4	4-5	Adult		
Lesser black-backed gull	Proportion	0.134	0.109	0.085	0.084	-	0.577		0.126
Little gull	Survival	-	-	-	-	-	0.800	-	0.200
	Proportion	-	-	-	-	-	-		
Little tern	Survival	-	-	-	-	-	0.800	0.518	0.200
	Proportion	-	-	-	-	-	-		
Puffin	Survival	-	-	0.709	0.760	0.805	0.906	0.617	0.866
	Proportion	0.180	-	0.068	0.068	0.068	0.550		
Razorbill	Survival	0.630	0.630	0.895	0.895	-	0.895	0.570	0.174
	Proportion	0.159	0.102	0.065	0.059	-	0.613		
Red-throated diver	Survival	0.600	0.620	-	-	-	0.840	0.571	0.228
	Proportion	0.179	0.145	-	-	-	0.678		
Sandwich tern	Survival	0.358	0.741	0.741	0.741	-	0.898	0.702	0.240
	Proportion	0.200	0.063	0.063	0.063	-	0.610		

11.5.2 Relative Importance of the Aerial Survey Study Area

57. The relative importance of the region within which SEP and DEP are situated to the species recorded has been investigated. The purpose of this is to provide context of the importance of SEP and DEP, and the wider aerial survey study area to offshore ornithology receptors. This also enables comment on whether the data collected by the baseline survey programme concord with key trends identified.

58. A modelled at-sea dataset which provides details of density and distribution of several offshore ornithology receptors across the northeast Atlantic Ocean (Waggitt *et al*., 2019), indicates that for many offshore ornithology receptors recorded during the baseline surveys, the area within which SEP and DEP are situated is relatively unimportant in the context of the large area considered by the study. None of the 12 seabird species examined by Waggitt *et al*. (2019) are expected to occur in large numbers in the area occupied by SEP and DEP during the breeding season. This is reflected by the fact that there are a limited number of large seabird breeding colonies within foraging range of SEP and DEP. Exceptions with respect to species included within this study were herring gull and lesser black-backed gull. These species breed in relatively modest numbers along the Norfolk coast. These breeding locations lie within the mean maximum foraging range of SEP and DEP (Woodward *et al*., 2019). However, data presented in Waggitt *et al*. (2019) suggest that SEP and DEP may be more important during the non-breeding season than the breeding season for these species.

59. Sandwich tern, a species not included in Waggitt *et al*. (2019), breed at the North Norfolk Coast SPA, with the Greater Wash SPA protecting key foraging areas. Neither SPA overlaps SEP and DEP. However, SEP and DEP are within the mean maximum foraging range of the breeding Sandwich tern population of these SPAs, and are also within the maximum recorded foraging range of Sandwich tern from this particular breeding site (Woodward *et al*., 2019). Data from Sandwich tern tracking work carried out as part of the DOW OMP clearly demonstrates functional linkage between SEP and DEP, and Sandwich terns breeding at this SPA (Green *et al*., 2019, 2018; Scragg *et al*., 2016; Thaxter *et al*., 2018). This species is therefore a key focus of the assessment. The North Norfolk Coast SPA and Greater Wash SPA also support breeding common tern. The foraging range of this species is shorter than Sandwich tern (Woodward *et al*., 2019), but the species may occur at SEP and DEP during the breeding and passage periods.

60. The Flamborough and Filey Coast SPA is another internationally important seabird colony which is within published foraging ranges of SEP and DEP for some qualifying features (notably kittiwake and gannet) (Woodward *et al*., 2019). However, a number of studies of tracked birds from the SPA indicate that SEP and DEP do not fall within the core foraging ranges for any of the qualifying features (kittiwake, gannet, guillemot and razorbill) breeding at this SPA (Cleasby *et al*., 2018; Langston *et al*., 2013; Wakefield *et al*., 2017, 2013; Wischnewski *et al*., 2017). This is defined as the area of habitat in which 50% of a colony's activity is expected to occur, based on modelled at-sea distribution data. These findings were supported by a review (Sansom *et al*., 2018) of a range of data sources (Bradbury *et al*., 2017, 2014; Kober *et al*., 2010; Wakefield *et al*., 2017), which indicated that "high use" areas of marine habitats for qualifying features of the Flamborough and Filey Coast

SPA do not overlap with SEP and DEP. However, evidence from the literature indicates that breeding birds from this SPA are expected to be present at SEP and DEP during the non-breeding season (Furness, 2015; Waggitt *et al*., 2019). Indeed, Waggitt *et al*. (2019) suggest that SEP and DEP may be more important during the non-breeding season than the breeding season for kittiwake, guillemot and razorbill, particularly with respect to the latter two species.

61. For some species (fulmar, great skua, Manx shearwater and puffin), Waggitt *et al*. (2019) indicated that higher densities of these species do not occur anywhere near SEP and DEP year round.

62. It is expected that a wide range of migratory birds (including seabirds and non-breeding waterbirds) may pass through SEP and DEP during the autumn and spring migration seasons. Such birds move across seas in large numbers but over a short time period, often at night and sometimes in bad weather, so are often not adequately recorded by baseline surveys (Wright *et al*., 2012). These are considered by the assessment.

63. Overall, whilst there are clearly a number of offshore ornithology receptors that require detailed consideration in this assessment, existing information indicates that generally, the area in which SEP and DEP are situated does not seem to be of particularly high importance to seabirds at any time of year relative to some other areas in the wider North Sea, UK waters, and the northeast Atlantic.

11.5.3 Existing Pressures on Wider Environment

64. There are a number of pressures acting on offshore ornithology receptors in the North Sea and beyond. These include changes in prey availability, bycatch, invasive alien species, disturbance and displacement, collision risk and pollution (Dias *et al*., 2019; Mitchell *et al*., 2020; Royal HaskoningDHV, 2019).

65. A large body of evidence identifies climate change as a major driver of seabird population demographics (Daunt *et al*., 2017; Daunt and Mitchell, 2013; Mitchell *et al*., 2020). Anthropogenic climate change has exposed ocean and coastal ecosystems to conditions that are unprecedented over millennia, and this has greatly impacted life in the ocean and along its coasts (IPCC, 2022). In the UK, and particularly in the northern North Sea, seabird populations are generally undergoing substantial declines, which have been occurring for at least two decades (Grandgeorge *et al*., 2008; JNCC, 2020; Mitchell *et al*., 2020). Whilst there are exceptions (for instance gannet), the wider population trend is negative. This is reflected in the fact that according to the UK Marine Strategy, UK breeding seabirds have not achieved good environmental status (DEFRA, 2019).

66. Climate change has the potential to impact seabird populations in two main ways; indirectly through prey availability impacts, and directly through impacts such as mortality or reduced breeding success due to extreme weather events. Whilst effects may not extend to all areas (e.g. some areas where prey recruitment may be less affected (ClimeFish, 2019; Frederiksen *et al*., 2005)), climate models generally predict increased incidences of warming and extreme weather in the future (Palmer *et al*., 2018). Indeed, such patterns are already occurring (IPCC, 2021). This means that it is reasonable to assume that future trends will see effects on seabirds increase in both frequency and magnitude. Existing pressures on seabirds will

therefore increase in future years as a direct consequence of climate change. Ocean conditions are projected to continue diverging from a pre-industrial state, increasing risk of regional extirpations and global extinctions of marine species (IPCC, 2022).

67. In general, as mean breeding season temperatures have increased due to climate change, it seems some seabirds have struggled to find sufficient food for their chicks (Brander *et al*., 2016). A range of interactions between prey availability and climate change have been demonstrated which explain these observations (Lindegren *et al*., 2018; MacDonald *et al*., 2019, 2018, 2015; Régnier *et al*., 2019; Sandvik *et al*., 2012, 2005; Wright *et al*., 2018). In some cases, links have also been established between population declines and the rate of warming caused by climate change, rather than warming itself (Descamps *et al*., 2017).

68. With respect to direct impacts, it is apparent that seabirds are susceptible to substantial population-level impacts due to poor weather and extreme weather events (Daunt *et al*., 2017; Daunt and Mitchell, 2013; Jenouvrier, 2013; Mitchell *et al*., 2020; Morley *et al*., 2016; Newell *et al*., 2015). The mechanisms by which these effects can manifest include chilling of eggs and killing of unfledged chicks during the breeding season, and impairment of foraging, which can occur at all times of year.

69. Whilst the significance of climate change impacts likely exceed any other factor for a wide range of offshore ornithology receptors on a larger scale, there is considerable geographical variation in the magnitude of the impact of other factors on population trends. For example, clear links between kittiwake breeding success and reduced sandeel availability due to fishing activities have been demonstrated (Carroll *et al*., 2017; Daunt *et al*., 2008; Frederiksen *et al*., 2004; Furness and Tasker, 2000; Greenstreet *et al*., 2010; Hayhow *et al*., 2017; Lindegren *et al*., 2018; Wright *et al*., 2018). It has been identified that three traits that make kittiwake particularly sensitive to sandeel depletion by fisheries activity are the species low ability to dive, lack of spare time in its daily budget, and its low ability to switch diet (Furness and Tasker, 2000).

70. For offshore ornithology, the assessment is carried out in a context of declining baseline populations of a number of receptor species. Furthermore, it considered likely that a range of pressures are likely to continue to impact offshore ornithology receptors in the North Sea, and these pressures are likely to increase in the future (Royal HaskoningDHV, 2019). Other pressures, for example the widespread outbreak of avian influenza seen at many breeding seabird colonies during the 2022 breeding season (including key colonies considered by this assessment), will also add additional stress to seabird populations. At the present time, the outcome of this disease outbreak at the population level, and whether such events may become more frequent in the future, is unknown.

71. The assessment takes into account whether a given impact is likely to exacerbate a decline in the relevant reference population and prevent a receptor species from recovery should environmental conditions become more favourable.

11.6 Potential Impacts

72. Potential impacts included within the offshore ornithology assessment due to the construction, operation and decommissioning of SEP and DEP are as previously presented in the Scoping Report and PEIR, and are as follows:

- In the construction phase:
  - Impact 1: Disturbance and displacement covering work activity, vessel movements and lighting, as well as barrier effects due to presence of turbines and infrastructure (from erection of first turbines).
  - Impact 2: Indirect impacts through effects on habitats and prey species during the construction phase.
- In the operational phase:
  - Impact 3: Displacement and barrier effects due to presence of turbines and infrastructure, as well as disturbance and displacement covering work activity, vessel movements and lighting.
  - Impact 4: Collision risk.
  - Impact 5: Indirect impacts through effects on habitats and prey species during the operational phase.
- In the decommissioning phase:
  - Impact 6: Disturbance and displacement covering work activity, vessel movements, lighting, as well as barrier effects due to presence of turbines and infrastructure (until final turbine is removed).
  - Impact 7: Indirect impacts through effects on habitats and prey species during the decommissioning phase.

73. In the assessment of potential impacts below, all impacts are assessed in the order of construction, operation and decommissioning, following the impact assessment methodology that is described in **Section 11.4.3**, on the basis of the worst-case scenarios set out in **Section 11.3.2** and accounting for the embedded mitigation described in **Section 11.3.3**.

11.6.1 Potential Impacts During Construction

11.6.1.1 Impact 1: Disturbance, Displacement and Barrier Effects

74. During the construction phase, SEP and DEP have the potential to impact offshore ornithology receptors through disturbance, leading to displacement of birds from construction sites and the areas that surround them. Barrier effects are also possible as turbines are installed.

75. These potential impacts effectively result in temporary habitat loss through reduction in the area available for behaviours such as foraging, loafing and moulting in the case of displacement, or commuting and migration in the case of barrier effects. These effects have the potential to last for the duration of the construction phase of SEP and DEP. The approximate duration of offshore construction for SEP and DEP would be four years (two years per Project). Construction could occur

simultaneously, or sequentially, with a maximum gap between construction at SEP and DEP of four years, giving a maximum construction period duration of eight years (**Section 11.3.2**).

76. Details of activities to be undertaken during the construction phase are provided in **Chapter 4 Project Description**. In summary, this phase will require the mobilisation of vessels (day or night), helicopters and equipment and the installation of foundations, turbines, offshore platforms (OSPs), offshore export cables and other infrastructure.

77. Construction will not occur across the whole of SEP and DEP simultaneously or every day. Whilst up to 16 construction vessels could be active within SEP or DEP during construction, these would not be equally spread throughout the SEP or DEP wind farm site and therefore areas subject to disturbance would be concentrated at discrete locations. Until wind turbines (and other structures) are placed on foundations, disturbance effects will occur only in the areas where vessels are operating at any given point and not the entire SEP and DEP offshore sites. For this reason, the assessment assumes that construction activities will occur at a maximum of three discrete locations simultaneously for SEP or DEP in isolation or six discrete locations for SEP and DEP. The exact level of disturbance at each work location would differ depending on the activities taking place. Causes of potential disturbance and displacement of offshore ornithology receptors comprise a visual element due to the presence of construction vessels and associated human activity (including lighting), and noise and vibration from construction activities. At such time as the first wind turbines (and other infrastructure) are installed onto foundations, the impact of displacement and barrier effects in relation to the presence of turbines would increase incrementally until construction is completed, at which point they are considered as operational impacts (**Section 11.6.2.1**).

78. Offshore ornithology receptors differ considerably in their sensitivity to anthropogenic disturbance in the marine environment, which is detailed in a considerable amount of literature (Fliessbach *et al*., 2019; Furness *et al*., 2013; Furness and Wade, 2012; Garthe and Hüppop, 2004; MMO, 2018). Despite this, considerable variability and uncertainty exists with regard to displacement effects (Wade *et al*., 2016), and disentangling the relative contribution of different disturbance pathways is challenging.

79. This assessment takes the approach of dealing with disturbance and displacement as a whole, rather than attempting to disentangle the effects attributable to visual disturbance, airborne noise disturbance due to the presence of vessels and anthropogenic activity, underwater noise and any other potential impact pathways that could contribute to the effect.

80. With respect to underwater noise, the possibility of serious injury to diving birds within a certain distance of piling activities exists. Some diving birds possess specialised anatomical traits that may be associated with improved underwater hearing (Crowell *et al*., 2015; Johansen *et al*., 2016), which may render them more sensitive to potential effects resulting from underwater noise. That said, such anatomical adaptations have been shown to include protection against the large pressure changes that may occur while diving, which may actually protect the ear from damage during acoustic overexposure (Dooling and Therrien, 2012). Measurements of the underwater hearing capabilities of seabirds are limited, and

contain quite large sources of error (Johansen *et al*., 2016). The principal source of noise during construction of SEP and DEP would be subsea noise from piling works associated with the installation of foundations for wind turbines and associated offshore substations. It is expected that a high proportion of offshore ornithology receptors will be displaced prior to underwater noise being created by piling. The potential for underwater noise impacts on fish ecology and marine mammal receptors has been considered in detail in **Chapter 9 Fish and Shellfish Ecology** and **Chapter 10 Marine Mammal Ecology**. Mitigation measures provide an opportunity for receptors to leave the zone within which permanent injury could occur prior to piling being ramped up to full power. These measures are expected to have similar effects on any offshore ornithology receptors that are sensitive to these effects, that have not already been displaced by the presence of vessels. Therefore, underwater noise impacts are not anticipated to have substantial effects on offshore ornithology receptors, and are not considered further by the assessment.

81. Lighting of construction sites, vessels and other structures at night may potentially be a source of attraction (phototaxis), as opposed to displacement. Phototaxis can be a serious hazard for fledglings of some seabird species, particularly those that nest in burrows (Deppe *et al*., 2017; Raine *et al*., 2007; Rodríguez *et al*., 2015). Research indicates that this impact occurs over short distances in response to bright light close to breeding colonies. It is not seen over large distances or in older (adult and immature) seabirds. Construction sites associated with SEP and DEP would be far enough removed from any seabird breeding colonies as to render this risk negligible. Phototaxis of nocturnal migrating birds can be a problem, especially in autumn during conditions of poor visibility, but is generally seen where birds are exposed to intense white lighting such as from lighthouses; light from construction sites is likely to be less powerful than that from lighthouses, and therefore it is not considered that this will be an issue for offshore ornithology receptors at SEP and DEP.

82. The effects of construction disturbance and displacement on the key resident species are considered together. Birds are considered to be most at risk from disturbance and displacement effects when they are resident in an area at any time of year. Birds that are resident in an area may regularly encounter and be displaced by an OWF that is under construction. During the breeding season, this could occur during daily commuting trips to foraging areas from nest sites. During the non-breeding season, birds using marine habitat adjacent to a construction site could also be displaced. No disturbance at breeding colonies due to construction activities at SEP and DEP is anticipated; no breeding site for any offshore ornithology receptor falls within the Zone of Influence (ZoI).

83. Birds on passage may encounter (and potentially be displaced from) a particular OWF that is under construction only once during a given migration journey. The costs of one-off avoidances during migration have been calculated to be relatively small, accounting for less than 2% of available fat reserves (Masden *et al*., 2012, 2009; Speakman *et al*., 2009). Therefore, the impacts of construction disturbance, displacement and barrier effects on birds that only migrate through SEP and DEP (including seabirds, waders and waterbirds on passage) are considered negligible and these have been scoped out of the assessment.

84. A screening exercise has been undertaken to identify offshore ornithology receptors most likely to be at risk of significant impacts through disturbance, displacement and barrier effects during the construction of SEP and DEP (**Table 11-18**). Any species recorded only in very small numbers and/or infrequently within the estimated ZoI (considered to extend to 4km from SEP and DEP wind farm site permanent work areas), present only as a migrant species, or with a low sensitivity to disturbance, displacement and/or barrier effects according to the literature consulted, was screened out of further assessment.

85. A range of highly applicable existing information of high quality (encompassing peer-reviewed and other research, and previous OWF assessments) was referred to during the screening process. Confidence in the estimated sensitivity assigned to each receptor is also presented. This was considered to be high where evidence of behaviour around anthropogenic disturbance sources in the marine environment was identified, and this concorded with expert opinion (i.e. Furness and Wade (2012) and Garthe and Hüppop (2004)). Where no such evidence was identified, but expert opinion was available, a medium confidence level was assigned. Where expert opinion and any recorded effects did not concord, confidence was reduced accordingly. For some species, it was not possible to assign an estimated sensitivity level due to a lack of evidence.

86. The evidence used was predominantly a recent review by Fliessbach *et al*. (2019), the extensive, systematic literature review of the Marine Management Organisation (MMO) (2018), and observations local to SEP and DEP from the ornithological monitoring carried out at SOW, LID and Lincs OWFs (Harwood *et al*., 2018; Hi Def Aerial Surveying, 2017)).

87. The relative frequency and abundances for each species were assigned qualitatively through assessment of the baseline survey data. In general, the low frequency category was used to describe species present within the aerial survey study area on only one, or slightly more than one occasion during the survey programme. Medium frequency was used to describe species routinely present in the aerial survey study area during a particular season, or with patchy abundance across multiple seasons, whilst the high frequency descriptor was reserved for species recorded on most or all surveys. The abundance descriptors were used to describe numbers of birds relative to the background population from which they likely originated.

88. For each of the species screened into further assessment, matrix-based assessments of displacement were carried out, and the outputs used to populate the tables in the following sections. The matrices are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

Table 11-18: Construction Disturbance and Displacement Screening for SEP and DEP

Species	Estimated sensitivity to disturbance and displacement due to OWF construction	Confidence in sensitivity estimate	Relative frequency in ZoI	Relative abundance in ZoI	Screening result
Arctic skua	Low	Medium	Low (migrant)	Low	Out
Arctic tern	Low	High	Low	Low	Out
Black-headed gull	Low	Medium	Low	Medium	Out
Common gull	Low	High	Medium	Low	Out
Common scoter	High	High	Low	Low	Out
Common tern	Low	High	Medium	Medium	Out
Cormorant	Medium	High	Low	Low	Out
Fulmar	Low	High	High	Low	Out
Gannet	Low	High	High	Medium	Out
Golden plover	Unknown	N/A	Low (migrant)	Low	Out
Great black-backed gull	Low	High	Medium	Medium	Out
Great crested grebe	High	Medium	Low (migrant)	Low	Out
Great skua	Low	Medium	Low (migrant)	Low	Out
Guillemot	Medium	High	High	High	In
Herring gull	Low	High	Medium	Low	Out
Kestrel	Unknown	N/A	Low (migrant)	Low	Out
Kittiwake	Low	High	High	High	Out
Knot	Unknown	N/A	Low (migrant)	Low	Out
Lapwing	Unknown	N/A	Low (migrant)	Low	Out
Lesser black-backed gull	Low	High	Medium	Medium	Out
Little gull	Medium	High	Medium (migrant)	Medium	Out

Species	Estimated sensitivity to disturbance and displacement due to OWF construction	Confidence in sensitivity estimate	Relative frequency in ZoI	Relative abundance in ZoI	Screening result
Little tern	Low	Medium	Medium	Low	Out
Long-tailed duck	Unknown	N/A	Low (migrant)	Low	Out
Long-tailed skua	Low	Low	Low (migrant)	Low	Out
Manx shearwater	Medium	Low	Low (migrant)	Medium	Out
Oystercatcher	Unknown	N/A	Low (migrant)	Low	Out
Pomarine skua	Low	Low	Low (migrant)	Low	Out
Puffin	Medium	Medium	Medium	Low	Out
Razorbill	Medium	High	High	High	In
Red-throated diver	High	High	Medium	Medium	In
Sandwich tern	Low	High	Medium	High	Out
Shag	Medium	Medium	Low	Low	Out
Tufted duck	Unknown	N/A	Low (migrant)	Low	Out
Woodpigeon	Unknown	N/A	Low (migrant)	Low	Out

11.6.1.1.1 Auks (Guillemot and Razorbill)

89. Much of the general information on the potential sensitivity of guillemot and razorbill to disturbance and displacement during the construction of OWFs referred to in **Section 11.6.1.1** indicates that both species are moderately sensitive to such effects. Locally to SEP and DEP, evidence from the SOW OMP (Harwood *et al*., 2018) indicates that avoidance of the OWF by guillemot and razorbill occurred during construction, and that the minor adverse impact significance predicted by the SOW ES for both species was an appropriate prediction. No construction displacement effects were reported for either species at the LID and Lincs OWFs (Hi Def Aerial Surveying, 2017).

90. Recent reviews of available evidence for auk displacement at operational OWFs (APEM, 2022; MacArthur Green, 2019a; Vattenfall, 2019) concluded that the increase in density of auks outside a displacement zone will be negligible, because the available habitat for birds to be displaced into is vast. The mortality rate due to displacement may therefore feasibly be 0%, and is highly unlikely to be anywhere near to the total annual mortality rates for guillemot (6%) and razorbill (10%) (Horswill and Robinson, 2015). Precautionary rates of displacement and mortality of guillemot and razorbill from operational OWFs of 50% and 1% respectively were suggested by each of the above reviews.

91. Based on all of the available information, guillemot and razorbill are considered to possess a medium sensitivity to disturbance and displacement from SEP and DEP during the construction phase. Confidence in this level of sensitivity is considered to be high due to the relatively high applicability, concordance, and quality of the available information sources.

92. In the PEIR, it was assumed that 100% displacement of guillemot and razorbill will occur within 2km of construction activities, and a mortality rates of 1% to 10% of displaced birds is predicted. This approach is retained in this assessment.

93. Escape distances of auks was much lower than 2km according to evidence presented by Fliessbach *et al*. (2019). The mean escape distance for individual guillemot was 127m (standard deviation 110m), with a maximum of 500m (sample size of 86 birds). The mean escape distance for individual razorbill was 395m (standard deviation 216m), with a maximum of 900m (sample size of 53 birds). The same study presented data indicating that 37% of guillemots and 78% of razorbills responded to the presence of a vessel by escape diving or flying. Therefore it is considered that both the displacement distance, and the proportion of birds potentially affected by construction activities that are assumed by the assessment are a substantial overestimate.

94. The upper limit of the mortality range used in PEIR is nearly double the background annual adult mortality for guillemot, and approximately equivalent to the annual adult mortality for razorbill (Horswill and Robinson, 2015). This level of annual mortality is the result of the combined contributions of a range of environmental and anthropogenic pressures. These include prey availability driven by climate change and fisheries activities, bycatch, predation, displacement by operational OWFs, shipping, oil and gas, aggregate extraction and military activity, and pollution (both one off events such as oil spills, and chronic pollution by microplastics and other

substances), as well as birds that die of natural causes. It seems improbable that disturbance and displacement would result in a level of mortality similar to all of these other factors combined.

95. A calculation using the quantitative evidence of ship-induced disturbance presented by Fliessbach *et al*. (2019) has been included in the assessment. For guillemot, this assumes 40% displacement within 500m of construction activity for guillemot, and 80% displacement within 900m of construction activity for razorbill. The mortality rate selected for the evidence-based assessment is 1%, as discussed above. It is acknowledged that disturbance from OWF construction sites might sometimes be greater than disturbance from a transiting vessel, which is the situation from which much of the Fliessbach *et al*. (2019) figures were obtained. However, it is considered that these outputs may represent a more realistic scenario than those used previously by other OWF assessments. The assessment uses this information when assessing confidence in the assessment.

96. This assessment uses densities of birds within SEP and DEP plus their respective 2km buffers. The reason that OWF plus buffer zone densities are used is that the ZoI for construction sites at the extremities of SEP and DEP will extend into the buffer zones. It should also be noted that mean peak density estimates (along with their 95% CIs) are used in this assessment. These are substantially greater than mean density estimates, which are considered to be far more representative of typical densities of offshore ornithology receptors found in the ZoI for this impact. Their inclusion in the assessment provides an additional layer of precaution as densities of birds typically subject to this impact on a given day are highly likely to be lower than those used as inputs into the assessment.

11.6.1.1.1.1 Guillemot

97. The UK North Sea and Channel Biologically Defined Minimum Population Scale (BDMPS) is considered to be the relevant background population for guillemot during the non-breeding season (Furness, 2015). Using the published average annual mortality for this species for all age classes (14.0%; **Table 11-17**), the number of guillemots expected to die annually from this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 226,423 (i.e. 1,617,306 x 0.140).

98. The non-breeding component of the UK North Sea and Channel BDMPS (i.e. juvenile and immature birds) is considered to be the relevant background population for the breeding season. At the published baseline annual mortality for all guillemots (14.0%; **Table 11-17**), the number of guillemots expected to die annually that are members of this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 97,362 (i.e. 695,441 x 0.140).

11.6.1.1.1.1.1 DEP

99. The predicted effects on guillemot within 2km of the three construction sites due to disturbance and displacement during the construction of DEP are summarised in **Table 11-19**. **Table 11-20** uses evidence discussed in **Section 11.6.1.1.1** to perform the assessment with parameters informed by Fliessbach *et al*. (2019).

Table 11-19: Guillemot Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at DEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Previously Recommended by SNCBs, and used in Other OWF Assessments

Parameter	Non-breeding density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	27.19	51.70	85.11	8.26	13.34	20.21
Number of birds displaced[1]	1,025	1,949	3,209	311	503	762
Estimated mortality[2]	10 - 103	19 - 195	32 - 321	3 - 31	5 - 50	8 - 76
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.05	0.01 - 0.09	0.01 - 0.14	0.00 - 0.03	0.01 - 0.05	0.01 - 0.08

Notes
1. Assumes 100% displacement of birds within 2km of construction activity (an area of 12.57km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds, 1% being considered to be a precautionary prediction
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

Table 11-20: Guillemot Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at DEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Identified from Fliessbach et al. (2019)

Parameter	Non-breeding density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	27.19	51.70	85.11	8.26	13.34	20.21
Number of birds displaced[1]	26	49	80	8	13	19
Estimated mortality[2]	0 - 3	0 - 5	1 - 8	0 - 1	0 - 1	0 - 2
Estimated mortality as % increase to existing background	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00

Parameter	Non-breeding density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
population mortality[3]						

Notes
1. Assumes 40% displacement of birds within 0.5km of construction activity (an area of 0.79km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds, 1% being considered to be a precautionary prediction
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

100. As presented in **Table 11-19**, the mean peak density of flying and sitting guillemots during the non-breeding season within DEP and its 2km buffer was 51.70 birds/km^2. Within 2km of three construction locations, 1,949 birds would be displaced due to this impact. The estimated annual mortality of displaced birds during construction, based on mortality rates of 1% to 10% for displaced birds, is 19 to 195 birds. Adding this predicted mortality to the existing mortality levels within the relevant BDMPS population will increase the existing annual mortality within this population by 0.01% to 0.09%. Even if the upper 95% confidence interval (CI) for mean peak density is considered, mortality increases relative to existing mortality are still very small (0.01% to 0.14%).

101. As presented in **Table 11-19**, the mean peak density of flying and sitting guillemots during the breeding season within DEP and its 2km buffer was 13.34 birds/km^2. Within 2km of three construction locations, 503 birds would be displaced due to this impact. The estimated annual mortality of displaced birds during construction, based on mortality rates of 1% to 10% for displaced birds, is five to 50 birds. Adding this predicted mortality to the existing mortality levels for the non-breeding birds within the relevant BDMPS population will increase the existing annual mortality within this population by 0.01% to 0.05%. Even if the upper 95% CI for mean peak density is considered, mortality increases relative to existing mortality are still very small (0.01% to 0.08%).

102. Summing the seasonal totals in **Table 11-19**, the estimated number of guillemots subject to construction disturbance and displacement throughout the year at DEP is 2,452 individuals, of which between 25 and 245 could be at risk of mortality. Adding the predicted annual mortality due to construction-related disturbance and displacement at DEP to existing mortality levels within the largest BDMPS population throughout the year, the UK North Sea and Channel BDMPS (226,423 individuals), will increase the existing mortality level of this population by 0.01% to 0.11%.

103. The predicted increase in existing mortality due to this impact is very small across all seasons, would not materially alter the background mortality of the population, and would be undetectable in the context of natural variation. During the non-breeding season, breeding season, and year round, the magnitude of effect of construction-related disturbance and displacement at DEP is assessed as

negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.1.1.1.1.2 SEP

104. The predicted effects on guillemot within 2km of three construction sites due to construction disturbance and displacement during the construction of SEP are summarised in **Table 11-21**. **Table 11-22** uses evidence discussed in **Section 11.6.1.1.1** to perform the assessment with parameters informed by Fliessbach *et al*. (2019).

Table 11-21: Guillemot Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Previously Recommended by SNCBs, and used in Other OWF Assessments.

Parameter	Non-breeding density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	3.18	5.21	7.54	2.85	5.26	8.99
Number of birds displaced[1]	120	196	284	107	198	339
Estimated mortality[2]	1 - 12	2 - 20	3 - 28	1 - 11	2 - 20	3 - 34
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.01	0.00 - 0.01	0.00 - 0.01	0.00 - 0.01	0.00 - 0.02	0.00 - 0.03

Notes
1. Assumes 100% displacement of birds within 2km of construction activity (an area of 12.57km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds, 1% being considered to be a precautionary prediction
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

Table 11-22: Guillemot Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Identified from Fliessbach et al. (2019).

Parameter	Non-breeding density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	3.18	5.21	7.54	2.85	5.26	8.99
Number of birds displaced[1]	3	5	7	3	5	8
Estimated mortality[2]	0	0	0 - 1	0	0	0 - 1
Estimated mortality as % increase to existing background population mortality[3]	0	0	0.00 - 0.00	0	0	0.00 - 0.00

Notes
1. Assumes 40% displacement of birds within 0.5km of construction activity (an area of 0.79km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds, 1% being considered to be a precautionary prediction
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

105. As presented in **Table 11-21**, the mean peak density of flying and sitting guillemots during the non-breeding season within SEP and its 2km buffer was 5.21 birds/km^2. Within 2km of three construction locations, 196 birds would be displaced due to this impact. The estimated annual mortality of displaced birds during construction, based on mortality rates of 1% to 10% for displaced birds, is 2 to 20 birds. Adding this predicted mortality to the existing mortality levels within the relevant BDMPS population will increase the existing annual mortality within this population by 0.00% to 0.01%. Even if the upper 95% CI for mean peak density is considered, mortality increases relative to existing mortality are still very small (0.01% to 0.01%).

106. As presented in **Table 11-21**, the mean peak density of flying and sitting guillemots during the breeding season within SEP and its 2km buffer was 5.26 birds/km^2. Within 2km of three construction locations, 198 birds would be displaced due to this impact. The estimated annual mortality of displaced birds during construction, based on mortality rates of 1% to 10% for displaced birds, is 2 to 20 birds. Adding this predicted mortality to the existing mortality levels for the non-breeding birds within the relevant BDMPS population will increase the existing annual mortality within this population by 0.00% to 0.02%. Even if the upper 95% CI for mean peak density is considered, mortality increases relative to existing mortality are still very small (0.01% to 0.03%).

107. Summing the seasonal totals in **Table 11-21**, the estimated number of guillemots subject to construction disturbance and displacement throughout the year at SEP is 395 individuals, of which between 4 and 39 could be at risk of mortality. Adding the predicted annual mortality due to construction-related disturbance and displacement at SEP to existing mortality levels within the largest BDMPS population throughout the year, the UK North Sea and Channel BDMPS (226,423 individuals), will increase the existing mortality level of this population by 0.00% to 0.02%.

108. The predicted increase in existing mortality due to this impact is very small across all seasons, would not materially alter the background mortality of the population, and would be undetectable in the context of natural variation. During the non-breeding season, breeding season, and year round the magnitude of effect of construction-related disturbance and displacement at SEP is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.1.1.1.1.3 SEP and DEP Combined

109. The predicted effects on guillemot within 2km of six simultaneous construction sites (i.e. three each at SEP and DEP) due to construction disturbance and displacement are summarised in **Table 11-23**. **Table 11-24** uses evidence discussed in **Section 11.6.1.1.1** to perform the assessment with parameters informed by Fliessbach *et al*. (2019).

Table 11-23: Guillemot Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP and DEP Combined, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Previously Recommended by SNCBs, and used in Other OWF Assessments

Parameter	Non-breeding density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Number of birds displaced[1]	1,145	2,145	3,493	418	701	1,101
Estimated mortality[2]	11 - 114	21 - 215	35 - 349	4 - 42	7 - 70	11 - 110
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.05	0.01 - 0.09	0.02 - 0.15	0.00 - 0.04	0.01 - 0.07	0.01 - 0.11

Notes
1. Assumes 100% displacement of birds within 2km of construction activity (an area of 12.57km^2), six construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

Table 11-24: Guillemot Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP and DEP Combined, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Identified from Fliessbach et al. (2019).

Parameter	Non-breeding density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Number of birds displaced[1]	29	54	87	10	18	28
Estimated mortality[2]	0 - 3	1 - 5	1 - 9	0 - 1	0 - 2	0 - 3
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00

Notes
1. Assumes 40% displacement of birds within 0.5km of construction activity (an area of 0.79km^2), six construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds, 1% being considered to be a precautionary prediction
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

110. As presented in **Table 11-23**, within 2km of three construction locations in SEP and DEP combined (i.e. six construction sites in total; simultaneous construction of both OWFs), 2,145 birds would be displaced due to this impact in the non-breeding season. The estimated annual mortality of displaced birds during construction, based on mortality rates of 1% to 10% for displaced birds, is 21 to 215 birds. Adding this predicted mortality to the existing mortality levels within the relevant BDMPS population will increase the existing annual mortality within this population by 0.01% to 0.09%. Even if the upper 95% CI for mean peak density is considered, mortality increases relative to existing mortality are still very small (0.02% to 0.15%).

111. As presented in **Table 11-23**, within 2km of three construction locations in SEP and DEP combined (i.e. six construction sites in total, simultaneous construction of both OWFs), 701 birds would be displaced due to this impact in the breeding season. The estimated annual mortality of displaced birds during construction, based on mortality rates of 1% to 10% for displaced birds, is seven to 70 birds. Adding this predicted mortality to the existing mortality levels for the non-breeding birds within the relevant BDMPS population will increase the existing annual mortality within this population by 0.01% to 0.07%. Even if the upper 95% CI for mean peak density is considered, mortality increases relative to existing mortality are still very small (0.02% to 0.11%).

112. Summing the seasonal totals in **Table 11-23**, the estimated number of guillemots subject to construction disturbance and displacement throughout the year at SEP

and DEP combined (assuming simultaneous construction) is 2,847 individuals, of which between 28 and 285 could be at risk of mortality. Adding the predicted annual mortality due to construction-related disturbance and displacement at SEP and DEP combined to existing mortality levels within the largest BDMPS population throughout the year, the UK North Sea and Channel BDMPS (226,423 individuals), will increase the existing mortality level of this population by 0.01% to 0.13%.

113. The predicted increase in existing mortality due to this impact is very small across all seasons, would not materially alter the background mortality of the population, and would be undetectable in the context of natural variation. During the non-breeding season, breeding season, and year round, the magnitude of effect of construction-related disturbance and displacement at SEP and DEP combined is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.1.1.1.1.4 Summary and Confidence Assessment

114. Overall, the impact significance for guillemot displacement during the construction phase of SEP and DEP combined is **minor adverse**. This applies to all potential construction options (i.e. simultaneous or sequential construction), as outlined in **Section 11.3.2.2**, all seasons, and year round impacts.

115. The confidence of this prediction is high for two reasons. Firstly, the use of upper 95% CI mean peak density estimates in the assessment does not alter the conclusions of the assessment for either OWF in isolation or combined with the other, for any biologically relevant season. Secondly, the evidence-based assessments (**Table 11-20**, **Table 11-22** and **Table 11-24**) undertaken in parallel with the established assessment (**Table 11-19**, **Table 11-21** and **Table 11-23**) predict much lower impacts. This indicates that the more established parameters are likely to overestimate the magnitude of the potential impact and that the assessment is precautionary.

116. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. A comparison between the encounter rates of this species within the different parts of DEP indicated that year round, the encounter rate for this species from the raw baseline survey data was 18.8% higher at DEP-N than DEP as a whole. However, since the differences between densities at DEP-N and DEP (as a whole) are considered unlikely to be statistically significant, and due to the low impact magnitudes predicted, the conclusion of the assessment presented above is unaffected by this observation.

11.6.1.1.1.2 Razorbill

117. The UK North Sea and Channel BDMPS is considered to be the relevant background population for razorbill during the autumn migration season, the winter season and the spring migration season (Furness, 2015). Using the published baseline annual mortality averaged across all age classes (17.4%; **Table 11-17**), the number of razorbills expected to die annually from the BDMPS during the spring and autumn migration seasons (**Appendix 11.1 Offshore Ornithology Technical**

Report) is 102,986 (i.e. 591,874 x 0.174). During the winter season, existing mortality from the BDMPS is estimated to be 38,040 (i.e. 218,622 x 0.174).

118. The non-breeding component of the winter season UK North Sea and Channel BDMPS (i.e. juvenile and immature birds) is considered to be the relevant razorbill background population for the breeding season (**Appendix 11.1 Offshore Ornithology Technical Report**). At the published annual mortality averaged across all age classes (17.4%; **Table 11-17**), the number of razorbills expected to die in the breeding season that are members of this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 16,357 (i.e. 94,007 x 0.174).

11.6.1.1.1.2.1 DEP

119. The predicted effects on razorbill within 2km of three construction locations due to disturbance and displacement during the construction of DEP are summarised in **Table 11-25**. **Table 11-26** uses evidence discussed in **Section 11.6.1.1.1** to perform the assessment with parameters informed by Fliessbach *et al*. (2019).

Table 11-25: Razorbill Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at DEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Previously Recommended by SNCBs, and used in Other OWF Assessments

Parameter	Autumn migration density			Winter density			Spring migration density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	4.39	12.99	23.80	1.56	2.93	4.68	0.29	1.11	2.26	1.80	3.21	5.10
Number of birds displaced[1]	165	490	897	59	110	176	11	42	85	68	121	192
Estimated mortality[2]	2 - 17	5 - 49	9 - 90	1 - 6	1 - 11	2 - 18	0 - 1	0 - 4	1 - 9	1 - 7	1 - 12	2 - 19
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.02	0.00 - 0.05	0.01 - 0.09	0.00 - 0.02	0.00 - 0.03	0.00 - 0.05	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.04	0.01 - 0.07	0.01 - 0.12

Notes
1. Assumes 100% displacement of birds within 2km of construction activity (an area of 12.57km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

Table 11-26: Razorbill Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at DEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Identified from Fliessbach et al. (2019)

Parameter	Autumn migration density			Winter density			Spring migration density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	4.39	12.99	23.8	1.56	2.93	4.68	0.29	1.11	2.26	1.8	3.21	5.1
Number of birds displaced[1]	27	79	145	10	18	29	2	7	14	11	20	31
Estimated mortality[2]	0 - 3	1 - 8	1 - 15	0 - 1	0 - 2	0 - 3	0 - 0	0 - 1	0 - 1	0 - 1	0 - 2	0 - 3
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.00	0.00 - 0.01	0.00 - 0.01	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.01	0.00 - 0.02

Notes

1. Assumes 80% displacement of birds within 0.9km of construction activity (an area of 2.54km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

120. The mean peak density of flying and sitting razorbills during the autumn migration season within DEP and its 2km buffer was 12.99 birds/km^2. This means that, assuming 100% displacement within 2km of three simultaneous construction locations across the site, 490 individuals would be displaced. The estimated annual mortality of birds displaced during construction, based on mortality rates of 1% to 10%, is 5 to 49 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.00% to 0.05%. If the upper 95% CI for mean peak density is considered instead, mortality increases relative to existing mortality would still be very small (0.01% to 0.09%).

121. During the winter season, the mean peak density of flying and sitting razorbills within DEP and its 2km buffer was 2.93 birds/km^2. Within 2km of three simultaneous construction locations, 110 individuals would be displaced. The estimated annual mortality, based on mortality rates of 1% to 10%, is 1 to 11 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.00% to 0.03%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small (0.00% to 0.05%).

122. During the spring migration season, the mean peak density of flying and sitting razorbills within DEP and its 2km buffer was 1.11 birds/km^2. Within 2km of three simultaneous construction locations, 42 individuals would be displaced. The estimated annual mortality, based on mortality rates of 1% to 10%, is 0 to 4 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by less than 0.01%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small (0.00% to 0.01%).

123. During the breeding season, the mean peak density of flying and sitting razorbills within DEP and its 2km buffer was 3.21 birds/km^2. Within 2km of three simultaneous construction locations, 121 individuals would be displaced. The estimated annual mortality, based on mortality rates of 1% to 10% for displaced birds, is 1 to 12 individuals. Adding this to the existing annual mortality for the non-breeding component of the winter BDMPS would increase annual mortality in this population by 0.01% to 0.07%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small to small (0.01% to 0.12%).

124. Summing the seasonal totals in **Table 11-25**, the estimated number of razorbills subject to construction disturbance and displacement throughout the year at DEP is 763 individuals, of which between 8 and 76 could be at risk of mortality. Adding the predicted annual mortality due to construction-related disturbance and displacement at DEP to the existing mortality level within the largest BDMPS population throughout the year (i.e. the autumn and spring migration BDMPS) would increase the annual mortality in this population by 0.01% to 0.07%.

125. The predicted increase in existing mortality due to this impact is very small across all seasons, would not materially alter the background mortality of the population, and would be undetectable in the context of natural variation. During the autumn and spring migration seasons, winter season and breeding season, as well as on a year-round basis, the magnitude of effect of construction-related disturbance and displacement at DEP is assessed as negligible. As razorbill is considered to possess medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.1.1.1.2.2 SEP

126. The predicted effects on razorbill within 2km of three construction locations due to disturbance and displacement during the construction of SEP are summarised in **Table 11-27**. **Table 11-28** uses evidence discussed in **Section 11.6.1.1.1** to perform the assessment with parameters informed by Fliessbach *et al*. (2019).

Table 11-27: Razorbill Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Previously Recommended by SNCBs, and used in Other OWF Assessments

Parameter	Autumn migration density			Winter density			Spring migration density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	1.57	3.65	5.98	1.63	3.30	5.34	0.12	0.69	1.44	0.99	1.52	2.02
Number of birds displaced[1]	59	138	225	61	124	201	5	26	54	37	57	76
Estimated mortality[2]	1-6	1-14	2-23	1-6	1-12	2-20	0-0	0-3	1-5	0-4	1-6	1-8
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.01	0.00 - 0.01	0.00 - 0.02	0.00 - 0.02	0.00 - 0.03	0.01 - 0.05	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.02	0.00 - 0.04	0.00 - 0.05

Notes
1. Assumes 100% displacement of birds within 2km of construction activity (an area of 12.57km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

Table 11-28: Razorbill Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Identified from Fliessbach et al. (2019)

Parameter	Autumn migration density			Winter density			Spring migration density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	1.57	3.65	5.98	1.63	3.3	5.34	0.12	0.69	1.44	0.99	1.52	2.02
Number of birds displaced[1]	10	22	37	10	20	33	1	4	9	6	9	12
Estimated mortality[2]	0-1	0-2	0-4	0-1	0-2	0-3	0-0	0-0	0-1	0-1	0-1	0-1
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.01	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.01

Notes
1. Assumes 80% displacement of birds within 0.9km of construction activity (an area of 2.54km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

127. The mean peak density of flying and sitting razorbills during the autumn migration season within SEP and its 2km buffer was 3.65 birds/km^2. This means that, assuming 100% displacement within 2km of three simultaneous construction locations across the site, 138 individuals would be displaced. The estimated annual mortality of birds displaced during construction, based on mortality rates of 1% to 10%, is 1 to 14 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.00% to 0.01%. If the upper 95% CI for mean peak density is considered instead, mortality increases relative to existing mortality would still be very small (0.00% to 0.02%).

128. During the winter season, the mean peak density of flying and sitting razorbills within SEP and its 2km buffer was 3.30 birds/km^2. Within 2km of three simultaneous construction locations, 124 individuals would be displaced. The estimated annual mortality, based on mortality rates of 1% to 10%, is 1 to 12 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.00% to 0.03%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small (0.00% to 0.05%).

129. During the spring migration season, the mean peak density of flying and sitting razorbills within SEP and its 2km buffer was 0.69 birds/km^2. Within 2km of three simultaneous construction locations, 26 individuals would be displaced. The estimated annual mortality, based on mortality rates of 1% to 10%, is 0 to 3 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by less than 0.01%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small (0.00% to 0.01%).

130. During the breeding season, the mean peak density of flying and sitting razorbills within SEP and its 2km buffer was 1.52 birds/km^2. Within 2km of three simultaneous construction locations, 57 individuals would be displaced. The estimated annual mortality, based on mortality rates of 1% to 10%, is 1 to 6 individuals. Adding this to the existing annual mortality for the non-breeding component of the winter population would increase annual mortality in this population by 0.00% to 0.04%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small (0.00% to 0.05%).

131. Summing the seasonal totals in **Table 11-27**, the estimated number of razorbills subject to construction disturbance and displacement throughout the year at SEP is 345 individuals, of which between 3 and 35 could be at risk of mortality. Adding the predicted annual mortality due to construction-related disturbance and displacement at SEP to the existing mortality level within the largest BDMPS population throughout the year (i.e. the autumn and spring migration BDMPS) would increase the annual mortality in this population by 0.00% to 0.03%.

132. The predicted increase in existing mortality due to this impact is very small across all seasons, would not materially alter the background mortality of the population, and would be undetectable in the context of natural variation. During the autumn and spring migration seasons, winter season and breeding season, as well as on a year-round basis, the magnitude of effect of construction-related disturbance and displacement at SEP is assessed as negligible. As razorbill is considered to possess a medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.1.1.1.2.3 SEP and DEP Combined

133. The predicted effects on razorbill within 2km of six simultaneous construction sites (i.e. three each at SEP and DEP) due to disturbance and displacement are summarised in **Table 11-29**. **Table 11-30** uses evidence discussed in **Section 11.6.1.1.1** to perform the assessment with parameters informed by Fliessbach *et al*. (2019).

Table 11-29: Razorbill Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP and DEP Combined, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Previously Recommended by SNCBs, and used in Other OWF Assessments

Parameter	Autumn migration density			Winter density			Spring migration density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Number of birds displaced[1]	225	627	1,123	120	235	378	15	68	139	105	178	268
Estimated mortality[2]	2 - 22	6 - 63	11 - 112	1 - 12	2 - 23	4 - 38	0 - 2	1 - 7	1 - 14	1 - 11	2 - 18	3 - 27
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.02	0.01 - 0.06	0.01 - 0.11	0.00 - 0.03	0.01 - 0.06	0.01 - 0.10	0.00 - 0.00	0.00 - 0.01	0.00 - 0.01	0.01 - 0.06	0.01 - 0.11	0.02 - 0.16

Notes

1. Assumes 100% displacement of birds within 2km of construction activity (an area of 12.57km^2), six construction sites simultaneously (three each at SEP / DEP)
2. Assumes 1% to 10% mortality of displaced birds
3. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

Table 11-30: Razorbill Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP and DEP Combined, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Identified from Fliessbach et al. (2019).

Parameter	Autumn migration density			Winter density			Spring migration density			Breeding density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Number of birds displaced[2]	36	102	182	19	38	61	3	11	23	17	29	43
Estimated mortality[3]	0 - 4	1 - 10	2 - 18	0 - 2	0 - 4	1 - 6	0 - 0	0 - 1	0 - 2	0 - 2	0 - 3	0 - 4
Estimated mortality as % increase to existing background population mortality[4]	0.00 - 0.00	0.00 - 0.01	0.00 - 0.02	0.00 - 0.01	0.00 - 0.01	0.00 - 0.02	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.02	0.00 - 0.03

Notes
1. Not calculated for combined OWF+2km buffers
2. Assumes 80% displacement of birds within 0.9km of construction activity (an area of 2.54km^2), six construction sites simultaneously (three each at SEP / DEP)
3. Assumes 1% to 10% mortality of displaced birds
4. Non-breeding season populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

134. Assuming 100% displacement within 2km of six simultaneous construction locations (i.e. three each at SEP and DEP, assuming simultaneous construction of both OWFs), 627 individuals would be displaced in the autumn migration season. The estimated annual mortality of birds displaced during construction, based on mortality rates of 1% to 10%, is 6 to 63 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.01% to 0.06%. If the upper 95% CI for mean peak density is considered instead, mortality increases relative to existing mortality would still be small (0.01% to 0.11%).

135. Within 2km of six simultaneous construction locations (assuming simultaneous construction of SEP and DEP), 235 individuals would be displaced in the winter season. The estimated annual mortality, based on mortality rates of 1% to 10%, is 2 to 23 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.01% to 0.06%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small to small (0.01% to 0.10%).

136. Within 2km of six simultaneous construction locations (assuming simultaneous construction of SEP and DEP), 68 individuals would be displaced in the spring migration season. The estimated annual mortality, based on mortality rates of 1% to 10%, is 1 to 7 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.00% to 0.01%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be between 0.00% and 0.01%.

137. Within 2km of six simultaneous construction locations (assuming simultaneous construction of SEP and DEP), 178 individuals would be displaced in the breeding season. The estimated annual mortality, based on mortality rates of 1% to 10%, is 2 to 18 individuals. Adding this to the existing annual mortality for the non-breeding component of the winter BDMPS would increase annual mortality in this population by 0.01% to 0.11%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small to small (0.02% to 0.16%).

138. Summing the seasonal totals in **Table 11-29**, the estimated number of razorbills subject to construction disturbance and displacement throughout the year at SEP and DEP combined (assuming simultaneous construction) is 1,108 individuals, of which between 11 and 111 could be at risk of mortality. Adding the predicted annual mortality due to construction-related disturbance and displacement at SEP and DEP to the existing mortality level within the largest BDMPS population throughout the year (i.e. the autumn and spring migration BDMPS) would increase the annual mortality in this population by 0.01% to 0.11%.

139. The predicted increase in existing mortality due to this impact is very small to small across all seasons, would not materially alter the background mortality of the relevant populations, and would be undetectable in the context of natural variation. During the autumn and spring migration seasons, winter season and breeding season, as well as on a year-round basis, the magnitude of effect of construction-related disturbance and displacement at SEP and DEP (combined) is assessed as negligible. As razorbill is considered to possess a medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.1.1.1.2.4 Summary and Confidence Assessment

140. Overall, the impact significance for razorbill displacement during the construction phase of SEP and DEP is **minor adverse**. This applies to all potential construction options (i.e. simultaneous or sequential construction), as outlined in **Section 11.3.2.2**, all seasons, and for year-round impacts.

141. The confidence of this prediction is high for two reasons. Firstly, the use of upper 95% CI mean peak density estimates in the assessment does not alter the conclusions of the assessment for either OWF alone or combined with the other, for any biologically relevant season. Secondly, the evidence-based assessments (**Table 11-26**, **Table 11-28** and **Table 11-30**) undertaken in parallel with the established assessment (**Table 11-25**, **Table 11-27** and **Table 11-29**) predict much lower impacts. This indicates that the more established parameters are likely to overestimate the magnitude of the potential impact and that the assessment is precautionary.

142. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. A comparison between the encounter rates of this species within the different parts of DEP indicated that year round, the encounter rate for this species from the raw baseline survey data was 12.6% higher at DEP-N than DEP as a whole. However, since the differences between densities at DEP-N and DEP are considered unlikely to be statistically significant, and due to the low impact magnitudes predicted, the conclusion of the assessment presented above is unaffected by this observation.

11.6.1.1.2 Red-Throated Diver

143. Information referred to in **Section 11.6.1.1** indicates that red-throated diver possesses a very high sensitivity to disturbance and displacement due to anthropogenic activity in the marine environment (Bellebaum *et al*., 2006; Fliessbach *et al*., 2019; Furness *et al*., 2013; Furness and Wade, 2012; Garthe and Hüppop, 2004; Jarrett *et al*., 2018; MMO, 2018; Schwemmer *et al*., 2011).

144. Birds commonly avoid disturbed areas associated with shipping (Bellebaum *et al*., 2006; Irwin *et al*., 2019; Jarrett *et al*., 2018; Schwemmer *et al*., 2011). Flushing effects due to the presence of ships have been recorded up to 2km from vessels (Fliessbach *et al*., 2019). Birds also avoid operational OWFs (**Section 11.6.2.1.3**) and those under construction (Elston *et al*., 2016; Gill *et al*., 2018; Hi Def Aerial Surveying, 2017; NIRAS Consulting, 2016). There is a high degree of concordance of the available literature with respect to effects of anthropogenic activity on red-throated diver distribution. It is therefore anticipated that the majority of birds present before OWFs are constructed are displaced by the construction (and operation; **Section 11.6.2.1.3**) of OWFs. It is expected (based on expert opinion), that these effects during the construction phase are due to a combination of anthropogenic activities (mainly vessel-based), as well as the presence of OWF infrastructure as construction progresses.

145. For this assessment, it has been assumed that 100% displacement will occur within 2km of construction activities within the SEP and DEP wind farm sites. Literature

indicates that the majority of red-throated divers present will flush from approaching vessels at a distance of 1km or less (Bellebaum *et al*., 2006; Jarrett *et al*., 2018; Topping and Petersen, 2011). Fliessbach *et al*. (2019) stated that 95% of red-throated divers observed during their study elicited an escape response when approached by a vessel, with a mean escape distance of 750m (standard deviation 437m) and a maximum escape distance of 1,700m. Unidentified diver species were recorded flushing at distances of 2km from the survey vessel. Therefore, 100% displacement at 2km from construction activities is considered to be appropriately precautionary.

146. There is no empirical evidence that displaced red-throated divers suffer any consequent mortality. Any mortality due to displacement would be most likely a result of increased density in areas outside the affected area. This would cause increased competition for food where density of birds was elevated. Such impacts are most likely to be negligible (Dierschke *et al*., 2017), and below levels that could be quantified. In the German Bight, where multiple OWFs have been operational for a number of years, no population-level effects have been identified, though displacement effects were readily apparent (Vilela *et al*., 2021). Impacts of displacement are also likely to be context-dependent. In years when food supply has been severely depleted, displacement of sandeel-dependent seabirds from optimal habitat may increase mortality. In years when food supply is good, displacement would be less likely to have any negative effect on seabird populations. Red-throated divers take a wide diversity of small fish prey (Kleinschmidt *et al*., 2019), and this relatively high flexibility would buffer the species (to an extent) from fluctuations in abundance of individual prey species.

147. The annual mortality rate of red-throated divers is 16% for adults (three years and older), and 38% to 40% for juveniles (Horswill and Robinson, 2015). These rates are the result of the combined contributions of a range of environmental and anthropogenic pressures. These include prey availability driven by climate change and fisheries activities, bycatch, predation, displacement by vessels, operational OWFs, shipping, oil and gas, aggregate extraction and military activity, and pollution (both one off events such as oil spills, and chronic pollution by microplastics and other substances), as well as birds that die of natural causes.

148. Natural England's recent advice during the preparation of OWF assessments is that a maximum mortality rate of 10% should be used for birds displaced by cable laying vessels. Cable laying vessels are static for large periods of time and move slowly and over short distances as cable installation takes place. Offshore cable installation activity is a relatively low noise operation, particularly when compared to activities such as piling. As red-throated divers will often fly away from approaching vessels (Fliessbach *et al*., 2019; Jarrett *et al*., 2018; Schwemmer *et al*., 2011), the energy costs of displacement from vessels may be considerably greater than those of avoiding static structures. The mortality (if any) of disturbance by ships must already be incorporated in the existing estimates of survival.

149. Given that Natural England's suggested maximum mortality rate would equate to more than half the natural annual adult mortality rate (16%) as a result of what would effectively be a single occasion of disturbance, it is highly improbable that such a large magnitude of effect would occur. MacArthur Green (2019b) concluded that 1%

is an appropriately precautionary mortality rate estimate for displacement for red-throated diver, and that in reality the additional mortality rate may be closer to zero.

150. As well as the wind farm sites and buffers, displacement effects could also occur on red-throated divers within the offshore export cable corridor by cable laying vessels. This includes the area between SEP and DEP, and also between SEP and Weybourne. This section of the export cable corridor could be particularly sensitive, since it passes through the Greater Wash SPA (of which red-throated diver is a qualifying species) for approximately 9km. Where it overlaps with the Greater Wash SPA, the offshore export cable corridor is between 1km and 2km wide, but funnels out to 3,200m on approach to landfall. This results in an overlap between the export cable corridor and the SPA of approximately 26km^2, or 0.7% of the area within the SPA. This represents the area of search; the actual export cable corridor (once defined) will have a smaller overlap.

151. On a precautionary basis, the assessment assumes 100% displacement of birds within 2km of the cable laying vessel, along with a mortality of 1% to 10%. In the case of the offshore export cable corridor, it is considered reasonable to assume that birds will reoccupy areas following the passage of the vessels.

152. The UK North Sea BDMPS is considered to be the relevant background population for red-throated diver during the spring and autumn migration seasons (Furness, 2015). At the published baseline annual mortality for this species, averaged across all age classes (22.8%; **Table 11-17**), the number of red-throated divers expected to die annually that are members of this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 3,027 (i.e. 13,277 x 0.228).

153. The SW North Sea BDMPS is considered to be the relevant background population for red-throated diver during the winter season (Furness, 2015). At the published baseline annual mortality for this species, averaged across all age classes (22.8%; **Table 11-17**), the number of red-throated divers expected to die that are members of this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 2,320 (i.e. 10,177 x 0.228).

11.6.1.1.2.1.1 DEP

154. The predicted effects on red-throated diver within 2km of three construction locations due to disturbance and displacement during the construction of DEP are summarised in **Table 11-31**.

Table 11-31: Red-Throated Diver Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at DEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Previously Recommended by SNCBs, and used in Other OWF Assessments

Parameter	Autumn migration density			Winter density			Spring migration density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	0.02	0.06	0.12	0	0.01	0.03	0.07	0.11	0.15
Number of birds displaced[1]	1	2	4	0	0	1	2	4	6
Estimated mortality[2]	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 0	0 - 1
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.00	0.00 - 0.01	0.00 - 0.01	0.00 - 0.00	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.01	0.00 - 0.02

Notes
1. Assumes 100% displacement of birds within 2km of construction activity (an area of 12.57km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds
3. Autumn and spring migration season populations from UK North Sea Waters BDMPS (all birds) (Furness, 2015), winter season population from SW North Sea BDMPS (all birds) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

155. The mean peak density of flying and sitting red-throated divers during the autumn migration season within DEP and its 2km buffer was 0.06 birds/km^2. This means that, assuming 100% displacement within 2km of three simultaneous construction locations across the site, 2 individuals would be displaced. The estimated annual mortality of birds displaced during construction, based on rates of 1% to 10%, is less than one individual. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.00% to 0.01%. This would also be the case if the upper 95% CI for mean peak density is considered instead.

156. During the winter season, the mean peak density of flying and sitting red-throated divers within DEP and its 2km buffer was 0.01 birds/km^2. Within 2km of three simultaneous construction locations, less than 1 individual would be displaced. The estimated annual mortality, based on rates of 1% to 10%, is also less than one individual. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by less than 0.01%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small.

157. During the spring migration season, the mean peak density of flying and sitting red-throated divers within DEP and its 2km buffer was 0.11 birds/km^2. Within 2km of three simultaneous construction locations, 4 individuals would be displaced. The estimated annual mortality, based on rates of 1% to 10%, is less than one individual. Adding this to the existing annual mortality within the UK relevant BDMPS would increase annual mortality in this population by 0.00 to 0.01%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small (0.00% to 0.02%).

158. Summing the mean seasonal totals in **Table 11-31**, the estimated number of red-throated divers subject to construction disturbance and displacement throughout the year at DEP is 6 individuals, of which up to 1 could be at risk of mortality. Adding the predicted annual mortality due to construction-related disturbance and displacement at DEP to the existing mortality level within the largest BDMPS (i.e. the autumn and spring migration BDMPS) would increase the mortality in this population by 0.00% to 0.03%.

159. The predicted increase in existing mortality due to this impact is very small across all seasons, would not materially alter the background mortality of the relevant populations, and would be undetectable in the context of natural variation. During the autumn and spring migrations seasons and winter season, as well as on a year-round basis, the magnitude of effect of construction-related disturbance and displacement at DEP on red-throated diver is assessed as negligible. As this species is considered to possess a high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.1.1.2.1.2 SEP

160. The predicted effects on red-throated diver within 2km of three construction locations due to disturbance and displacement during the construction of SEP are summarised in **Table 11-32**.

Table 11-32: Red-Throated Diver Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Previously Recommended by SNCBs, and used in Other OWF Assessments

Parameter	Autumn migration density			Winter density			Spring migration density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Mean peak density (birds/km^2)	0.17	0.22	0.39	0	0.01	0.03	0.17	0.55	1.33
Number of birds displaced[1]	6	8	15	0	0	1	6	21	50
Estimated mortality[2]	0 - 1	0 - 1	0 - 1	0 - 0	0 - 0	0 - 0	0 - 1	0 - 2	1 - 5
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.02	0.00 - 0.03	0.00 - 0.05	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.02	0.01 - 0.07	0.02 - 0.17

Notes
1. Assumes 100% displacement of birds within 2km of construction activity (an area of 12.57km^2), three construction sites simultaneously
2. Assumes 1% to 10% mortality of displaced birds
3. Autumn and spring migration season populations from UK North Sea Waters BDMPS (all birds) (Furness, 2015), winter season population from SW North Sea BDMPS (all birds) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

161. The mean peak density of flying and sitting red-throated divers during the autumn migration season within SEP and its 2km buffer was 0.22 birds/km^2. This means that, assuming 100% displacement within 2km of three simultaneous construction locations across the site, 8 individuals would be displaced. The estimated annual mortality of birds displaced during construction, based on mortality rates of 1% to 10%, is 0 to 1 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.00% to 0.03%. If the upper 95% CI for mean peak density is considered instead, mortality increases relative to existing mortality would still be very small (0.00% to 0.05%).

162. During the winter season, the mean peak density of flying and sitting red-throated divers within SEP and its 2km buffer was 0.01 birds/km^2. Within 2km of three simultaneous construction locations, less than 1 individual would be displaced. The estimated annual mortality, based on mortality rates of 1% to 10%, is also less than 1 individual. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by less than 0.01%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small.

163. During the spring migration season, the mean peak density of flying and sitting red-throated divers within SEP and its 2km buffer was 0.55 birds/km^2. Within 2km of three simultaneous construction locations, 21 individuals would be displaced. The estimated annual mortality, based on mortality rates of 1% to 10%, is 0 to 2 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.01% to 0.07%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small to small (0.02% to 0.17%).

164. Summing the mean seasonal totals in **Table 11-32**, the estimated number of red-throated divers subject to construction disturbance and displacement throughout the year at SEP is 29 individuals, of which between 0 and 3 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the largest BDMPS (i.e. the UK North Sea BDMPS, autumn and spring migration seasons) would increase the existing mortality level within this population by 0.01% to 0.10%.

165. The predicted increase in existing mortality due to this impact is very small across all seasons, would not materially alter the background mortality of the relevant populations, and would be undetectable in the context of natural variation. During the autumn and spring migration seasons and winter season, as well as on a year-round basis, the magnitude of effect of construction-related disturbance and displacement at SEP is assessed as negligible. As red-throated diver is considered to possess a high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.1.1.2.1.3 SEP and DEP Combined

166. The predicted effects on red-throated diver within 2km of six simultaneous construction sites (i.e. three each at SEP and DEP) due to disturbance and displacement are summarised in **Table 11-33**.

Table 11-33: Red-Throated Diver Mortality by Biologically Relevant Season due to Disturbance and Displacement by Construction Activities at SEP and DEP Combined, Expressed as an Increase in Background Mortality from the Relevant Background Population. Values used for the Assessment are Based on those Previously Recommended by SNCBs, and used in Other OWF Assessments

Parameter	Autumn migration density			Winter density			Spring migration density		
	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI	95% LCI	Mean	95% UCI
Number of birds displaced[1]	3	11	19	0	1	2	9	25	56
Estimated mortality[2]	0 - 0	0 - 1	0 - 2	0 - 0	0 - 0	0 - 0	0 - 1	0 - 2	1 - 6
Estimated mortality as % increase to existing background population mortality[3]	0.00 - 0.01	0.00 - 0.03	0.01 - 0.06	0.00 - 0.00	0.00 - 0.00	0.00 - 0.01	0.00 - 0.03	0.01 - 0.08	0.02 - 0.18

Notes
1. Assumes 100% displacement of birds within 2km of construction activity (an area of 12.57km^2), six construction sites simultaneously (three each at SEP / DEP)
2. Assumes 1% to 10% mortality of displaced birds
3. Autumn and spring migration season populations from UK North Sea Waters BDMPS (all birds) (Furness, 2015), winter season population from SW North Sea BDMPS (all birds) (Furness, 2015). Published annual mortality for all age classes from Horswill and Robinson (2015)

167. Assuming 100% displacement within 2km of six simultaneous construction locations (i.e. three each at SEP and DEP, assuming simultaneous construction of both OWFs), 11 individuals would be displaced in the autumn migration season. The estimated annual mortality of birds displaced during construction, based on mortality rates of 1% to 10%, is 0 to 1 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.00% to 0.03%. If the upper 95% CI for mean peak density is considered instead, mortality increases relative to existing mortality would still be very small (0.01% to 0.06%).

168. Within 2km of six simultaneous construction locations (assuming simultaneous construction of SEP and DEP), less than 1 individual would be displaced in the winter season. The estimated annual mortality, based on mortality rates of 1% to 10%, is also less than 1 individual. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by less than 0.01%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small.

169. Within 2km of six simultaneous construction locations (assuming simultaneous construction of SEP and DEP), 25 individuals would be displaced in the spring migration season. The estimated annual mortality, based on mortality rates of 1% to 10%, is 0 to 2 individuals. Adding this to the existing annual mortality within the relevant BDMPS would increase annual mortality in this population by 0.01% to 0.08%. If the upper 95% CI is considered instead, mortality increases relative to existing mortality would still be very small to small (0.02% to 0.18%).

170. Summing the mean seasonal totals in **Table 11-33**, the estimated number of red-throated divers subject to construction disturbance and displacement throughout the year at SEP and DEP combined (assuming simultaneous construction) is 36 individuals, of which between 0 and 4 could be at risk of mortality. Adding the predicted annual mortality due to construction-related disturbance and displacement at SEP and DEP to the existing mortality level within the largest BDMPS population throughout the year (i.e. the autumn and spring migration BDMPS) would increase the annual mortality in this population by 0.01% to 0.12%.

171. The predicted increase in existing mortality due to this impact is very small to small in all cases, would not materially alter the background mortality of the relevant populations and would be undetectable in the context of natural variation. During the autumn and spring migration seasons and winter season, as well as on a year-round basis, the magnitude of effect of construction-related disturbance and displacement at SEP and DEP (combined) is assessed as negligible. As red-throated diver is considered to possess a high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.1.1.2.1.4 Export Cable Corridor

172. The baseline surveys did not cover large parts of the offshore export cable corridor. To perform an assessment of potential disturbance and displacement for red-throated diver due to construction activities within the offshore export cable corridor, two data sources have been consulted (Bradbury *et al*., 2014; Lawson *et al*., 2016). Both provide grid-based modelled estimates of red-throated diver densities during

the non-breeding season, with data from Lawson *et al*. (2016) used for the designation of the Greater Wash SPA.

173. Bradbury *et al*. (2014) indicates that within the offshore export cable corridor, the maximum modelled density of red-throated diver is 0.170 birds/km^2, whilst Lawson *et al*. (2016) suggests a maximum modelled density of 0.512 birds/km^2. Using the highest value, a maximum of seven red-throated divers could be displaced by the cable laying vessel at any time assuming 100% displacement within 2km of a single cable laying vessel. Assuming a mortality rates of 1% to 10% amongst displaced birds, 0.07 to 0.7 birds would be expected to be lost from the population annually. During the autumn and spring migration seasons, this level of displacement would increase the expected mortality of the UK North Sea and Channel BDMPS by 0.00% to 0.02%. During the winter season, the mortality increase due to this level of displacement would increase the expected mortality of the SW North Sea BDMPS by 0.00% to 0.03%.

174. The predicted increase in existing mortality due to this impact is very small in all cases, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Furthermore, as the maximum reported density has been used to represent the entire offshore export cable corridor, this is a highly precautionary assessment. During the autumn and spring migration seasons and winter season, as well as on a year-round basis, the magnitude of effect of construction-related disturbance and displacement within the offshore export cable corridor is assessed as negligible. As red-throated diver is considered to possess a high sensitivity to disturbance, the impact significance is **minor adverse**. This conclusion also applies if the predicted mortality is added to that predicted at the SEP and DEP wind farm sites and interlink cable corridors.

11.6.1.1.2.1.5 Summary and Confidence Assessment

175. Overall, the impact significance for red-throated diver displacement during the construction phase of SEP and DEP is **minor adverse**. This applies to all potential construction options (i.e. simultaneous or sequential construction), as outlined in **Section 11.3.2.2**, all seasons, and for year-round impacts.

176. The confidence of this prediction is high for two reasons. Firstly, the use of upper 95% CI mean peak density estimates in the assessment does not alter the conclusions of the assessment for either OWF in isolation or combined with the other, for any biologically relevant season. Secondly, the evidence-based assessments indicate that escape distance, displacement rates and mortality rates used in the assessment (**Table 11-25**, **Table 11-27** and **Table 11-29**) are suitably precautionary. For the export cable corridor, a confidence level of medium is considered more appropriate, given the age of the data used to carry out the assessment.

11.6.1.2 Impact 2: Indirect Effects Through Effects on Habitats and Prey Species during the Construction Phase

177. Indirect effects on offshore ornithology receptors may occur during the construction phase of SEP and DEP if there are impacts on prey species and/or their habitats. Potential indirect effects could result from the production of underwater noise (e.g.

during piling) or the generation of suspended sediments (e.g. during preparation of the sea bed for foundation or cable installation). These impact pathways may cause injury or mortality to, or alter the behaviour or availability of prey species. Underwater noise may cause fish and mobile invertebrates to avoid the construction area and also affect their physiology and behaviour. Suspended sediments may cause fish and mobile invertebrates to avoid the construction area and may smother and hide immobile benthic prey. These mechanisms may result in less prey being available to offshore ornithology receptors within the impact zone surrounding the construction area. Potential effects on benthic invertebrates and fish have been assessed in **Chapter 8 Benthic Ecology** and **Chapter 9 Fish and Shellfish Ecology** and the conclusions of those assessments inform this assessment of indirect effects on offshore ornithology receptors.

178. With regard to noise impacts on fish, **Chapter 9 Fish and Shellfish Ecology** considers the potential impacts upon fish relevant to ornithology as prey species of SEP and DEP. This includes herring, sprat and sandeel, which are the main prey items of a range of seabirds including Sandwich tern, kittiwake, gannet and auks. The construction underwater noise assessment (including for physical injury or behavioural changes) on these species concluded impacts of minor adverse significance. All offshore ornithology receptors are considered to possess a medium sensitivity to this potential impact. It is therefore concluded that the impact significance on all offshore ornithology receptors occurring in or around SEP and DEP during the construction phase due to this impact is **minor adverse**.

179. **Chapter 6 Marine Geology, Oceanography and Physical Processes** and **Chapter 8 Benthic Ecology** discuss the potential impacts on the sea bed and benthic habitats due to the construction of SEP and DEP. The changes predicted to occur as a result of these activities will be temporary, small scale and highly localised. The consequent indirect impact on fish through habitat loss is considered to be minor or negligible for species such as herring, sprat and sandeel. All offshore ornithology receptors are considered to possess a medium sensitivity to this potential impact. It is therefore concluded that the impact significance on all offshore ornithology receptors occurring in or around SEP and DEP during the construction phase due to this impact is **minor adverse**.

180. These impact significance levels apply to SEP and DEP in isolation and combined.

181. The confidence of this prediction is high. This is primarily because the other chapters of the assessment have used the best available evidence, and best practice methodologies, in assessing potential impacts and drawing conclusions. Therefore, the assessment of these potential effects on offshore ornithology receptors is robust. In addition, though difficult to measure, no substantial effects have been recorded due to these impact pathways at other OWFs.

11.6.2 Potential Impacts During Operation

11.6.2.1 Impact 3: Disturbance, Displacement and Barrier Effects

182. During operation, SEP and DEP have the potential to impact offshore ornithology receptors through disturbance leading to displacement of birds or through barrier effects.

183. Operational phase displacement is defined as a reduced number of birds occurring within or immediately adjacent to an OWF (Furness *et al*., 2013). This impact pathway involves flying birds and those on the water (UK SNCBs, 2017). Birds that do not intend to utilise an operational OWF but would have previously flown through it on the way to a feeding, resting or nesting area, and which either stop short or detour around it, are subject to barrier effects (UK SNCBs, 2017). These potential impacts effectively result in habitat loss through reduction in the area available for behaviours such as foraging, loafing and moulting in the case of displacement, or commuting and migration in the case of barrier effects. These effects have the potential to last for the duration of the operational phase of SEP and DEP, which is 40 years, with a gap of up to four years between each Project commencing operation. The worst-case scenarios outlined in **Section 11.3.2** describe the relevant elements of SEP and DEP considered by this assessment, which in turn provides a worst-case scenario of potential effects. Displacement and barrier effects will begin as turbines are installed during the latter part of the construction period and will persist into the decommissioning period until turbines are removed.

184. Offshore ornithology receptors differ considerably in their sensitivity to anthropogenic disturbance in the marine environment, which is detailed in a considerable amount of literature (Fliessbach *et al*., 2019; Furness *et al*., 2013; Furness and Wade, 2012; Garthe and Hüppop, 2004; MMO, 2018). Despite this, uncertainty exists on displacement effects (Wade *et al*., 2016), and disentangling the relative contribution of different disturbance pathways is challenging. Dierschke *et al*. (2016) reviewed evidence from 20 operational OWFs in European waters. The review suggested strong avoidance behaviour by divers, gannet, great crested grebe, and fulmar. Less consistent displacement evidence was identified for razorbill, guillemot, little gull and Sandwich tern. No evidence of any consistent displacement response was recorded for kittiwake, common tern and Arctic tern. There was evidence of weak attraction to OWFs for common gull, black-headed gull, great black-backed gull, herring gull, lesser black-backed gull and red-breasted merganser, and strong attraction for shag and cormorant. It is clear that displacement, disturbance and attraction effects of operational OWFs vary considerably by species.

185. The primary cause of displacement from operational OWFs is considered to be visual cues due to the presence of operational turbines and other infrastructure. It is possible that noise and vibration from operation and maintenance activities could result in disturbance and displacement for short periods over small areas in the vicinity of such activities (e.g. as per the impacts considered in **Section 11.6.1.1**), but in comparison to the permanent presence of an operational turbine array these are considered to have a negligible contribution to operational OWF disturbance and displacement. This assessment therefore does not consider operation and maintenance activities within the wind farm sites.

186. Offshore wind turbines and other infrastructure will be equipped with lighting for air and navigational safety. Air safety lights will be placed high on the wind turbine structures, and as a minimum, on wind turbines at the periphery of SEP and DEP. Navigational lights for shipping will be placed lower on wind turbine structures and other offshore structures. Other lighting for personnel working at night will also be present, though these would not be as bright as air and navigational safety lighting.

A review of the potential effects of operational lighting on birds considered available evidence to investigate potential impacts across eight categories (MacArthur Green, 2018). This suggested that lights on offshore wind turbines in European shelf seas are extremely unlikely to have any detectable effect on birds as a consequence of any of the processes listed above. The effects of operational lighting are therefore not assessed further.

187. The required operational and maintenance activities for the offshore export cable may have short-term and localised disturbance and displacement impacts on offshore ornithology receptors (e.g. as per the impacts considered in **Section 11.6.1.1**). However, disturbance from operational activities would be temporary and localised, and is unlikely to result in detectable effects on offshore ornithology receptors at either the local or regional population level. No impact due to cable operation and maintenance is predicted.

188. As OWFs are relatively new features in the marine environment, there is limited robust empirical evidence regarding disturbance and displacement effects of the operational infrastructure in the long term. When reviewing the results of previous studies it is crucial to understand the context of displacement effects to avoid misinterpretation. For example, an understanding of the level (and if possible, the nature) of use of an OWF site by a particular offshore ornithology receptor prior to its construction is required to comment on the true magnitude of a given decline in use due to displacement effects (as opposed to a simple percentage reduction). Similarly, the use of distances in isolation to describe the spatial extent of an effect is somewhat meaningless unless accompanied by information providing insight into level of displacement at different distances from an OWF.

189. Also extremely important to recognise when considering this impact pathway is the appreciation that observed OWF displacement impacts have as yet not been shown to illicit effects at the population level for any species . This includes species for which displacement from OWFs has been demonstrated (e.g. divers and auks), most recently for the former in the German Bight (Vilela *et al*., 2021). Whilst displacement or barrier effects due to operational OWFs could potentially result in the reduction of survival rates under certain circumstances (i.e. mortality rate increases) of impacted offshore ornithology receptors, no empirical evidence has been collected to date that supports this possibility. Any mortality due to displacement would most likely be a result of increased densities of foraging birds in locations outside the affected area, resulting in increased competition for food. This would be unlikely for offshore ornithology receptors 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 (Bradbury *et al*., 2014; Furness and Wade, 2012).

190. The effects of operational phase disturbance and displacement on the key resident species are considered together. Birds may be more at risk from disturbance and displacement effects when they are resident in an area at any time of year. Such birds may regularly encounter and be displaced by an operational OWF. During the breeding season, this could occur during daily commuting trips to foraging areas from nest sites. During the non-breeding season, birds using marine habitat adjacent to a construction site could also be displaced. However, modelling of the

consequences of displacement for seabirds suggests that even in the case of breeding seabirds that are displaced from marine habitats on a daily basis, there is likely to be little or no impact on survival unless the OWF causing the effect is located close to the breeding colony (Searle *et al*., 2017, 2014). Another study suggested that the energetic costs of extra flight during breeding season foraging trips to avoid an operational OWF appear to be much less than those imposed by low food abundance or adverse weather, though they would be additive (Masden *et al*., 2010). No disturbance at breeding colonies due to operational phase activities at SEP and DEP is anticipated; no breeding site for any offshore ornithology receptor falls within the ZoI.

191. Birds on passage may encounter (and potentially be displaced from) a particular OWF only once during a given migration journey. The costs of one-off avoidances during migration have been calculated to be relatively small, accounting for less than 2% of available fat reserves (Masden *et al*., 2012, 2009; Speakman *et al*., 2009). Therefore, the impacts on birds that only migrate through SEP and DEP (including seabirds, waders and waterbirds on passage) are considered negligible and these have been scoped out of the assessment.

192. A screening exercise was undertaken to identify offshore ornithology receptors most likely to be at risk of significant impacts (**Table 11-34**). Any species recorded only in very small numbers and/or infrequently within the estimated ZoI (considered to extend to 4km from SEP and DEP, though actual displacement buffers vary by species) was screened out. The same applies to species present in the ZoI only as a migrant species, or with a low sensitivity to disturbance, displacement and/or barrier effects according to the literature consulted. Due to its conservation value, little gull was screened in despite being a passage species with a relatively low sensitivity to displacement by operational OWFs.

193. A range of highly applicable existing information of high quality was referred to during the literature review for the screening process and subsequent assessment. These include studies at other OWFs (APEM, 2017; Dierschke *et al*., 2016; Elston *et al*., 2016; Harwood *et al*., 2018; Heinänen and Skov, 2018; Hi Def Aerial Surveying, 2017; Leopold *et al*., 2013; Vanermen *et al*., 2016), along with other work which considers disturbance and displacement in a wider context (Bradbury *et al*., 2014; Fliessbach *et al*., 2019; Furness *et al*., 2013; Furness and Wade, 2012; Garthe and Hüppop, 2004; MMO, 2018; Schwemmer *et al*., 2011).

194. Confidence in the estimated sensitivity of offshore ornithology receptors was considered to be high if similar behaviour around operational OWFs was identified from a range of sources. Where no such evidence was identified, but expert opinion was available (Furness *et al*., 2013; Garthe and Hüppop, 2004), a medium confidence level was assigned. Where expert opinion and any recorded effects did not concord, confidence was adjusted accordingly. For some species, it was not possible to assign an estimated sensitivity level due to a lack of evidence.

195. For species screened into further assessment, the methodology presented in UK SNCBs (2017) recommends a matrix is presented for each species showing bird losses at differing rates of displacement and mortality. This assessment uses the range of predicted losses previously advocated by SNCBs, 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 SEP and/or DEP. These losses are then placed in the context of the relevant population (e.g. SPA or BDMPS) to determine the magnitude of effect. The use of seasonal mean peak density estimates in this assessment provides an additional layer of precaution, as densities of birds typically subject to this impact on a given day are likely to be lower than those used as inputs into the assessment. The assessment below presents summary tables of the matrix outputs. The matrices are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

Table 11-34: Operational Disturbance and Displacement Screening for SEP and DEP

Species	Estimated sensitivity to disturbance and displacement from operational OWFs	Confidence in sensitivity estimate	Relative frequency in ZoI	Relative abundance in ZoI	Screening result
Arctic skua	Low	Medium	Low (migrant)	Low	Out
Arctic tern	Low	High	Low	Low	Out
Black-headed gull	Low	Medium	Low	Medium	Out
Common gull	Low	High	Medium	Low	Out
Common scoter	Medium	Medium	Low	Low	Out
Common tern	Low	High	Medium	Medium	Out
Cormorant	Low	High	Low	Low	Out
Fulmar	Low	High	High	Low	Out
Gannet	Medium	High	High	Medium	In
Golden plover	Unknown	N/A	Low (migrant)	Low	Out
Great black-backed gull	Low	High	Medium	Medium	Out
Great crested grebe	High	Medium	Low (migrant)	Low	Out
Great skua	Low	Medium	Low	Low	Out
Guillemot	Medium	High	High	High	In
Herring gull	Low	High	Medium	Low	Out
Kestrel	Unknown	N/A	Low (migrant)	Low	Out
Kittiwake	Low	High	High	High	Out
Knot	Unknown	N/A	Low (migrant)	Low	Out
Lapwing	Unknown	N/A	Low (migrant)	Low	Out
Lesser black-backed gull	Low	High	Medium	Medium	Out

Species	Estimated sensitivity to disturbance and displacement from operational OWFs	Confidence in sensitivity estimate	Relative frequency in ZoI	Relative abundance in ZoI	Screening result
Little gull	Medium	Medium	Medium (migrant)	Medium	Out
Little tern	Low	Medium	Medium	Low	Out
Long-tailed duck	Low	Low	Low (migrant)	Low	Out
Long-tailed skua	Low	Medium	Low (migrant)	Low	Out
Manx shearwater	Medium	Low	Low (migrant)	Medium	Out
Oystercatcher	Unknown	N/A	Low (migrant)	Low	Out
Pomarine skua	Low	Low	Low (migrant)	Low	Out
Puffin	Low	Medium	Medium	Low	Out
Razorbill	Medium	High	High	High	In
Red-throated diver	High	High	Medium	Medium	In
Sandwich tern	Medium	Low	Medium	High	In
Shag	Low	Medium	Low	Low	Out
Tufted duck	Unknown	N/A	Low (migrant)	Low	Out
Woodpigeon	Unknown	N/A	Low (migrant)	Low	Out

11.6.2.1.1 Gannet

196. Gannet is known to be sensitive to displacement from operational OWFs (Cook *et al*., 2018; Elston *et al*., 2016, p. 20; Gill *et al*., 2018; Krijgsveld *et al*., 2011; Rehfisch *et al*., 2014; Skov *et al*., 2018; Wade *et al*., 2016). Locally to SEP and DEP, evidence from the SOW OMP (Harwood *et al*., 2018) recorded almost total avoidance of the operational OWF by gannet. Operational displacement effects were also detected at the Lincs OWF (Hi Def Aerial Surveying, 2017).

197. Gannet displacement rates from OWFs of 0.640 to 1.000 were reported from a review by Cook *et al*. (2018). It was recommended that the lowest of the quantified macro-avoidance rates, 64% for Egmond aan Zee OWF (Krijgsveld *et al*., 2011) was an appropriately precautionary avoidance rate for this species. A study of seabird flight behaviour at Thanet OWF, not included in the above review, found a macro-avoidance rate of 79.7% for gannets approaching within 3km of the OWF (Skov *et al*., 2018).

198. Based on the available information, gannet is considered to possess a medium sensitivity to disturbance and displacement from operational OWFs. Confidence in this level of sensitivity is considered to be high due to the relatively high applicability, concordance, and quality of the available information sources.

199. Following statutory guidance (UK SNCBs, 2017), abundance estimates for gannet for DEP and its 2km buffer, and SEP and its 2km buffer, for the relevant biological periods (**Section 11.5.1.2**) have been used to produce displacement matrices. Based on the recommended displacement rate of Cook *et al*. (2018) and the findings of Skov *et al*. (2018), displacement rates of 0.600 to 0.800 are considered.

200. The mortality rate of displaced birds due to displacement is assumed to be a maximum of 1%. This value has been selected firstly because gannet is known to possess high habitat flexibility (Furness and Wade, 2012). This suggests that displaced birds will readily find alternative habitats including foraging areas. Secondly, no evidence of displacement-induced mortality has been identified, which means there is limited justification for setting predicted mortality rates at a higher level.

11.6.2.1.1.1 Autumn Migration

201. The UK North Sea and Channel BDMPS is considered to be the relevant background population for gannet during the autumn migration season. At the published baseline annual mortality for this species averaged across all age classes (19.1%; **Table 11-17**), the number of gannets expected to die annually that are members of this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 87,153 (i.e. 456,298 x 0.191).

11.6.2.1.1.1.1 DEP

Table 11-35: Predicted Operational Phase Displacement and Mortality of Gannet at DEP During the Autumn Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	554	3 - 4	0.00 - 0.01
Mean	343	2 - 3	0.00 - 0.00
Lower 95% CI	186	1 - 1	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (456,298 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)

202. Gannet mortality during the autumn migration season due to operational phase displacement from DEP is estimated to be 2-3 individuals annually, based on a mean peak abundance of 343 birds at the site and 2km buffer, displacement rates of 0.600 to 0.800 and a mortality rate of 1% (**Table 11-35**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01% irrespective of whether the mean or upper 95% CI mean peak abundance estimate is used.

203. The increase in existing mortality due to this impact is very small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the autumn migration season is assessed as negligible. As gannet is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.1.1.2 SEP

Table 11-36: Predicted Operational Phase Displacement and Mortality of Gannet at SEP During the Autumn Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	426	3 - 3	0.00 - 0.00
Mean	295	2 - 2	0.00 - 0.00
Lower 95% CI	193	1 - 2	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (456,298 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)

204. At SEP, gannet mortality during the autumn migration season due to operational displacement is estimated to be 2 individuals annually, based on a mean peak abundance of 295 birds at the site and 2km buffer, displacement rates of 0.600 to

0.800 and a mortality rate of 1% (**Table 11-36**). Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%, irrespective of whether the mean or upper 95% CI mean peak abundance estimate is used.

205. The increase in existing mortality due to this impact is very small. It is likely that this would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the autumn migration season is assessed as negligible. As gannet is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.1.1.3 SEP and DEP Combined

Table 11-37: Predicted Operational Phase Displacement and Mortality of Gannet at SEP and DEP Combined During the Autumn Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	980	6 - 8	0.01 - 0.01
Mean	638	4 - 5	0.00 - 0.01
Lower 95% CI	378	2 - 3	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (456,298 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)

206. When combined (**Table 11-37**), operational displacement impacts at SEP and DEP during the autumn migration season could result in the mortality of between 4 and 5 gannets annually, based on a mean peak abundance of 638 birds at both sites and 2km buffers. This represents an increase of 0.01% of existing gannet mortality within the UK North Sea and Channel BDMPS. The increase in existing mortality due to this impact is very small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation.

207. Therefore, during the autumn migration season, the magnitude of effect of operational displacement due to SEP and DEP combined is assessed as negligible. Gannet has a medium sensitivity to disturbance, meaning that the impact significance is **minor adverse**.

11.6.2.1.1.2 Spring Migration

208. The UK North Sea and Channel BDMPS is considered to be the relevant background population for gannet during the spring migration season. At the published baseline annual mortality for this species averaged across all age classes (19.1%; **Table 11-17**), the number of gannets expected to die annually that are members of this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 47,527 (i.e. 248,835 x 0.191).

11.6.2.1.1.2.1 DEP

Table 11-38: Predicted Operational Phase Displacement and Mortality of Gannet at DEP During the Spring Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	103	1 - 1	0.00 - 0.00
Mean	47	0 - 0	0.00 - 0.00
Lower 95% CI	10	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (248,835 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)

209. Gannet mortality during the spring migration season due to operational phase displacement from DEP is estimated to be <1 individuals annually, based on a mean peak abundance of 47 birds at the site and 2km buffer, displacement rates of 0.600 to 0.800 and a mortality rate of 1% (**Table 11-38**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01% irrespective of whether the mean or upper 95% CI mean peak abundance estimate is used.

210. The increase in existing mortality due to this impact is very small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the autumn migration season is assessed as negligible. As gannet is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.1.2.2 SEP

Table 11-39: Predicted Operational Phase Displacement and Mortality of Gannet at SEP During the Spring Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	31	1 - 1	0.00 - 0.00
Mean	11	0 - 0	0.00 - 0.00
Lower 95% CI	0	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (248,835 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)

211. At SEP, gannet mortality during the spring migration season due to operational displacement is estimated to be <1 individual annually, based on a mean peak abundance of 47 birds at the site and 2km buffer, displacement rates of 0.600 to

0.800 and a mortality rate of 1% (**Table 11-39**). Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%, irrespective of whether the mean or upper 95% CI mean peak abundance estimate is used.

212. The increase in existing mortality due to this impact is very small. It is likely that this would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the spring migration season is assessed as negligible. As gannet is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.1.2.3 SEP and DEP Combined

Table 11-40: Predicted Operational Phase Displacement and Mortality of Gannet at SEP and DEP Combined During the Spring Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	133	1 - 1	0.00 - 0.00
Mean	57	0 - 0	0.00 - 0.00
Lower 95% CI	10	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (248,835 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)

213. When combined (**Table 11-40**), operational displacement impacts at SEP and DEP during the spring migration season will result in the mortality of <1 gannet annually, based on a mean peak abundance of 57 birds at both sites and 2km buffers. This represents an increase of <0.01% of existing gannet mortality within the UK North Sea and Channel BDMPS. The increase in existing mortality due to this impact is very small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation.

214. Therefore, during the spring migration season, the magnitude of effect of operational displacement due to SEP and DEP combined is assessed as negligible. Gannet has a medium sensitivity to disturbance, meaning that the impact significance is **minor adverse**.

11.6.2.1.1.3 Breeding

215. The breeding adult population of the Flamborough and Filey Coast SPA is considered to be the relevant background population for gannet during the breeding season. At the published baseline annual mortality for this species for adults only (given the assumption that all birds at SEP and DEP during this season are breeding adults) (8.8%; **Table 11-17**), the number of gannets expected to die annually that are members of the population at the Flamborough and Filey Coast SPA (**Appendix 11.1 Offshore Ornithology Technical Report**) is 2,357 (i.e. 26,784 x 0.088).

11.6.2.1.1.3.1 DEP

Table 11-41: Predicted Operational Phase Displacement and Mortality of Gannet at DEP During the Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	692	4 - 6	0.19 - 0.26
Mean	417	3 - 3	0.12 - 0.15
Lower 95% CI	180	1 - 1	0.05 - 0.07

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is Flamborough and Filey Coast SPA (26,784 individuals), adult age class annual mortality rate of 8.8% (Horswill and Robinson, 2015)

216. Gannet mortality during the breeding season due to operational phase displacement from DEP is estimated to be 3 individuals annually, based on a mean peak abundance of 417 birds at the site and 2km buffer, displacement rates of 0.600 to 0.800 and a mortality rate of 1% (**Table 11-41**). This increases the annual mortality of the Flamborough and Filey Coast SPA breeding adult population by 0.12% to 0.15%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 4 to 6 individuals. This increases the annual mortality of the Flamborough and Filey Coast SPA population by 0.19% to 0.26%.

217. The predicted increase in existing mortality due to this impact is small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the breeding season is assessed as negligible. As gannet is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.1.3.2 SEP

Table 11-42: Predicted Operational Phase Displacement and Mortality of Gannet at SEP During the Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	47	0 - 0	0.00 - 0.00
Mean	23	0 - 0	0.01 - 0.01
Lower 95% CI	3	0 - 0	0.01 - 0.02

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is Flamborough and Filey Coast SPA (26,784 individuals), adult age class annual mortality rate of 8.8% (Horswill and Robinson, 2015)

218. At SEP, gannet mortality during the breeding season due to operational displacement is estimated to be <1 individual annually, based on a mean peak

abundance of 23 birds at the site and 2km buffer, displacement rates of 0.600 to 0.800 and a mortality rate of 1% (**Table 11-42**). Adding this impact to existing mortality levels increases the annual mortality of the Flamborough and Filey Coast SPA breeding adult population by <0.01%, irrespective of whether the mean or upper 95% CI mean peak abundance estimate is used.

219. The increase in existing mortality due to this impact is very small. It is likely that this would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the breeding season is assessed as negligible. As gannet is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.1.3.3 SEP and DEP Combined

Table 11-43: Predicted Operational Phase Displacement and Mortality of Gannet at SEP and DEP Combined During the Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	739	4 - 6	0.20 - 0.27
Mean	440	3 - 4	0.12 - 0.16
Lower 95% CI	183	1 - 1	0.05 - 0.07

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is Flamborough and Filey Coast SPA (26,784 individuals), adult age class annual mortality rate of 8.8% (Horswill and Robinson, 2015)

220. When combined (**Table 11-43**), operational displacement impacts at SEP and DEP during the breeding season will result in the mortality of 3 to 4 gannets annually, based on a mean peak abundance of 440 birds at both sites and 2km buffers. This represents an increase of 0.12% to 0.16% of existing gannet mortality within the Flamborough and Filey Coast SPA breeding adult population. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 4 to 6 individuals. This increases the annual mortality of the Flamborough and Filey Coast SPA population by 0.20% to 0.27%. The increase in existing mortality due to this impact is very small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation.

221. Therefore, during the breeding season, the magnitude of effect of operational displacement due to SEP and DEP combined is assessed as negligible. Gannet has a medium sensitivity to disturbance, meaning that the impact significance is **minor adverse**.

11.6.2.1.1.4 Year Round

222. At the published baseline annual mortality for this species averaged across all age classes (19.1%; **Table 11-17**), the number of gannets expected to die from the largest UK North Sea and Channel BDMPS population (the autumn migration season) (**Appendix 11.1 Offshore Ornithology Technical Report**) is 87,153 (i.e. 456,298 x 0.191). The biogeographic population of gannets with connectivity to UK

waters is 1,180,000 (Furness, 2015). The number of individuals expected to die annually from this population is 225,380 (i.e. 1,180,000 x 0.191).

11.6.2.1.1.4.1 DEP

Table 11-44: Predicted Operational Phase Displacement and Mortality of Gannet at DEP Year Round

Mean peak abundance estimate	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	1,349	8 - 11	0.01 - 0.01	0.00 - 0.00
Mean	807	5 - 6	0.01 - 0.01	0.00 - 0.00
Lower 95% CI	375	2 - 3	0.00 - 0.00	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (456,298 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)
3. Background population is biogeographic population with connectivity to UK waters (1,180,000 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)

223. Annual gannet mortality due to operational phase displacement from DEP is estimated to be 5 to 6 individuals annually, based on a summed mean peak abundance across all relevant seasons of 807 birds at the site and 2km buffer, displacement rates of 0.600 to 0.800 and a mortality rate of 1% (**Table 11-44**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.01%, irrespective of whether the mean or upper 95% CI mean peak abundance estimate is used. The impact on the annual mortality within the biogeographic population with connectivity to UK waters is virtually zero.

224. The predicted increase in existing mortality due to this impact is small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP year round is assessed as negligible. As gannet is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.1.4.2 SEP

Table 11-45: Predicted Operational Phase Displacement and Mortality of Gannet at SEP Year Round

Mean peak abundance estimate	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	504	3 - 4	0.00 - 0.00	0.00 - 0.00
Mean	328	2 - 3	0.00 - 0.00	0.00 - 0.00
Lower 95% CI	195	1 - 2	0.00 - 0.00	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds

Mean peak abundance estimate	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
2. Background population is UK North Sea and Channel BDMPS (456,298 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015) 3. Background population is biogeographic population with connectivity to UK waters (1,180,000 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)				

225. Annual gannet mortality due to operational phase displacement from SEP is estimated to be 2 to 3 individuals annually, based on a summed mean peak abundance across all relevant seasons of 504 birds at the site and 2km buffer, displacement rates of 0.600 to 0.800 and a mortality rate of 1% (**Table 11-45**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%, irrespective of whether the mean or upper 95% CI mean peak abundance estimate is used. The impact on the annual mortality within the biogeographic population with connectivity to UK waters is virtually zero.

226. The predicted increase in existing mortality due to this impact is small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP year round is assessed as negligible. As gannet is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.1.4.3 SEP and DEP Combined

Table 11-46: Predicted Operational Phase Displacement and Mortality of Gannet at SEP and DEP Combined Year Round

Mean peak abundance estimate	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	1,852	11 - 15	0.01 - 0.02	0.00 - 0.00
Mean	1,135	7 - 9	0.01 - 0.01	0.00 - 0.00
Lower 95% CI	570	3 - 5	0.00 - 0.01	0.00 - 0.00
Notes 1. Assumes displacement rates of 0.600 to 0.800 and mortality rate of 1% of displaced birds 2. Background population is UK North Sea and Channel BDMPS (456,298 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015) 3. Background population is biogeographic population with connectivity to UK waters (1,180,000 individuals), all age class annual mortality rate of 19.1% (Horswill and Robinson, 2015)				

227. Annual gannet mortality due to operational phase displacement from SEP and DEP combined is estimated to be 7 to 9 individuals annually, based on a summed mean peak abundance across all relevant seasons of 1,135 birds at the site and 2km buffer, displacement rates of 0.600 to 0.800 and a mortality rate of 1% (**Table 11-44**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.01%. Using the upper 95% CI mean peak abundance estimate instead of the mean value causes the annual mortality increase to change

to up to 0.02%. The impact on the annual mortality within the biogeographic population with connectivity to UK waters is virtually zero.

228. The predicted increase in existing mortality due to this impact is small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP combined year round is assessed as negligible. As gannet is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.1.5 Summary and Confidence Assessment

229. The impact significance for autumn migration, spring migration, breeding season and year round gannet displacement during the operational phase of SEP and DEP combined is **minor adverse**.

230. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. A comparison between the encounter rates of this species within the different parts of DEP indicated that year round, the encounter rate for this species from the raw baseline survey data was 22.0% higher at DEP-N than DEP as a whole. However, in the event that all of DEP's turbines were installed at DEP-N, the footprint of the OWF would be smaller than if turbines were installed across all of DEP, thereby resulting in smaller impacts than those presented here. Therefore, the assessment presented represents a suitably precautionary approach.

231. The confidence in the assessment is high for several reasons. Firstly, the evidence used to set the displacement rates presented at the start of this section is of high applicability and quality. Whilst there is limited available evidence to inform mortality rates, 1% is considered to be sufficiently precautionary based on expert opinion. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI mean peak abundances are used to calculate potential mortality and increases in the baseline mortality rate of the background population.

11.6.2.1.2 Auks (Guillemot and Razorbill)

232. A range of literature describing the potential sensitivity of guillemot and razorbill to operational displacement by OWFs is referred to in **Section 11.6.2.1**. Additional evidence is provided in the following paragraphs.

233. The SOW OMP study (Harwood *et al*., 2018) indicates that avoidance of the OWF by guillemot and razorbill occurred during the operational phase, and that the minor adverse impact significance predicted by the SOW ES for both species was an appropriate prediction. Inconclusive displacement effects were detected for auk species collectively at the LID/Lincs OWFs (Hi Def Aerial Surveying, 2017).

234. Studies from Germany indicate that guillemots avoid operational OWFs. Research involving birds tracked using GPS tags suggested that displacement rates within OWFs north of Helgoland were 0.630, increasing to 0.750 when turbines were actually turning (Peschko *et al*., 2020b). Effects outside OWFs were not quantified, though it was noted that some individuals used habitats adjacent to OWFs despite the presence of operational turbines. A study in the same geographical region using

a long term dataset of boat-based and visual aerial survey data, found a similar impact level during spring. Displacement from the OWF and 3km buffer was calculated to be 0.630 relative to the surrounding area (Peschko *et al*., 2020a), with effects detectable up to 9km from OWF boundaries. During the breeding season, the effect was weaker, at 0.440 displacement. There was no statistically significant differences between the effects observed in two seasons. It was hypothesised that guillemots may possess greater flexibility during the spring, allowing them to avoid the OWF and surrounding area. During the breeding season however, birds are more closely associated with their breeding colonies (in this case located 23km from the nearest OWF). This might reduce their flexibility with respect to habitat preferences, including OWF avoidance.

235. A recent review of available evidence for auk displacement (Vattenfall, 2019) concluded that displacement of guillemots and razorbills by OWFs is incomplete (i.e. lower than 100%), and may reduce with habituation as birds become accustomed to the presence of an operational OWF. The review also suggested that in the longer term, OWFs may increase food availability by providing enhanced habitat for fish populations. Mortality due to displacement might arise if said displacement increased competition for resources in the remaining areas of unimpacted habitat outside the OWF. However, this competition may not ever occur, since the area that birds will be displaced into is vast. The mortality rate due to displacement may therefore feasibly be 0%. The review suggested appropriately precautionary rates of displacement and mortality of auks from operational OWFs of 0.500 and 1% respectively. A recent review (APEM, 2022) made the same recommendations for displacement and mortality rates.

236. Individual behaviour and energetics based modelling has been undertaken on the potential effects of OWF displacement on guillemots (Searle *et al*., 2014, 2017, 2020). A range of scenarios were considered in the two most recent studies using the SeabORD model , which carried out a cumulative impact assessment of operational OWF displacement across the Forth and Tay region (comprising the Neart Na Gaoithe, Inch Cape, and Seagreen Phase 1 OWFs, plus the proposed Seagreen Phase 2 project). In these models, adult guillemot and razorbill mortality at three SPA colonies within the maximum breeding season foraging range was predicted to increase by <1% in the majority of scenarios considered. This suggests that impacts of displacement and barrier effects for guillemots and razorbills have a small impact on adult survival, even when tested in scenarios with multiple OWFs situated close to colonies between breeding sites and foraging grounds.

237. Based on the available information, guillemot and razorbill are considered to possess a medium sensitivity to disturbance and displacement from operational OWFs. Confidence in this level of sensitivity is considered to be high due to the relatively high applicability, concordance, and quality of the available information sources.

238. Following statutory guidance (UK SNCBs, 2017), abundance estimates for each auk species for DEP and its 2km buffer, and SEP and its 2km buffer, for the relevant biological periods (**Table 11-15**) have been used to produce displacement matrices.

239. Natural England has advised that a range of mortality rates of 1% to 10% and displacement rates of 0.300 to 0.700, should be considered. This guidance is followed by the assessment. The available evidence (including that discussed

above) indicates that the displacement rates at the upper end of this range may be possible. However, there is no evidence of displacement-induced mortality occurring due to this impact.

240. To put a predicted mortality rate of 10% into context, this is almost double the total annual mortality rates for adult guillemot (6%), and equal to the total annual mortality rate for razorbill (10%). These rates cover all factors contributing to mortality, including prey availability, bycatch, predation, shipping, oil and gas, aggregate extraction and military activity, and pollution (both one off events such as oil spills, and chronic pollution by microplastics and other substances), as well as birds that die of natural causes. It seems improbable that disturbance and displacement by OWFs would result in a level of mortality similar to all of these other factors combined, particularly since no evidence for displacement-induced mortality has been collected to date. This means that there is limited justification for selecting predicted mortality rates at the higher level of the range suggested by Natural England.

11.6.2.1.2.1 Guillemot: Non-breeding

241. The UK North Sea and Channel BDMPS is considered to be the relevant background population for guillemot during the non-breeding season (Furness, 2015). Using the published average annual mortality for this species for all age classes (14.0%; **Table 11-17**), the number of guillemots expected to die annually from this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 226,423 (i.e. 1,617,306 x 0.140).

11.6.2.1.2.1.1 DEP

Table 11-47: Predicted Operational Phase Displacement and Mortality of Guillemot at DEP During the Non-Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	24,511	74 - 1,716 (123)	0.03 - 0.76 (0.05)
Mean	14,887	45 - 1,042 (74)	0.02 - 0.46 (0.03)
Lower 95% CI	7,827	23 - 548 (39)	0.01 - 0.24 (0.02)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (1,617,306 individuals), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

242. Guillemot mortality during the non-breeding season due to operational phase displacement from DEP is estimated to be 45 to 1,042 individuals annually, based on a mean peak abundance of 14,887 birds at the site and 2km buffer, displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% (**Table 11-47**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.02% to 0.46%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 74 to 1,716 individuals. This increases

the annual mortality of the UK North Sea and Channel BDMPS population by 0.03% to 0.76%. Applying the precautionary displacement and mortality figures of 0.500 and 1%, the predicted annual mortality is 74 if the mean peak abundance is used, representing a 0.03% increase to background population annual mortality. The use of the upper 95% CI mean peak in this calculation increases this value to 123 individuals, or a 0.05% increase to background population annual mortality.

243. The predicted increase in existing mortality due to this impact is small at most if the upper 95% CI mean peak abundance is used, and very small if mean peak abundance is relied upon. Such impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the non-breeding season is assessed as negligible. As guillemot is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.1.2 SEP

Table 11-48: Predicted Operational Phase Displacement and Mortality of Guillemot at SEP During the Non-Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	1,569	5 - 110 (8)	0.00 - 0.05 (0.00)
Mean	1,085	3 - 76 (5)	0.00 - 0.03 (0.00)
Lower 95% CI	661	2 - 46 (3)	0.00 - 0.02 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (1,617,306 individuals), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

244. Guillemot mortality during the non-breeding season due to operational phase displacement from SEP is estimated to be 3 to 76 individuals annually, based on a mean peak abundance of 1,085 birds at the site and 2km buffer, displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% (**Table 11-48**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.00% to 0.03%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 5 to 110 individuals. This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.00% to 0.05%. Applying the precautionary displacement and mortality figures of 0.500 and 1%, the predicted annual mortality is 5 if the mean peak abundance is used, representing a 0.00% increase to background population annual mortality. The use of the upper 95% CI mean peak in this calculation increases this value to 8 individuals, or a 0.00% increase to background population annual mortality.

245. The increase in existing mortality due to this impact is very small even if the upper 95% CI mean peak abundance is used. Such impacts would not materially alter the background mortality of the population and would be undetectable in the context of

natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the non-breeding season is assessed as negligible. As guillemot is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.1.3 SEP and DEP Combined

Table 11-49: Predicted Operational Phase Displacement and Mortality of Guillemot at SEP and DEP Combined During the Non-Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	26,080	78 - 1,826 (130)	0.03 - 0.81 (0.06)
Mean	15,972	48 - 1,118 (80)	0.02 - 0.49 (0.04)
Lower 95% CI	8,488	25 - 594 (42)	0.01 - 0.26 (0.02)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (1,617,306 individuals), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

246. When combined (**Table 11-49**), guillemot mortality during the non-breeding season due to operational phase displacement from SEP and DEP is estimated to be 48 to 1,118 individuals annually, based on a mean peak abundance of 1,085 birds at the site and 2km buffer, displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10%. This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.02% to 0.49%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 78 to 1,826 individuals. This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.03% to 0.81%. Applying the precautionary displacement and mortality figures of 0.500 and 1%, the predicted annual mortality is 80 if the mean peak abundance is used, representing a 0.04% increase to background population annual mortality. The use of the upper 95% CI mean peak in this calculation increases this value to 130 individuals, or a 0.06% increase to background population annual mortality.

247. The increase in existing mortality due to this impact is very small even if the upper 95% CI mean peak abundance is used. Such impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the non-breeding season is assessed as negligible. As guillemot is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.2 Guillemot: Breeding

248. The non-breeding component of the UK North Sea and Channel BDMPS is considered to be the relevant background population for the breeding season. At

the published baseline annual mortality for all age classes of guillemot (14.0%; **Table 11-17**), the number of guillemots expected to die annually that are members of this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 97,362 (i.e. 695,441 x 0.140).

11.6.2.1.2.2.1 DEP

Table 11-50: Predicted Operational Phase Displacement and Mortality of Guillemot at DEP During the Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	5,817	17 - 407 (29)	0.02 - 0.42 (0.03)
Mean	3,839	12 - 269 (19)	0.01 - 0.28 (0.02)
Lower 95% CI	2,376	7 - 166 (12)	0.01 - 0.17 (0.01)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is non-breeding component UK North Sea and Channel BDMPS (605,441 individuals), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

249. Guillemot mortality during the breeding season due to operational phase displacement from DEP is estimated to be 12 to 269 individuals annually, based on a mean peak abundance of 3,839 birds at the site and 2km buffer, displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% (**Table 11-50**). This increases the annual mortality of the non-breeding component of the UK North Sea and Channel BDMPS population by 0.01% to 0.28%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 17 to 407 individuals. This increases the annual mortality of the non-breeding component of the UK North Sea and Channel BDMPS population by 0.02% to 0.42%. Applying the precautionary displacement and mortality figures of 50% and 1%, the predicted annual mortality is 19 if the mean peak abundance is used, representing a 0.02% increase to background population annual mortality. The use of the upper 95% CI mean peak in this calculation increases this value to 29 individuals, or a 0.03% increase to background population annual mortality.

250. The predicted increase in existing mortality due to this impact is small at most even if the upper 95% CI mean peak abundance is used at the upper end of mortality rates suggested by Natural England, and are far smaller at more realistic mortality rates (i.e. 1%). Such impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the breeding season is assessed as negligible. As guillemot is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.2.2 SEP

251. The non-breeding component of the UK North Sea and Channel BDMPS is considered to be the relevant background population for the breeding season. At

the published baseline annual mortality for all age classes of guillemot (14.0%; **Table 11-17**), the number of guillemots expected to die annually that are members of this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 97,362 (i.e. 695,441 x 0.140).

Table 11-51: Predicted Operational Phase Displacement and Mortality of Guillemot at SEP During the Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	1,868	6 - 131 (9)	0.01 - 0.13 (0.01)
Mean	1,095	3 - 77 (5)	0.00 - 0.08 (0.01)
Lower 95% CI	592	2 - 41 (3)	0.00 - 0.04 (0.01)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is non-breeding component UK North Sea and Channel BDMPS (605,441 individuals), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

252. Guillemot mortality during the breeding season due to operational phase displacement from SEP is estimated to be 3 to 77 individuals annually, based on a mean peak abundance of 1,095 birds at the site and 2km buffer, displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% (**Table 11-51**). This increases the annual mortality of the non-breeding component of the UK North Sea and Channel BDMPS population by 0.01% to 0.08%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 6 to 131 individuals. This increases the annual mortality of the non-breeding component of the UK North Sea and Channel BDMPS population by 0.01% to 0.13%. Applying the precautionary displacement and mortality figures of 50% and 1%, the predicted annual mortality is 5 if the mean peak abundance is used, representing a 0.01% increase to background population annual mortality. The use of the upper 95% CI mean peak in this calculation increases this value to 9 individuals, or a 0.01% increase to background population annual mortality.

253. The predicted increase in existing mortality due to this impact is small at most even if the upper 95% CI mean peak abundance is used at the upper end of mortality rates suggested by Natural England, and are far smaller at more realistic mortality rates (i.e. 1%). Such impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the breeding season is assessed as negligible. As guillemot is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.2.3 SEP and DEP Combined

Table 11-52: Predicted Operational Phase Displacement and Mortality of Guillemot at SEP and DEP Combined During the Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	7,685	23 - 538 (38)	0.02 - 0.55 (0.04)
Mean	4,934	15 - 345 (25)	0.02 - 0.35 (0.03)
Lower 95% CI	2,968	9 - 208 (15)	0.01 - 0.21 (0.02)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is non-breeding component UK North Sea and Channel BDMPS (605,441 individuals), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

254. Combined, the guillemot mortality during the breeding season due to operational phase displacement from SEP and DEP is estimated to be 15 to 345 individuals annually, based on a mean peak abundance of 4,934 birds at the sites and 2km buffers, displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% (**Table 11-52**). This increases the annual mortality of the non-breeding component of the UK North Sea and Channel BDMPS population by 0.02% to 0.35%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 23 to 538 individuals. This increases the annual mortality of the non-breeding component of the UK North Sea and Channel BDMPS population by 0.02% to 0.55%. Applying the precautionary displacement and mortality figures of 50% and 1%, the predicted annual mortality is 25 if the mean peak abundance is used, representing a 0.03% increase to background population annual mortality. The use of the upper 95% CI mean peak in this calculation increases this value to 38 individuals, or a 0.04% increase to background population annual mortality.

255. The predicted increase in existing mortality due to this impact is small at most even if the upper 95% CI mean peak abundance is used at the upper end of mortality rates suggested by Natural England, and are far smaller at more realistic mortality rates (i.e. 1%). Such impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP combined during the breeding season is assessed as negligible. As guillemot is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.3 Guillemot: Year Round

256. At the published baseline annual mortality for this species averaged across all age classes (14.0%; **Table 11-17**), the number of guillemots expected to die annually that are members of the UK North Sea and Channel BDMPS (**Appendix 11.1 Offshore Ornithology Technical Report**) is 226,423 (i.e. 1,617,306 x 0.140). The

biogeographic population of guillemots with connectivity to UK waters is 4,125,000 (Furness, 2015). The number of individuals expected to die annually from this population is 577,500 (i.e. 4,125,000 x 0.140).

11.6.2.1.2.3.1 DEP

Table 11-53: Predicted Operational Phase Displacement and Mortality of Guillemot at DEP Year Round

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	30,328	91 - 2,123 (152)	0.04 - 0.94 (0.07)	0.01 - 0.27 (0.02)
Mean	18,726	56 - 1,311 (94)	0.02 - 0.58 (0.04)	0.01 - 0.17 (0.01)
Lower 95% CI	10,202	31 - 714 (51)	0.01 - 0.32 (0.02)	0.00 - 0.09 (0.01)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (1,617,306 individuals), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
3. Background population is biogeographic population of guillemots with connectivity to UK waters (4,125,000), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

257. Year round guillemot mortality due to operational phase displacement from DEP is estimated to be 56 to 1,311 individuals annually, based on a mean peak abundance of 18,726 birds at both sites and 2km buffers, displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% (**Table 11-53**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.02% to 0.58%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 91 to 2,123 individuals. This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.04% to 0.94%. Applying the precautionary displacement and mortality figures of 50% and 1%, the predicted annual mortality is 94 if the mean peak abundance is used, representing a 0.04% increase to the UK North Sea and Channel BDMPS annual mortality. The use of the upper 95% CI mean peak in this calculation increases this value to 152 individuals, or a 0.07% increase to the UK North Sea and Channel BDMPS annual mortality. Mortality rate increases for the biogeographic population are around a third of that calculated for the UK North Sea and Channel BDMPS population.

258. The predicted increase in existing mortality due to this impact is small at most even if the upper 95% CI mean peak abundance is used at the upper end of mortality rates suggested by Natural England, and are far smaller at more realistic mortality rates (i.e. 1%). Such impacts would not materially alter the background mortality of either population considered and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the breeding season is assessed as negligible. As guillemot is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.3.2 SEP

Table 11-54: Predicted Operational Phase Displacement and Mortality of Guillemot at SEP Year Round

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	3,437	10 – 241 (17)	0.00 - 0.11 (0.01)	0.00 - 0.03 (0.00)
Mean	2,179	7 – 153 (11)	0.00 - 0.07 (0.00)	0.00 - 0.02 (0.00)
Lower 95% CI	1,253	4 – 88 (6)	0.00 - 0.04 (0.00)	0.00 - 0.01 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (1,617,306 individuals), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
3. Background population is biogeographic population of guillemots with connectivity to UK waters (4,125,000), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

259. Year round guillemot mortality due to operational phase displacement from SEP is estimated to be 7 to 153 individuals annually, based on a mean peak abundance of 2,179 birds at both sites and 2km buffers, displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% (**Table 11-54**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.00% to 0.07%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 10 to 241 individuals. This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.00% to 0.11%. Applying the precautionary displacement and mortality figures of 50% and 1%, the predicted annual mortality is 11 if the mean peak abundance is used, representing a 0.00% increase to background population annual mortality. The use of the upper 95% CI mean peak in this calculation increases this value to 17 individuals, or a 0.01% increase to background population annual mortality. Mortality rate increases for the biogeographic population are around a third of that calculated for the UK North Sea and Channel BDMPS population.

260. The predicted increase in existing mortality due to this impact is small at most even if the upper 95% CI mean peak abundance is used at the upper end of mortality rates suggested by Natural England, and are far smaller at more realistic mortality rates (i.e. 1%). Such impacts would not materially alter the background mortality of either population considered and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the breeding season is assessed as negligible. As guillemot is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.3.3 SEP and DEP Combined

Table 11-55: Predicted Operational Phase Displacement and Mortality of Guillemot at SEP and DEP Combined Year Round

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	33,764	101 -2,363 (169)	0.04 - 1.04 (0.07)	0.01 - 0.30 (0.02)
Mean	20,905	63 - 1,463 (105)	0.03 - 0.65 (0.05)	0.01 - 0.19 (0.01)
Lower 95% CI	11,455	34 - 802 (57)	0.02 - 0.35 (0.03)	0.00 - 0.10 (0.01)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (1,617,306 individuals), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
3. Background population is biogeographic population of guillemots with connectivity to UK waters (4,125,000), all age class annual mortality rate of 14.0% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

261. Combined year round guillemot mortality due to operational phase displacement from SEP and DEP is estimated to be 63 to 1,463 individuals annually, based on a mean peak abundance of 20,905 birds at both sites and 2km buffers, displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% (**Table 11-55**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.03% to 0.65%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 101 to 2,363 individuals. This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.04% to 1.04%. Applying the precautionary displacement and mortality figures of 50% and 1%, the predicted annual mortality is 105 if the mean peak abundance is used, representing a 0.05% increase to background population annual mortality. The use of the upper 95% CI mean peak in this calculation increases this value to 169 individuals, or a 0.07% increase to background population annual mortality. Mortality rate increases for the biogeographic population are around a third of that calculated for the UK North Sea and Channel BDMPS population.

262. The predicted increase in existing mortality due to this impact is small at most even if the upper 95% CI mean peak abundance is used at the upper end of mortality rates suggested by Natural England, and are far smaller at more realistic mortality rates (i.e. 1%). Such impacts would not materially alter the background mortality of either population considered and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the breeding season is assessed as negligible. As guillemot is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.4 Summary and Confidence Assessment

263. Overall, the impact significance for breeding season, non-breeding season and year round guillemot displacement during the operational phase of SEP and DEP combined is **minor adverse**.

264. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. A comparison between the encounter rates of this species within the different parts of DEP indicated that year round, the encounter rate for this species from the raw baseline survey data was 18.8% higher at DEP-N than DEP as a whole. However, in the event that all of DEP's turbines were installed at DEP-N, the footprint of the OWF would be smaller than if turbines were installed across all of DEP, thereby resulting in smaller impacts than those presented here. Therefore, the assessment presented represents a suitably precautionary approach.

265. The confidence in the assessment is high. The evidence used to set the displacement rates presented at the start of this section is of high applicability and quality, and suggests far lower impacts than the upper end of the displacement and mortality ranges suggested by Natural England, which themselves may be undetectable in the context of existing mortality amongst the wider population. Whilst there is limited available evidence to inform mortality rates, 1% is considered to be sufficiently precautionary based on expert opinion. Finally, the conclusion of the assessment is the same irrespective of whether the mean or upper 95% CI mean peak abundances are used to calculate potential mortality.

11.6.2.1.2.5 Razorbill: Autumn Migration

266. The UK North Sea and Channel BDMPS is considered to be the relevant background population for razorbill during the autumn migration season (Furness, 2015). Using the published annual mortality across all age classes (17.4%; **Table 11-17**), the number of razorbills expected to die annually from this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 102,986 (i.e. 591,874 x 0.174).

11.6.2.1.2.5.1 DEP

Table 11-56: Predicted Operational Phase Displacement and Mortality of Razorbill at DEP During the Autumn Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	1,469	4 - 103 (7)	0.00 - 0.10 (0.01)
Mean	923	3 - 65 (5)	0.00 - 0.06 (0.00)
Lower 95% CI	518	2 - 36 (3)	0.00 - 0.04 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
2. Background population is UK North Sea and Channel BDMPS (591,874 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)			

267. Razorbill mortality during the autumn migration season due to operational phase displacement at DEP is estimated to be 3 to 65 individuals, based on a mean peak abundance of 923 birds at the site (including 2km buffer), displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds (**Table 11-56**). This would increase the annual mortality of the BDMPS by 0.00% to 0.06%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicted mortality range to 4 to 103 individuals. This would represent a 0.00% to 0.10% increase in the annual mortality of the BDMPS.

268. The magnitude of increase in annual mortality (using either the mean or upper 95% CI) would be small, would not materially alter the baseline mortality of the BDMPS and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the autumn migration season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.5.2 SEP

Table 11-57: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP During the Autumn Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	421	1 - 29 (2)	0.00 - 0.03 (0.00)
Mean	316	1 - 22 (2)	0.00 - 0.02 (0.00)
Lower 95% CI	206	1 - 14 (1)	0.00 - 0.01 (0.00)
Notes 1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019) 2. Background population is UK North Sea and Channel BDMPS (591,874 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015);0 number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)			

269. Razorbill mortality during the autumn migration season due to operational displacement at SEP is estimated to be 1 to 22 individuals, based on a mean peak abundance of 316 birds at the site (including 2km buffer) and using the same displacement and mortality rates as for DEP (**Table 11-57**). This would increase the annual mortality of the BDMPS by 0.00% to 0.02%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicted mortality range to 1 to 29 individuals. This would represent a 0.00% to 0.03% increase in the annual mortality of the BDMPS.

270. The magnitude of increase in annual mortality (using either the mean or upper 95% CI) would be very small, would not materially alter the baseline mortality of the BDMPS and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the autumn

migration season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.5.3 SEP and DEP Combined

Table 11-58: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP and DEP Combined During the Autumn Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	1,890	6 - 132 (9)	0.01 - 0.13 (0.01)
Mean	1,239	4 - 87 (6)	0.00 - 0.08 (0.01)
Lower 95% CI	724	2 - 51 (4)	0.00 - 0.05 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (591,874 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

271. Razorbill mortality during the autumn migration season due to operational phase displacement at SEP and DEP combined is estimated to be 4 to 87 individuals, based on a mean peak abundance of 1,239 birds across the sites (including 2km buffers) and using the same displacement and mortality rates as for SEP and DEP in isolation. This would increase the annual mortality of the BDMPS by 0.00% to 0.08%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicted mortality range to 6 to 132 individuals. This would represent a 0.01% to 0.13% increase in the annual mortality of the BDMPS.

272. The magnitude of increase in annual mortality (using either the mean or upper 95% CI) would be very small to small, would not materially alter the baseline mortality of the BDMPS and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP (combined) during the autumn migration season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.6 Razorbill: Winter

273. The UK North Sea and Channel BDMPS is considered to be the relevant background population for razorbill during the winter season (Furness, 2015). Using the published average annual mortality across all age classes (17.4%; **Table 11-17**), the number of razorbills expected to die annually from this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 38,040 (i.e. 218,622 x 0.174).

11.6.2.1.2.6.1 DEP

Table 11-59: Predicted Operational Phase Displacement and Mortality of Razorbill at DEP During the Winter Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	1,348	4 - 94 (7)	0.01 - 0.25 (0.02)
Mean	845	3 - 59 (4)	0.00 - 0.16 (0.01)
Lower 95% CI	450	1 - 31 (2)	0.00 - 0.08 (0.01)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (218,622 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

274. Razorbill mortality during the winter season due to operational phase displacement at DEP is estimated to be 3 to 59 individuals, based on a mean peak abundance of 845 birds at the site (including 2km buffer), displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds (**Table 11-59**). This would increase the annual mortality of the BDMPS by 0.00% to 0.16%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicted mortality range to 4 to 94 individuals. This would represent a 0.01% to 0.25% increase in the annual mortality of the BDMPS.

275. The magnitude of increase in annual mortality (using either the mean or upper 95% CI) would be small, would not materially alter the baseline mortality of the BDMPS, and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the winter season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.6.2 SEP

Table 11-60: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP During the Winter Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	1,112	3 - 78 (6)	0.01 - 0.20 (0.01)
Mean	686	2 - 48 (3)	0.01 - 0.13 (0.01)
Lower 95% CI	339	1 - 24 (2)	0.00 - 0.06 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (218,622 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

276. Razorbill mortality during the winter season due to operational displacement at SEP is estimated to be 2 to 48 individuals, based on a mean peak abundance of 686

birds at the site (including 2km buffer) and using the same displacement and mortality rates as for DEP (**Table 11-60**). This would increase the annual mortality of the BDMPS by 0.01% to 0.13%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicated mortality range to 3 to 78 individuals. This would represent a 0.01% to 0.20% increase in the annual mortality of the BDMPS.

277. The magnitude of increase in annual mortality (using either the mean or upper 95% CI) would be small, would not materially alter the baseline mortality of the BDMPS and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the winter season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.6.3 SEP and DEP Combined

Table 11-61: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP and DEP Combined During the Winter Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	2,460	7 - 172 (12)	0.02 - 0.45 (0.01)
Mean	1,531	5 - 107 (8)	0.01 - 0.28 (0.01)
Lower 95% CI	789	2 - 55 (4)	0.01 - 0.15 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (218,622 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

278. Razorbill mortality during the winter season due to operational phase displacement at SEP and DEP combined is estimated to be 5 to 107 individuals, based on a peak mean abundance of 1,531 birds across the sites (including 2km buffers) and using the same displacement and mortality rates as for SEP and DEP separately (**Table 11-61**). This would increase the annual mortality of the BDMPS by 0.01% to 0.28%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicted mortality range to 7 to 172 individuals. This would represent a 0.02% to 0.45% increase in the annual mortality of the BDMPS.

279. The magnitude of increase in annual mortality (using either the mean or upper 95% CI) would be small, would not materially affect the baseline mortality of the BDMPS and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP (combined) during the winter season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.7 Razorbill: Spring Migration

280. The UK North Sea and Channel BDMPS is considered to be the relevant background population for razorbill during the spring migration season (Furness, 2015). Using the published average annual mortality across all age classes (17.4%;

Table 11-17), the number of razorbills expected to die annually from this population (Appendix 11.1 Offshore Ornithology Technical Report) is 102,986 (i.e. 591,874 x 0.174).

11.6.2.1.2.7.1 DEP

Table 11-62: Predicted Operational Phase Displacement and Mortality of Razorbill at DEP During the Spring Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	652	2 - 46 (3)	0.00 - 0.04 (0.00)
Mean	320	1 - 22 (2)	0.00 - 0.02 (0.00)
Lower 95% CI	85	0 - 6 (0)	0.00 - 0.01 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (591,874 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

281. Razorbill mortality during the spring migration season due to operational phase displacement at DEP is estimated to be 1 to 22 individuals, based on a mean peak abundance of 320 birds at the site (including 2km buffer), displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds (Table 11-62). This would increase the annual mortality of the BDMPS by 0.00% to 0.02%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicted mortality range to 2 to 46 individuals. This would represent a 0.00% to 0.04% increase in the annual mortality of the BDMPS.

282. The predicted increase in existing mortality due to this impact (using either the mean or upper 95% CI) is very small, would not materially alter the baseline mortality of the BDMPS and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the spring migration season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.7.2 SEP

Table 11-63: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP During the Spring Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	300	1 - 21 (1)	0.00 - 0.02 (0.00)
Mean	144	0 - 10 (1)	0.00 - 0.01 (0.00)
Lower 95% CI	26	0 - 2 (0)	0.00 - 0.00 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
2. Background population is UK North Sea and Channel BDMPS (591,874 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)			

283. Razorbill mortality during the spring migration season due to operational displacement at SEP is estimated to be 0 to 10 individuals, based on a mean peak abundance of 144 birds at the site (including 2km buffer) and using the same displacement and mortality rates as for DEP (**Table 11-63**). This would increase the annual mortality of the BDMPS by 0.00% to 0.01%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicated mortality range to 1 to 21 individuals. This would represent a 0.00% to 0.01% increase in the annual mortality of the BDMPS.

284. The magnitude of increase in annual mortality (using either the mean or upper 95% CI) would be very small, would not materially alter the baseline mortality of the BDMPS and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the spring migration season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.7.3 SEP and DEP Combined

Table 11-64: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP and DEP Combined During the Spring Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	951	3 - 67 (5)	0.00 - 0.06 (0.00)
Mean	464	1 - 32 (2)	0.00 - 0.03 (0.00)
Lower 95% CI	111	0 - 8 (1)	0.00 - 0.01 (0.00)
Notes 1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019) 2. Background population is UK North Sea and Channel BDMPS (591,874 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)			

285. Razorbill mortality during the spring migration season due to operational phase displacement at SEP and DEP combined is estimated to be 5 to 107 individuals, based on a mean peak abundance of 1,531 birds across the sites (including 2km buffers) and using the same displacement and mortality rates as for SEP and DEP separately. This would increase the annual mortality of the BDMPS by 0.00% to 0.10%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicted mortality range to 7 to 172 individuals. This would represent a 0.01% to 0.17% increase in the annual mortality of the BDMPS.

286. The magnitude of increase in annual mortality (using either the mean of upper 95% CI) would be very small to small, would not materially affect the baseline mortality of the BDMPS and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP

(combined) during the spring migration season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.8 Razorbill: Breeding

287. Given that SEP and DEP are beyond the likely foraging ranges of colony-based breeding razorbills, the non-breeding component of the winter UK North Sea and Channel BDMPS is considered to be the relevant razorbill background population during the breeding season. Using the published average annual mortality across all age classes (17.4%; **Table 11-17**), the number of razorbills expected to die annually from this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 16,357 (i.e. 94,007 x 0.174).

11.6.2.1.2.8.1 DEP

Table 11-65: Predicted Operational Phase Displacement and Mortality of Razorbill at DEP During the Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	6,857	21 - 480 (34)	0.13 - 2.93 (0.21)
Mean	3,741	11 - 262 (19)	0.07 - 1.60 (0.11)
Lower 95% CI	1,266	4 - 89 (6)	0.02 - 0.54 (0.04)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is the non-breeding component of the UK North Sea and Channel BDMPS (94,007 individuals), average age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

288. Razorbill mortality during the breeding season due to operational phase displacement at DEP is estimated to be 11 to 262 individuals, based on a mean peak abundance of 3,741 birds at the site (including 2km buffer), displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds (**Table 11-65**). This would increase the annual mortality of the relevant population by 0.07% to 1.60%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicted mortality range to 21 to 480 individuals. This would represent a 0.13% to 2.93% increase in the annual mortality of the relevant population.

289. However, when applying the 50% displacement and 1% mortality figures, indicated as a precautionary approach by the evidence-based review of auk displacement (Vattenfall, 2019), the increase in annual mortality would be 0.11% (based on the mean peak abundance) or 0.21% (based on the upper 95% CI). This magnitude of increase (using either abundance estimate) would not materially affect the baseline mortality of the relevant population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP (combined) during the breeding season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.8.2 SEP

Table 11-66: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP During the Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	1,245	4 - 87 (6)	0.02 - 0.53 (0.04)
Mean	759	2 - 53 (4)	0.01 - 0.32 (0.02)
Lower 95% CI	326	1 - 23 (2)	0.01 - 0.14 (0.01)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is the non-breeding component of the UK North Sea and Channel BDMPS (94,007 individuals), average age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

290. Razorbill mortality during the breeding season due to operational displacement at SEP is estimated to be 2 to 53 individuals, based on a mean peak abundance of 759 birds at the site (including 2km buffer) and using the same displacement and mortality rates as for DEP (**Table 11-66**). This would increase the annual mortality of the relevant population by 0.01% to 0.32%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicated mortality range to 4 to 87 individuals. This would represent a 0.02% to 0.53% increase in the annual mortality of the relevant population.

291. The magnitude of increase in annual mortality (using either the mean or upper 95% CI) would be very small to small, would not materially alter the baseline mortality of the relevant population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the breeding season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.8.3 SEP and DEP Combined

Table 11-67: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP and DEP Combined During the Breeding Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	8,101	24 - 567 (41)	0.15 - 3.47 (0.25)
Mean	4,500	14 - 315 (23)	0.08 - 1.93 (0.14)
Lower 95% CI	1,591	5 - 111 (8)	0.03 - 0.68 (0.05)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is the non-breeding component of the UK North Sea and Channel BDMPS (94,007 individuals), average age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

292. Razorbill mortality during the breeding season due to operational phase displacement at SEP and DEP combined is estimated to be 14 to 315 individuals,

based on a mean peak abundance of 4,500 birds across the sites (including 2km buffers) and using the same displacement and mortality rates as for SEP and DEP separately. This would increase the annual mortality of the relevant population by 0.08% to 1.93%. Use of the upper 95% CI mean peak abundance in this calculation would increase the predicted mortality range to 24 to 567 individuals. This would represent a 0.15% to 3.47% increase in the annual mortality of the relevant population.

293. However, when applying the 50% displacement and 1% mortality figures, indicated as a precautionary approach by the evidence-based review of auk displacement (Vattenfall, 2019), the increase in annual mortality would be 0.14% (based on the mean peak abundance) or 0.25% (based on the upper 95% CI). This magnitude of increase (using either abundance estimate) would not materially affect the baseline mortality of the relevant population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP (combined) during the breeding season is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.9 Razorbill: Year Round

294. At the published average annual mortality across all age classes (17.4%; **Table 11-17**), the number of razorbills expected to die from the largest UK North Sea and Channel BDMPS population (i.e. the spring and autumn migration season BDMPS) (**Appendix 11.1 Offshore Ornithology Technical Report**) is 102,986 (i.e. 591,874 x 0.174). The biogeographic population of razorbills with connectivity to UK waters is 1,707,000 (Furness, 2015). The number of individuals expected to die annually from this population is 297,018 (i.e. 1,707,000 x 0.174).

11.6.2.1.2.9.1 DEP

Table 11-68: Predicted Operational Phase Displacement and Mortality of Razorbill at DEP Year Round

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	10,325	31 - 723 (52)	0.03 - 0.70 (0.05)	0.01 - 0.24 (0.02)
Mean	5,829	17 - 408 (29)	0.02 - 0.40 (0.03)	0.01 - 0.14 (0.01)
Lower 95% CI	2,318	7 - 162 (12)	0.01 - 0.16 (0.01)	0.00 - 0.05 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (591,874 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
3. Background population is biogeographic population with connectivity to UK waters (1,707,000 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

295. Razorbill mortality on a year-round basis due to operational phase displacement at DEP is estimated to be 17 to 408 individuals, based on a mean peak abundance of

5,829 birds at the site (including 2km buffer), displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds (**Table 11-68**). This would increase the annual mortality of the BDMPS by 0.02% to 0.40% and would increase the annual mortality of the biogeographic population by 0.01% to 0.14%. Use of the upper 95% CI mean peak abundance in these calculations would increase the predicted mortality range to 31 to 723 individuals. This would represent a 0.03% to 0.70% increase in the annual mortality of the BDMPS, and a 0.01% to 0.24% increase in the annual mortality of the biogeographic population.

296. The predicted increase in existing mortality due to this impact (using either the mean or upper 95% CI) is very small to small, would not materially alter the baseline mortality of either the BDMPS or the biogeographic population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP on a year-round basis is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.9.2 SEP

Table 11-69: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP Year Round

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	3,077	9 - 215 (15)	0.01 - 0.21 (0.01)	0.00 - 0.07 (0.01)
Mean	1,904	6 - 133 (10)	0.01 - 0.13 (0.01)	0.00 - 0.04 (0.00)
Lower 95% CI	896	3 - 63 (4)	0.00 - 0.06 (0.00)	0.00 - 0.02 (0.00)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds; number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
2. Background population is UK North Sea and Channel BDMPS (591,874 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)
3. Background population is biogeographic population with connectivity to UK waters (1,707,000 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015); number in brackets assumes displacement rate of 0.500 and mortality rate of 1% (Vattenfall, 2019)

297. Razorbill mortality on a year-round basis due to operational phase displacement at SEP is estimated to be 6 to 133 individuals, based on a mean peak abundance of 1,905 birds at the site (including 2km buffer) and using the same displacement and mortality rates as for DEP. This would increase the annual mortality of the BDMPS by 0.01% to 0.13% and would increase the annual mortality of the biogeographic population by 0.00% to 0.04%. Use of the upper 95% CI mean peak abundance in these calculations would increase the predicted mortality range to 9 to 215 individuals. This would represent a 0.01% to 0.21% increase in the annual mortality of the BDMPS, and a 0.00% to 0.07% increase in the annual mortality of the biogeographic population.

298. The predicted increase in existing mortality due to this impact (using either the mean or upper 95% CI) is very small to small, would not materially alter the baseline mortality of either the BDMPS or the biogeographic population and would be

undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP on a year-round basis is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.9.3 SEP and DEP Combined

Table 11-70: Predicted Operational Phase Displacement and Mortality of Razorbill at SEP and DEP Combined Year Round

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	13,402	40 - 938 (67)	0.04 - 0.91 (0.07)	0.01 - 0.32 (0.02)
Mean	7,733	23 - 541 (39)	0.02 - 0.53 (0.04)	0.01 - 0.18 (0.01)
Lower 95% CI	3,214	10 - 225 (16)	0.01 - 0.22 (0.02)	0.00 - 0.08 (0.01)

Notes
1. Assumes displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (591,874 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015)
3. Background population is biogeographic population with connectivity to UK waters (1,707,000 individuals), all age class annual mortality rate of 17.4% (Horswill and Robinson, 2015)

299. Razorbill mortality on a year-round basis due to operational phase displacement at SEP and DEP combined is estimated to be 23 to 541 individuals, based on a mean peak abundance of 7,734 birds across the sites (including 2km buffers) and using the same displacement and mortality rates as for SEP and DEP separately. This would increase the annual mortality of the BDMPS by 0.02% to 0.53% and would increase the annual mortality of the biogeographic population by 0.01% to 0.18%. Use of the upper 95% CI mean peak abundance in these calculations would increase the predicted mortality range to 23 to 541 individuals. This would represent a 0.04% to 0.91% increase in the annual mortality of the BDMPS, and a 0.01% to 0.32% increase in the annual mortality of the biogeographic population.

300. The predicted increase in existing mortality due to this impact (using either the mean or upper 95% CI) is very small to small, would not materially alter the baseline mortality of either the BDMPS or the biogeographic population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP (combined) on a year-round basis is assessed as negligible. As razorbill is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.2.10 Summary and Confidence Assessment

301. Overall, the impact significance for breeding season, spring and autumn migration, winter and year round razorbill displacement during the operational phase of SEP and DEP combined is **minor adverse**.

302. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. A comparison between the encounter rates of this species within the different

parts of DEP indicated that year round, the encounter rate for this species from the raw baseline survey data was 12.6% higher at DEP-N than DEP as a whole. However, in the event that all of DEP's turbines were installed at DEP-N, the footprint of the OWF would be smaller than if turbines were installed across all of DEP, thereby resulting in smaller impacts than those presented here. Therefore, the assessment presented represents a suitably precautionary approach.

303. The confidence in the assessment is high. The evidence used to set the displacement rates presented at the start of this section is of high applicability and quality, and suggests far lower impacts than the upper end of the displacement and mortality ranges suggested by Natural England, which themselves may be undetectable in the context of existing mortality amongst the wider population. Whilst there is limited available evidence to inform mortality rates, 1% is considered to be sufficiently precautionary based on expert opinion. Finally, the conclusion of the assessment is the same irrespective of whether the mean or upper 95% CI mean peak abundances are used to calculate potential mortality.

11.6.2.1.3 Red-Throated Diver

304. Red-throated divers have a very high sensitivity to disturbance and displacement from operational OWFs. In addition to the information on the potential sensitivity of this species to operational displacement by OWFs included in the literature referred to in **Section 11.6.2.1**, a large body of work investigating the effects of displacement of red-throated divers due to operational OWFs exists (Dorsch *et al*., 2020; Elston *et al*., 2016; Gill *et al*., 2018; Heinänen and Skov, 2018; Hi Def Aerial Surveying, 2017; Irwin *et al*., 2019; MacArthur Green and Royal HaskoningDHV, 2021a; McGovern *et al*., 2016; Mendel *et al*., 2019; NIRAS Consulting, 2016; Percival, 2014; Percival and Ford, 2017; Petersen *et al*., 2006, 2014; Vilela *et al*., 2020; Welcker and Nehls, 2016).

305. There is a high degree of concordance of the available literature with respect to effects of operation of OWFs on red-throated diver distribution and abundance within OWFs. The majority of birds present before OWFs are constructed are displaced by the operation of OWFs. It is expected (based on expert opinion), that this is due to a combination of anthropogenic activities (mainly vessel movements), as well as the presence of OWF infrastructure. Of these, the latter is considered to exert a greater effect. There is evidence from a minority of studies that indicates habituation could occur, but based on expert opinion, it is presumed that at least in the first few years of operation, this would not be considered a typical response. Very little evidence exists either for or against the potential for habituation to operational OWFs beyond this period, although Leopold and Verdaat (2018) provides some evidence suggesting that some birds may habituate to OWFs over time.

306. There is also a high degree of concordance that displacement effects extend beyond OWF boundaries. However, there is considerable variation with respect to the distance at which this effect remains detectable. Whether this is due to genuine variability in effects, or if effects were masked or not detected for other reasons (for example if study areas were too small, or effects were confounded by environmental variables) is unknown. Studies within the UK have ranged from no significant displacement effects being reported (McGovern *et al*., 2016), displacement effects

being restricted to 1km to 2km of an OWF (NIRAS Consulting, 2016; Percival, 2014; Percival and Ford, 2017), to clear displacement effects across many years. These effects have been estimated, using modelling, to extend to 7km from OWFs (MacArthur Green and Royal HaskoningDHV, 2021a), 9km from OWFs (Elston *et al*., 2016; Hi Def Aerial Surveying, 2017), and beyond, though not all evidence was available to be referenced by this assessment. Studies from other countries have also recorded variable displacement distances, ranging from 1.5km to 2km (Welcker and Nehls, 2016) to 10km and beyond (Dorsch *et al*., 2020; Vilela *et al*., 2020). Displacement effects were detectable up to 20km from OWFs in one case.

307. There is also concordance in the studies reviewed that displacement effects on red-throated diver due to operational OWFs occur on a gradient, with the strongest effects observed either within, or close to OWFs. As the distance from the OWF increases, the magnitude of the effect reduces, until a distance is reached at which the effect is no longer detectable.

308. No study to date has managed to provide insight into whether changes in red-throated diver distribution at any spatial scale have the potential to result in population level effects, either at local, regional, national or international levels. Red-throated divers are capable of utilising a range of marine habitats and prey species (Dierschke *et al*., 2017; Guse *et al*., 2009; Kleinschmidt *et al*., 2016). Recent data from the Outer Thames Estuary SPA indicate that birds are much more commonly recorded in water depths of less than 20m (Irwin *et al*., 2019). During the non-breeding season, red-throated divers are mostly widely dispersed, at densities often less than four birds per km^2 (Dierschke *et al*., 2017), and are highly mobile (Dorsch *et al*., 2020; Duckworth *et al*., 2020). In some instances, home ranges of many thousands of square kilometres have been demonstrated (Nehls *et al*., 2018). This implies that following displacement, red-throated divers will be able to find alternative foraging sites, in some cases distant from the original area of displacement, which may already have been part of their existing non-breeding season range. It seems likely that in the vast majority of cases, mortality is not a consequence of displacement.

309. It has been suggested that in some circumstances, increased energetic requirements may be a consequence of birds being displaced by OWFs (Dierschke *et al*., 2017), though there is no evidence to support this. The wide-ranging nature of red-throated divers during the non-breeding season (independent of displacement) and apparent variability of behaviour between individuals and years (and even within years) means that there is considerable difficulty in reaching definitive conclusions on this effect. As well as the above possibilities, birds could experience no effects if displaced into equally good habitat so that their energy budget is unaffected.

310. A project to investigate the foraging activity and energy budgets of red-throated divers in the non-breeding season has been established by JNCC and partners (O'Brien *et al*., 2018). Results to date have been reported in Duckworth *et al*. (2020). Red-throated divers which breed in Scotland, Iceland and Finland spent about three to five hours per day foraging during the non-breeding season, showing no substantial changes with season (Duckworth *et al*., 2020). While an estimation of the energy budgets of these birds has not yet been reported, the data suggest that the birds were not subject to any severe foraging bottleneck during winter, and seem

likely to have had the capacity to buffer against additional energetic expenses by increasing time spent foraging.

311. Energetic consequences of displacement might also occur if displaced red-throated divers move into habitats where conspecifics are already present, resulting in increased competition or interference for prey, with the potential for reduced energy intake. No evidence of population-level effects due to OWF displacement were noted in the German Bight (Vilela *et al*., 2021), indicating that this may not occur at all, at least in certain situations.

312. Natural England has previously advised other OWF projects that for the assessment of red-throated diver operational displacement, a displacement rate of 1.000 within the OWF and 4km buffer and a mortality rate of up to 10% for displaced birds is used. However, during the baseline surveys, when SOW and DOW were both operational, red-throated divers were observed within 4km of both OWFs (**Appendix 11.1 Offshore Ornithology Technical Report**). This indicates that the suggestion of 1.000 displacement within this distance of these OWFs is an overestimate in this case. This was also the case at the London Array OWF, where displacement within the OWF was estimated at 0.550 (APEM, 2021).

313. MacArthur Green (2019b) recommended a precautionary rate of 0.900 displacement and 1% mortality from an OWF and 4km buffer based on a detailed review of available evidence, and this is considered to be a more realistic but still precautionary assumption. For context, the published annual mortality rate for all age classes of red-throated diver is 22.8% (Horswill and Robinson (2015), **Table 11-17**); this represents mortality from a wide range of sources such as prey availability driven by climate change and fisheries activities, bycatch, predation, displacement by other anthropogenic activities such as shipping, oil and gas, aggregate extraction and military activity, and pollution (both one off events such as oil spills, and chronic pollution by microplastics and other substances), as well as birds that die of natural causes. It seems unrealistic to assume that OWF displacement will increase the overall annual mortality by approximately 50% given the wide range of other pressures and sources of mortality that exist for this species.

314. The assessment follows the advice given by Natural England, but the evidence provided above is also used when drawing conclusions based on displacement and mortality rates.

11.6.2.1.3.1 Autumn Migration

315. The UK North Sea BDMPS is considered to be the relevant background population for red-throated diver during the spring and autumn migration seasons (Furness, 2015). At the published baseline annual mortality for this species averaged across all age classes (22.8%; **Table 11-17**), the number of red-throated divers expected to die annually that are members of this population is 3,027 (i.e. 13,277 x 0.228).

11.6.2.1.3.1.1 DEP

Table 11-71: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at DEP During the Autumn Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	59	1 - 6	0.02 - 0.19
Mean	31	1 - 3	0.01 - 0.10
Lower 95% CI	8	0 - 1	0.00 - 0.02
Notes 1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds 2. Background population is UK North Sea BDMPS (13,277 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)			

316. Red-throated diver mortality during the autumn migration season due to operational phase displacement from DEP is estimated to be 1 to 3 individuals annually, based on a mean peak abundance of 31 birds at the site and 4km buffer, a displacement rate of 1.000 and mortality rates of 1% to 10% (**Table 11-71**). This increases the annual mortality of the UK North Sea BDMPS population by 0.01% to 0.10%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.02% to 0.19%.

317. The predicted increase in existing mortality due to this impact is small, and at the higher end seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the autumn migration season is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.1.2 SEP

Table 11-72: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at SEP During the Autumn Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	137	1 - 14	0.05 - 0.45
Mean	75	1 - 8	0.02 - 0.25
Lower 95% CI	30	1 - 3	0.01 - 0.10
Notes 1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds 2. Background population is UK North Sea BDMPS (13,277 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)			

318. At SEP, red-throated diver mortality during the autumn migration season due to operational displacement is estimated to be 1 to 8 individuals annually, based on a mean peak abundance of 75 birds at the site and 4km buffer, a displacement rate

of 1.000 and mortality rates of 1% to 10% (**Table 11-72**). Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea BDMPS population by 0.02% to 0.25%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.05% to 0.45%.

319. The predicted increase in existing mortality due to this impact is small, and at the higher end seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the autumn migration season is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.1.3 SEP and DEP Combined

Table 11-73: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at SEP and DEP Combined During the Autumn Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	196	2 - 20	0.09 - 0.65
Mean	106	1 - 11	0.04 - 0.35
Lower 95% CI	37	0 - 4	0.01 - 0.12

Notes
1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds
2. Background population is UK North Sea BDMPS (13,277 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

320. When combined, operational displacement impacts at SEP and DEP during the autumn migration season could result in the mortality of between 1 and 11 red-throated divers annually (**Table 11-73**). This is based on a mean peak abundance of 130 birds at both sites and 4km buffers, a displacement rate of 1.000 and mortality rates of 1% to 10%. Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea BDMPS population by 0.04% to 0.35%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.09% to 0.65%.

321. The predicted increase in existing mortality due to this impact is small, and at the higher end seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. It is also considered that the use of the upper 95% CI mean peak for the combined impact assessment of SEP and DEP is overly precautionary. The mean peak value itself is considered precautionary, and the probability of the upper 95% CI mean peak abundance occurring at both SEP and DEP is very small. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore,

the magnitude of effect of operational displacement at SEP and DEP combined during the autumn migration season is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.2 Winter

322. The SW North Sea BDMPS is considered to be the relevant background population for red-throated diver during the winter season (Furness, 2015). At the published baseline annual mortality for this species averaged across all age classes (22.8%; **Table 11-17**), the number of red-throated divers expected to die that are members of this population (**Appendix 11.1 Offshore Ornithology Technical Report**) is 2,320 (i.e. 10,177 x 0.228).

11.6.2.1.3.2.1 DEP

Table 11-74: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at DEP During the Winter Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	15	0 - 2	0.01 - 0.07
Mean	5	0 - 1	0.00 - 0.02
Lower 95% CI	0	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds
2. Background population is SW North Sea BDMPS (10,177 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

323. Red-throated diver mortality during the winter season due to operational phase displacement from DEP is estimated to be 0 to 1 individuals annually, based on a mean peak abundance of 10 birds at the site and 4km buffer, a displacement rate of 1.000 and mortality rates of 1% to 10% (**Table 11-74**). This increases the annual mortality of the SW North Sea BDMPS population by 0.00% to 0.02%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.01% to 0.07%.

324. The predicted increase in existing mortality due to this impact is very small, and at the higher end seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the winter season is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.2.2 SEP

Table 11-75: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at SEP During the Winter Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	15	0 - 2	0.01 - 0.06
Mean	5	0 - 1	0.00 - 0.02
Lower 95% CI	0	0 - 0	0.00 - 0.00
Notes 1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds 2. Background population is SW North Sea BDMPS (10,177 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)			

325. At SEP, red-throated diver mortality during the winter season due to operational displacement is estimated to be 0 to 1 individuals annually, based on a mean peak abundance of 5 birds at the site and 4km buffer, a displacement rate of 1.000 and mortality rates of 1% to 10% (**Table 11-75**). This increases the annual mortality of the SW North Sea BDMPS population by 0.00% to 0.02%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.01% to 0.06%.

326. The predicted increase in existing mortality due to this impact is very small, and at the higher end seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the winter season is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.2.3 SEP and DEP Combined

Table 11-76: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at SEP and DEP Combined During the Winter Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	30	0 - 3	0.02 - 0.13
Mean	10	0 - 1	0.01 - 0.04
Lower 95% CI	0	0 - 0	0.00 - 0.00
Notes 1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds 2. Background population is SW North Sea BDMPS (10,177 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)			

327. When combined, operational displacement impacts at SEP and DEP during the winter season could result in the mortality of between 0 and 1 red-throated divers annually (**Table 11-76**). This is based on a mean peak abundance of 10 birds at

both sites and 4km buffers, a displacement rate of 1.000 and mortality rates of 1% to 10%. Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea BDMPS population by 0.01% to 0.04%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.02% to 0.13%.

328. The predicted increase in existing mortality due to this impact is small, and at the higher end seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. It is also considered that the use of the upper 95% CI mean peak for the combined impact assessment of SEP and DEP combined is overly precautionary. The mean peak value itself is considered precautionary, and the probability of the upper 95% CI mean peak abundance occurring at both SEP and DEP is very small. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP combined during the autumn migration season is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.3 Spring Migration

329. The UK North Sea BDMPS is considered to be the relevant background population for red-throated diver during the spring and autumn migration seasons (Furness, 2015). At the published baseline annual mortality for this species averaged across all age classes (22.8%; **Table 11-17**), the number of red-throated divers expected to die annually that are members of this population is 3,027 (i.e. 13,277 x 0.228).

11.6.2.1.3.3.1 DEP

Table 11-77: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at DEP During the Spring Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	76	1 - 8	0.03 - 0.25
Mean	54	1 - 5	0.02 - 0.18
Lower 95% CI	33	0 - 3	0.01 - 0.11

Notes
1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds
2. Background population is UK North Sea BDMPS (13,277 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

330. Red-throated diver mortality during the spring migration season due to operational phase displacement from DEP is estimated to be 1 to 5 individuals annually, based on a mean peak abundance of 54 birds at the site and 4km buffer, a displacement rate of 1.000 and mortality rates of 1% to 10% (**Table 11-77**). This increases the annual mortality of the UK North Sea BDMPS population by 0.02% to 0.18%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.03% to 0.25%.

331. The predicted increase in existing mortality due to this impact is small, and at the higher end seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the spring migration season is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.3.2 SEP

Table 11-78: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at SEP During the Spring Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	463	5 - 46	0.15 - 1.53
Mean	191	2 - 19	0.06 - 0.63
Lower 95% CI	29	0 - 3	0.01 - 0.10

Notes
1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds
2. Background population is UK North Sea BDMPS (13,277 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

332. At SEP, red-throated diver mortality during the spring migration season due to operational displacement is estimated to be 2 to 19 individuals annually, based on a mean peak abundance of 191 birds at the site and 4km buffer, a displacement rate of 1.000 and mortality rates of 1% to 10% (**Table 11-78**). Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea BDMPS population by 0.06% to 0.63%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.15% to 1.53%. This high upper 95% CI value was heavily influenced by the results of a single survey in March 2019.

333. Despite this, the predicted increase in existing mortality due to this impact when the peak mean abundance is considered is still small. At the higher end of the range it is considered that mortality is overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the spring migration season is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.3.3 SEP and DEP Combined

Table 11-79: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at SEP and DEP Combined During the Spring Migration Season

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	539	5 - 54	0.18 - 1.78
Mean	245	2 - 25	0.08 - 0.81
Lower 95% CI	62	1 - 6	0.02 - 0.20

Notes
1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds
2. Background population is UK North Sea BDMPS (13,277 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

334. When combined, operational displacement impacts at SEP and DEP during the spring migration season could result in the mortality of between 2 and 25 red-throated divers annually (**Table 11-79**). This is based on a mean peak abundance of 245 birds at both sites and 4km buffers, a displacement rate of 1.000 and mortality rates of 1% to 10%. Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea BDMPS population by 0.08% to 0.81%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.18% to 1.78%. This high upper 95% CI value was heavily influenced by the results of a single survey in March 2019 at SEP.

335. Despite this, the predicted increase in existing mortality due to this impact when the peak mean abundance is considered is still small. At the higher end of the range it is considered that mortality is overestimated, as a 10% mortality rate due to this impact is very high and lacks the evidence to support it. It is also considered that the use of the upper 95% CI mean peak for the combined impact assessment of SEP and DEP is overly precautionary. The mean peak value itself is considered precautionary, and the probability of the upper 95% CI mean peak abundance occurring at both SEP and DEP is very small. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP combined during the spring migration season is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.4 Year Round

336. The UK North Sea BDMPS (spring and autumn migration seasons) is the largest background population for red-throated diver (Furness, 2015). This is the appropriate background population to place year round displacement impacts of SEP and DEP into context. At the published baseline annual mortality for this species averaged across all age classes (22.8%; **Table 11-17**), the number of red-throated divers expected to die annually that are members of this population is 3,027 (i.e. 13,277 x 0.228).

337. The biogeographic population of red-throated divers with connectivity to UK waters is 27,000 (Furness, 2015). The number of individuals expected to die annually from this population is 6,156 (i.e. 27,000 x 0.228).

11.6.2.1.3.4.1 DEP

Table 11-80: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at DEP Year Round

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	150	2 - 15	0.05 - 0.50	0.02 - 0.24
Mean	90	1 - 9	0.03 - 0.30	0.01 - 0.15
Lower 95% CI	40	0 - 4	0.01 - 0.13	0.01 - 0.06

Notes
1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds
2. Background population is UK North Sea BDMPS (13,277 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)
3. Background population is biogeographic population of red-throated divers with connectivity to UK waters (27,000), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

338. Year round red-throated diver mortality due to operational phase displacement from DEP is estimated to be 1 to 9 individuals annually, based on a mean peak abundance of 90 birds at the site and 4km buffer, a displacement rate of 1.000 and mortality rates of 1% to 10% (**Table 11-80**). This increases the annual mortality of the UK North Sea BDMPS population by 0.03% to 0.30%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.05% to 0.50%. Mortality rate increases for the biogeographic population are around half of that calculated for the UK North Sea BDMPS population.

339. The predicted increase in existing mortality due to this impact is small, and at the higher end seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of year round operational displacement at DEP is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.4.2 SEP

Table 11-81: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at SEP Year Round

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	615	6 - 61	0.20 - 2.03	0.10 - 1.00
Mean	271	3 - 27	0.09 - 0.90	0.04 - 0.44

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Lower 95% CI	59	1 - 6	0.02 - 0.19	0.01 - 0.10

Notes
1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds
2. Background population is UK North Sea BDMPS (13,277 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)
3. Background population is biogeographic population of red-throated divers with connectivity to UK waters (27,000), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

340. At SEP, year round red-throated diver mortality due to operational displacement is estimated to be 3 to 27 individuals annually, based on a mean peak abundance of 271 birds at the site and 4km buffer, a displacement rate of 1.000 and mortality rates of 1% to 10% (**Table 11-81**). Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea BDMPS population by 0.09% to 0.90%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.20% to 2.03%. Mortality rate increases for the biogeographic population are around half of that calculated for the UK North Sea BDMPS population.

341. The predicted increase in existing mortality due to this impact is small, and at the higher end seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of year round operational displacement at SEP is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.4.3 SEP and DEP Combined

Table 11-82: Predicted Operational Phase Displacement and Mortality of Red-Throated Diver at SEP and DEP Combined Year Round

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]	% background population annual mortality increase[3]
Upper 95% CI	765	8 - 76	0.25 - 2.53	0.12 - 1.24
Mean	361	4 - 36	0.12 - 1.19	0.06 - 0.59
Lower 95% CI	99	1 - 10	0.03 - 0.33	0.02 - 0.16

Notes
1. Assumes displacement rate of 1.000 and mortality rates of 1% to 10% of displaced birds
2. Background population is UK North Sea BDMPS (13,277 individuals), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)
3. Background population is biogeographic population of red-throated divers with connectivity to UK waters (27,000), all age class annual mortality rate of 22.8% (Horswill and Robinson, 2015)

342. When combined, year round operational displacement impacts at SEP and DEP could result in the mortality of between 4 and 36 red-throated divers annually (**Table 11-82**). This is based on a mean peak abundance of 361 birds at both sites and 4km

buffers, a displacement rate of 1.000 and mortality rates of 1% to 10%. Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea BDMPS population by 0.12% to 1.24%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population of 0.25% to 2.53%. Mortality rate increases for the biogeographic population are around half of that calculated for the UK North Sea BDMPS population.

343. The predicted increase in mortality due to this impact at the higher end of the those presented seems likely to be overestimated. This is because a mortality rate of 10% due to this impact is considered to be very high. This is almost half of the published annual mortality for adult red-throated diver, and there is no evidence to support its use in this context. It is also considered that the use of the upper 95% CI mean peak for the combined impact assessment of SEP and DEP is overly precautionary. The mean peak value itself is considered precautionary, and the probability of the upper 95% CI mean peak abundance occurring at both SEP and DEP is very small. The predicted impacts would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of year round operational displacement at SEP and DEP combined is assessed as negligible. As red-throated diver is considered to be of high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.5 Assessment of Other Data Sources

344. Red-throated diver displacement has been shown by many studies to occur beyond 4km from OWF boundaries. This means that the baseline survey data collected to characterise SEP and DEP cannot be used to evaluate the potential for such effects, as this is the limit of its spatial extent.

345. Red-throated diver distribution within 12km of SEP and DEP, and potential impacts out to this distance from each OWF, has been investigated by assessment of Density Surface Models (DSM) from two sources (Bradbury *et al*., 2014; Lawson *et al*., 2016). This buffer distance was selected on the basis of advice given by Natural England to the East Anglia ONE North and TWO projects. Initial investigations showed that the 12km buffer of both SEP and DEP was not completely covered by the DSM of Lawson *et al*. (2016). This dataset was therefore excluded from further analysis.

346. For this analysis, two DSMs were used; one describing seabird densities in 3x3km squares using both boat-based surveys (named “BDMPS Non Breeding Boat Sitting Plus Flying DSM D”, the other using visual aerial surveys (named “BDMPS Non Breeding Aerial Sitting Plus Flying DSM D”. The survey data used to produce these DSMs were Wildfowl and Wetlands Trust (WWT) visual aerial survey data collected between 2001 and 2011, and JNCC European Seabirds At Sea (ESAS) boat-based survey data collected between 1979 and 2011. Data used to produce the models for red-throated diver were collected during the non-breeding season (September to February). It was not possible to subdivide this dataset further into smaller seasons. Further details of the models are available in Bradbury *et al*. (2014) and WWT Consulting (2015).

347. Using a GIS, both DSMs were clipped to only include the extent of the dataset of SEP, DEP, and a 12km buffer from both OWFs. Red-throated diver abundance in each cell within the area of interest was calculated by multiplying the modelled density estimate by the area of the clipped cell.

11.6.2.1.3.5.1 Non-breeding

348. At the published baseline annual mortality for this species averaged across all age classes (22.8%; **Table 11-17**), the number of red-throated divers expected to die from the largest BDMPS population (the UK North Sea and Channel BDMPS spring and autumn migration seasons) (**Appendix 11.1 Offshore Ornithology Technical Report**) is 3,027 (i.e. 13,277 x 0.228).

DEP

349. The DSM based on visual aerial survey data suggested that within DEP and its 12km buffer, 0.41 birds would be expected to occur, whilst the DSM that used boat-based survey data indicated that 7.06 birds would be expected to occur within the same area. The larger value has been used to estimate potential displacement mortality.

350. Assuming 100% displacement and 1% to 10% mortality rates of birds within the OWF and 12km buffer, the predicted annual mortality would be between 0.07 and 0.7 birds. This would increase the mortality within the UK North Sea and Channel BDMPS by 0.002% to 0.02%. This is not considered to represent a material change in the background mortality of the population and would be undetectable in the context of natural variation. The use of biologically realistic predictions of displacement (i.e. decreasing displacement with distance from the OWF) would result in considerably smaller increases in mortality being predicted.

351. Therefore, the magnitude of effect of operational displacement on red-throated diver out to 12km based on the DSM of Bradbury *et al*. (2014) is assessed as negligible. As red-throated diver is considered to possess a high sensitivity to disturbance, the impact significance is **minor adverse**.

SEP

352. The DSM based on visual aerial survey data suggested that within SEP and its 12km buffer, 8.33 red-throated divers would be expected to occur. The DSM that used boat-based survey data indicated that 20.00 birds would be expected to occur within the same area. The larger value has been used to estimate potential displacement mortality.

353. Assuming 100% displacement and 1% to 10% mortality rates of birds within the OWF and 12km buffer, the predicted annual mortality would be between 0.2 and 2 birds. The loss of 2 birds would increase the mortality within the UK North Sea and Channel BDMPS by 0.07%. This predicted magnitude of increase in the annual mortality of the wider population would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. The use of biologically realistic predictions of displacement (i.e. decreasing displacement with distance from the OWF) would result in considerably smaller increases in mortality being predicted.

354. Therefore, the magnitude of effect of operational displacement on red-throated diver out to 12km from SEP and DEP, based on the DSM of Bradbury *et al*. (2014) is assessed as negligible. As red-throated diver is considered to possess a high sensitivity to disturbance, the impact significance is **minor adverse**.

SEP and DEP Combined

355. The DSM based on visual aerial survey data suggested that within SEP, DEP and a combined 12km buffer around both OWFs, 8.43 birds would be expected to occur. The DSM that used boat-based survey data indicated that 23.23 birds would be expected to occur within SEP, DEP and the 12km buffer around both Projects. The larger value has been used to estimate potential displacement mortality.

356. Assuming 100% displacement and 1% to 10% mortality rates of birds within the OWF and 12km buffer, the predicted annual mortality would be between 0.23 and 2.3 birds. The loss of 2.3 birds would increase the mortality within the UK North Sea and Channel BDMPS by 0.08%. This predicted magnitude of increase in the annual mortality of the wider population would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. The use of biologically realistic predictions of displacement (i.e. decreasing displacement with distance from the OWF) would result in considerably smaller increases in mortality being predicted.

357. Therefore, the magnitude of effect of operational displacement on red-throated diver out to 12km based on the DSM of Bradbury *et al*. (2014) is assessed as negligible. As red-throated diver is considered to possess a high sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.3.6 Summary and Confidence Assessment

358. The impact significance for autumn migration, winter, spring migration and year round red-throated diver displacement during the operational phase of SEP and DEP combined is **minor adverse**.

359. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. A comparison between the encounter rates of this species within the different parts of DEP indicated that year round, the encounter rate for this species from the raw baseline survey data was 15.1% higher at DEP-N than DEP as a whole, though the sample size of birds recorded in DEP as a whole (43 birds) was so small that differences between DEP-N and DEP-S are unlikely to be statistically significant. However, in the event that all of DEP's turbines were installed at DEP-N, the footprint of the OWF would be smaller than if turbines were installed across all of DEP, thereby resulting in smaller impacts than those presented here. Therefore, the assessment presented represents a suitably precautionary approach.

360. The evidence used to set the displacement rates presented at the start of this section is of high applicability and quality. Whilst there is limited available evidence to inform mortality rates, 10% is considered to represent an overly precautionary mortality rate, on the grounds that it represents almost half of the annual adult mortality rate for this species. At lower mortality rates, the conclusion of the

assessment is the same irrespective of whether the mean or 95% upper CI mean peak abundances are used to calculate potential mortality and increases in the baseline mortality rate of the background population. However, the baseline survey data do not cover the entire spatial extent across which impacts are possible. Whilst the area of marine habitat within 12km of SEP and DEP does not seem to be particularly important based on the assessment of existing data, the available information is not recent. The confidence in the assessment is therefore considered to be medium.

11.6.2.1.4 Sandwich tern

361. Much of the previous work on the potential sensitivity of Sandwich terns to OWFs has focused on the risk of collision. However, there is potential for operational phase disturbance and displacement effects to occur based on the evidence available, which is summarised below.

362. Cook *et al*. (2014) suggested a macro-avoidance rate of 0.28 for tern species around operational OWFs, which may have been informed by a generic macro-avoidance rate from a single study at a Dutch OWF (Krijgsveld *et al*., 2011). Harwood *et al*. (2018) calculated that in three years of operational monitoring, the reduction of Sandwich terns entering SOW relative to the baseline (i.e. prior to OWF construction) was between 0.31 and 0.42. It was also reported that effects seemed to be largely restricted to within the OWF array, with no evidence of effects reported beyond 500m of the OWF boundary. Tracking data collected during the DOW OMP indicates that the area around SOW is largely used for commuting between breeding sites and foraging grounds by Sandwich terns (**Appendix 11.1 Offshore Ornithology Technical Report**). It has also been established through the same data that birds engaging in commuting behaviour are more likely to be displaced than those undertaking foraging behaviour. Qualitative assessment of the utilisation distributions presented in the DOW OMP suggests a macro-avoidance rate of zero to 0.500 might be appropriate depending on the behaviour associated with a particular area (**Appendix 11.1 Offshore Ornithology Technical Report**).

363. Some evidence of operational displacement effects were detected at the LID/Lincs OWF. However, effects were small and inconsistent and were not quantified. Some comparisons also indicated that in some years, abundance of Sandwich terns within the OWFs actually increased (Hi Def Aerial Surveying, 2017).

364. Assessment of the model-based density estimates for Sandwich tern (**Appendix 11.1 Offshore Ornithology Technical Report**) indicates that during the baseline surveys for SEP and DEP, there was a potentially strong displacement effect at SOW (between 0.70 to 1.00 when compared with the area surrounding the OWF), and DOW (between 0.36 to 1.00 when compared with the area surrounding the OWF, though the OWF contained more birds than the surrounding area on two of the nine surveys included in the analysis). However, due to the relatively small numbers of birds involved, no statistical significance could be attached to these observations.

365. Based on the available literature, Sandwich tern is considered to possess a medium sensitivity to disturbance and displacement from operational OWFs. Confidence in this level of sensitivity is considered to be medium. Whilst evidence of relatively high

applicability and quality exists, the evidence base is small, indicates that exact impact magnitudes are site-specific, and can be variable.

366. Following guidance from SNCBs (UK SNCBs, 2017), mean peak abundance estimates for Sandwich tern have been used to produce displacement matrices. The spatial extent of this impact is considered to be the OWFs only (i.e. no buffers). This has been selected due to evidence put forward by Perrow *et al*. (2010) that displacement effects for this species are unlikely beyond 1km of an OWF boundary, and Harwood *et al*. (2018) that birds continued to use areas of sea directly adjacent to SOW after the OWF had become operational. The assessment has been performed using both design-based and model-based density estimates; the outputs from both are presented.

367. Based on the range of macro-avoidance rates presented by Cook *et al*. (2014), Harwood *et al*. (2018), the observations of the DOW OMP Sandwich tern tagging programme between 2016 and 2019, and the model-based density assessment of the aerial survey study area (**Appendix 11.1 Offshore Ornithology Technical Report**) displacement rates of 0.000 to 0.500 are considered appropriate for Sandwich tern. However, in areas of habitat where foraging is known to occur (for example the waters in and around DOW and DEP), this value might be towards the lower end of the range identified.

368. As the mortality level of Sandwich tern due to displacement by operational OWFs is currently not known, consideration of a range of mortality rates is appropriate.

369. Masden *et al*. (2010) investigated the potential energetic consequence of barrier effects by OWFs in a range of species, including common tern. The study suggested that costs of extra flight to avoid an operational OWF appear to be in the region of around 1% of their daily energy expenditure. It was noted that such increases are quite trivial when compared with those imposed by low food abundance or adverse weather, though they would be additive to those impacts. This suggests that any displacement or barrier effects that do occur on Sandwich terns from the North Norfolk Coast SPA may not result in detectable effects at the population level, and that low mortality rates (i.e. close to 1%) would represent a realistic worst-case scenario.

370. The published mortality rate for adult Sandwich terns is 10.2% (Horswill and Robinson, 2015) (**Table 11-17**), which is relevant given the assumption that all birds at SEP and DEP during this season are breeding adults. Logically, it seems reasonable to set the maximum displacement mortality below this level, as the overall mortality values result from a wide range of pressures in addition to OWF displacement (e.g. loss of breeding habitat, prey availability driven by climate change and fisheries activities, predation, collision with OWFs, displacement by OWFs and other anthropogenic activities such as shipping, oil and gas, aggregate extraction and military activity, and pollution (both one off events such as oil spills, and chronic pollution by microplastics and other substances), as well as birds that die of natural causes).

371. Based on this information, and the fact that no evidence exists to support a higher mortality rate, a mortality rate of 1% due to displacement from SEP and DEP is considered to be appropriate.

11.6.2.1.4.1 Autumn Migration

372. The UK North Sea and Channel BDMPS is considered to be the relevant background population for Sandwich tern during the autumn migration season (Furness, 2015). At the published baseline annual mortality for this species averaged across all age classes (24.0%; **Table 11-17**), the number of Sandwich terns expected to die annually that are members of the UK North Sea and Channel BDMPS (**Appendix 11.1 Offshore Ornithology Technical Report**) is 9,132 (i.e. 38,051 x 0.240).

11.6.2.1.4.1.1 DEP

Table 11-83: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at DEP During the Autumn Migration Season using Design-Based Density Estimates.

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	38	0 - 0	0.00 - 0.00
Mean	14	0 - 0	0.00 - 0.00
Lower 95% CI	0	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

Table 11-84: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at DEP During the Autumn Migration Season using Model-Based density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate[1]	Mortality range[2]	% background population annual mortality increase[3]
Upper 95% CI	41	0 - 0	0.00 - 0.00
Mean	17	0 - 0	0.00 - 0.00
Lower 95% CI	6	0 - 0	0.00 - 0.00

Notes
1. Model-based density estimates could only be produced for a single survey in this season. It is assumed that the other surveys would have returned counts of zero.
2. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
3. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

373. Sandwich tern mortality during the autumn migration season due to operational phase displacement from DEP is estimated to be zero individuals annually, based on a mean peak abundance of 17 (using the model-based approach) (**Table 11-84**), or 14 (using the design-based) (**Table 11-83**) birds at the site, displacement rates of 0.000 to 0.500 and a mortality rate of 1% **Table 11-83**. This increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a near identical increase in mortality of the background population.

374. The predicted increase in existing mortality due to this impact is very small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the autumn migration season is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.1.2 SEP

Table 11-85: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP During the Autumn Migration Season using Design-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	8	0 - 0	0.00 - 0.00
Mean	3	0 - 0	0.00 - 0.00
Lower 95% CI	0	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

Table 11-86: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP During the Autumn Migration Season using Model-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate[1]	Mortality range[2]	% background population annual mortality increase[3]
Upper 95% CI	10	0 - 0	0.00 - 0.00
Mean	4	0 - 0	0.00 - 0.00
Lower 95% CI	1	0 - 0	0.00 - 0.00

Notes
1. Model-based density estimates could only be produced for a single survey in this season. It is assumed that the other surveys would have returned counts of zero.
2. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
3. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

375. Sandwich tern mortality during the autumn migration season due to operational phase displacement from SEP is estimated to be zero individuals annually, based on a mean peak abundance of seven birds at the site when model-based density estimates are used or eight birds if design-based density estimates are used, displacement rates of 0.000 to 0.500 and a mortality rate of 1% (**Table 11-85** and Error! Reference source not found.**Table 11-86**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak also results in a predicted increase in mortality of the background population of <0.01%.

376. The magnitude of effect of operational displacement at SEP during the autumn migration season is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.1.3 SEP and DEP Combined

Table 11-87: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP and DEP Combined During the Autumn Migration Season using Design-Based Density Estimates.

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	46	0 - 0	0.00 - 0.00
Mean	17	0 - 0	0.00 - 0.00
Lower 95% CI	0	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

Table 11-88: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP and DEP Combined During the Autumn Migration Season using Model-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	51	0 - 0	0.00 - 0.00
Mean	21	0 - 0	0.00 - 0.00
Lower 95% CI	7	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

377. Sandwich tern mortality during the autumn migration season due to operational phase displacement from SEP and DEP combined is estimated to be 0 individuals annually, based on a mean peak abundance of 21 birds at the sites when model-based density estimates are used, or 17 birds if design-based density estimates are used, displacement rates of 0.000 to 0.500 and a mortality rate of 1% (**Table 11-87** and **Table 11-88**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%. Using the upper 95% CI mean peak abundance estimate in place of the mean peak results in a predicted increase in mortality of the background population that is nearly identical.

378. Therefore, during the autumn migration season, the magnitude of effect of operational displacement due to SEP and DEP combined is assessed as negligible. Sandwich tern has a medium sensitivity to disturbance, meaning that the impact significance is **minor adverse**.

11.6.2.1.4.2 Spring Migration

379. The UK North Sea and Channel BDMPS is considered to be the relevant background population for Sandwich tern during the spring migration season

(Furness, 2015). At the published baseline annual mortality for this species averaged across all age classes (24.0%; **Table 11-17**), the number of Sandwich terns expected to die annually that are members of the UK North Sea and Channel BDMPS (**Appendix 11.1 Offshore Ornithology Technical Report**) is 9,132 (i.e. 38,051 x 0.240).

11.6.2.1.4.2.1 DEP

380. At DEP (and the wider aerial survey study area), no Sandwich terns were recorded within the site during the spring migration season. Mortality due to operational displacement during this season is therefore estimated to be zero, since the predicted abundance of Sandwich tern in the aerial survey study area was zero, using both methods of density estimation. The magnitude of effect of operational displacement at DEP during the spring migration season is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.2.2 SEP

381. At SEP (and the wider aerial survey study area), no Sandwich terns were recorded within the site during the spring migration season. Mortality due to operational displacement during this season is therefore estimated to be zero, since the predicted abundance of Sandwich tern in the aerial survey study area was zero, using both methods of density estimation. The magnitude of effect of operational displacement at SEP during the spring migration season is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.2.3 SEP and DEP Combined

382. At SEP and DEP combined, Sandwich tern mortality during the spring migration season due to operational displacement is estimated to be zero, on the basis that no birds were recorded at SEP, DEP, or the aerial survey study area.

383. Therefore, the magnitude of effect of operational displacement at SEP and DEP combined on Sandwich tern during the spring migration season is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.3 Breeding

11.6.2.1.4.3.1 DEP

384. During the breeding season, the relevant background population is the breeding adult population of the North Norfolk Coast SPA (9,443 birds on average during 2018 and 2019, when the baseline surveys were carried out). Using the published adult mortality rate of 10.2% (**Table 11-17**), the number of birds expected to die annually from this population would be 963.

Table 11-89: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at DEP During the Breeding Season using Design-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	391	0 - 2	0.04 - 0.20
Mean	202	0 - 1	0.02 - 0.10
Lower 95% CI	79	0 - 0	0.01 - 0.04

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is North Norfolk Coast SPA (9,443 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015)

Table 11-90: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at DEP During the Breeding Season using Model-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	327	0 - 2	0.03 - 0.17
Mean	202	0 - 1	0.02 - 0.10
Lower 95% CI	122	0 - 1	0.01 - 0.06

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is North Norfolk Coast SPA (9,443 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015)

385. Sandwich tern mortality during the breeding season due to operational phase displacement from DEP is estimated to be 0 to 1 individuals annually, based on either a mean peak abundance of 202 birds at the site using design-based density estimation methods (**Table 11-89**), or 202 birds using model-based density estimation methods (**Table 11-90**). In both cases, displacement rates of 0.000 to 0.500 and a mortality rate of 1% were assumed. This increases the annual mortality of the North Norfolk Coast SPA breeding adult population by 0.02% to 0.10%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 0 to 2 individuals. This increases the annual mortality of the North Norfolk Coast SPA population by 0.04% to 0.20%, or 0.04% to 0.17% if the model-based densities are used.

386. The predicted increase in existing mortality due to this impact is small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP during the breeding season is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.3.2 SEP

Table 11-91: Predicted Operational Phase Displacement and mortality of Sandwich tern at SEP during the breeding season using design-based density estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	127	0 - 1	0.01 - 0.07
Mean	71	0 - 0	0.01 - 0.04
Lower 95% CI	21	0 - 0	0.00 - 0.01

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is North Norfolk Coast SPA (9,443 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015)

Table 11-92: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP During the Breeding Season using Model-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	147	0 - 1	0.02 - 0.08
Mean	102	0 - 1	0.01 - 0.05
Lower 95% CI	81	0 - 0	0.01 - 0.04

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is North Norfolk Coast SPA (9,443 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015)

387. Sandwich tern mortality during the breeding season due to operational phase displacement from SEP is estimated to be 0 individuals annually, based on a mean peak abundance of 77 birds at the site using design-based density estimation methods (**Table 11-91**), or 0 to 1 individuals annually, based on a mean peak abundance of 102 birds at the site using model-based density estimation methods (**Table 11-92**). In both cases, displacement rates of 0.000 to 0.500 and a mortality rate of 1% are assumed. This increases the annual mortality of the North Norfolk Coast SPA breeding adult population by 0.01% to up to 0.05%. The use of the upper 95% CI mean peak abundance in this calculation does not alter the predicted mortality range, though this does increase the annual mortality of the North Norfolk Coast SPA population by 0.02% to up to 0.08%.

388. The predicted increase in existing mortality due to this impact is small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP during the breeding season is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.3.3 SEP and DEP Combined

Table 11-93: Predicted Operational Phase Displacement And Mortality Of Sandwich Tern At Sep And Dep Combined During the Breeding Season Using Design-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	518	1 - 3	0.05 - 0.27
Mean	273	0 - 1	0.03 - 0.14
Lower 95% CI	100	0 - 1	0.01 - 0.05

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is North Norfolk Coast SPA (9,443 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015)

Table 11-94: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP and DEP Combined During the Breeding Season using Model-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	474	0 - 2	0.05 - 0.25
Mean	304	0 - 1	0.03 - 0.16
Lower 95% CI	203	0 - 1	0.02 - 0.11

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is North Norfolk Coast SPA (9,443 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015)

389. When combined, operational displacement impacts at SEP and DEP during the breeding season that were calculated using design-based density estimates (**Table 11-93**) will result in the mortality of 0 to 1 Sandwich terns annually, based on a mean peak abundance of 273 birds at both sites. This represents an increase of 0.03% to 0.14% of existing Sandwich tern mortality within the North Norfolk Coast SPA breeding adult population. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 1 to 3 individuals. This increases the annual mortality of the North Norfolk Coast SPA population by 0.05% to 0.27%.

390. When combined, operational displacement impacts at SEP and DEP during the breeding season that were calculated using model-based density estimates (**Table 11-94**) result in the mortality of 0 to 2 Sandwich terns annually, based on a mean peak abundance of 304 birds at both sites. This represents an increase of 0.03% to 0.16% of existing Sandwich tern mortality within the North Norfolk Coast SPA breeding adult population. The use of the upper 95% CI mean peak abundance in this calculation also results in a mortality range to 0 to 2 individuals. This increases the annual mortality of the North Norfolk Coast SPA population by 0.05% to 0.25%.

391. In both cases, the predicted increase in existing mortality due to this impact is small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation.

392. Therefore, during the breeding season, the magnitude of effect of operational displacement due to SEP and DEP combined is assessed as negligible. Sandwich tern has a medium sensitivity to disturbance, meaning that the impact significance is **minor adverse**.

11.6.2.1.4.4 Year Round

393. At the published baseline annual mortality for this species averaged across all age classes (24.0%; **Table 11-17**), the number of Sandwich terns expected to die from the largest UK North Sea and Channel BDMPS (the spring and autumn migration seasons) (**Appendix 11.1 Offshore Ornithology Technical Report**) is 9,132 (i.e. 38,051 x 0.240). The biogeographic population of Sandwich terns with connectivity to UK waters is 148,000 (Furness, 2015). The number of individuals expected to die annually from this population is 35,520 (i.e. 148,000 x 0.240).

11.6.2.1.4.4.1 DEP

Table 11-95: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at DEP Year Round using Design-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	429	0 -2	0.01 - 0.03
Mean	216	0 - 1	0.00 - 0.01
Lower 95% CI	79	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

Table 11-96: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at DEP Year Round using Model-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	368	0 - 2	0.00 - 0.02
Mean	219	0 - 1	0.00 - 0.01
Lower 95% CI	128	0 - 1	0.00 - 0.01

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

394. Using the design-based density estimates, annual Sandwich tern mortality due to operational phase displacement from DEP is estimated to be 0 to 1 individuals annually, based on a summed mean peak abundance across all relevant seasons of 216 birds at the site, displacement rates of 0.000 to 0.500 and a mortality rate of

1% (**Table 11-95**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.00% to 0.01%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 1 to 3 individuals. This increases the annual mortality of the North Norfolk Coast SPA population by 0.01% to 0.03%.

395. Using the model-based density estimates, Annual Sandwich tern mortality due to operational phase displacement from DEP is estimated to be 0 to 1 individuals annually, based on a summed mean peak abundance across all relevant seasons of 219 birds at the site, displacement rates of 0.000 to 0.500 and a mortality rate of 1% (**Table 11-96**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.00% to 0.01%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 0 to 2 individuals. This increases the annual mortality of the North Norfolk Coast SPA population by 0.00% to 0.02%.

396. In both cases, the predicted increase in existing mortality due to this impact is very small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at DEP year round is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.4.2 SEP

Table 11-97: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP Year Round using Design-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	135	0 - 1	0.00 - 0.01
Mean	74	0 - 0	0.00 - 0.00
Lower 95% CI	21	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

Table 11-98: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP Year Round using Model-Based Density Estimates

Mean peak abundance estimate type	Mean peak abundance estimate	Mortality range[1]	% background population annual mortality increase[2]
Upper 95% CI	157	0 - 1	0.00 - 0.01
Mean	106	0 - 1	0.00 - 0.01
Lower 95% CI	82	0 - 0	0.00 - 0.00

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

397. Using the design-based density estimates, annual Sandwich tern mortality due to operational phase displacement from SEP is estimated to be <1 individual annually, based on a summed mean peak abundance across all relevant seasons of 74 birds at the site, displacement rates of 0.000 to 0.500 and a mortality rate of 1% (**Table 11-97**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 0 to 1 individuals. This increases the annual mortality of the North Norfolk Coast SPA population by 0.00% to 0.01%. The use of model-based density estimates in these calculations produces a very similar outcome (**Table 11-98**).

398. The predicted increase in existing mortality due to this impact is very small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP year round is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.4.3 SEP and DEP Combined

Table 11-99: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP and DEP Combined Year Round using Design-Based Density Estimates

Mean Peak Abundance Estimate Type	Mean Peak Abundance Estimate	Mortality Range[1]	% Background Population Annual Mortality Increase Range[2]
Upper 95% CI	564	1 - 3	0.01 - 0.03
Mean	290	0 - 1	0.00 - 0.02
Lower 95% CI	100	0 - 1	0.00 - 0.01

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

Table 11-100: Predicted Operational Phase Displacement and Mortality of Sandwich Tern at SEP and DEP Combined Year Round using Model-Based Density Estimates

Mean Peak Abundance Estimate Type	Mean Peak Abundance Estimate	Mortality Range[1]	% Background Population Annual Mortality Increase Range[2]
Upper 95% CI	525	1 - 3	0.01 - 0.03
Mean	325	0 - 2	0.00 - 0.02
Lower 95% CI	210	0 - 1	0.00 - 0.01

Notes
1. Assumes displacement rates of 0.000 to 0.500 and mortality rate of 1% of displaced birds
2. Background population is UK North Sea and Channel BDMPS (38,051 individuals), all age class annual mortality rate of 24.0% (Horswill and Robinson, 2015)

399. Using the design-based density estimates, annual Sandwich tern mortality due to operational phase displacement from SEP and DEP combined is estimated to be 0 to 1 individuals annually, based on a summed mean peak abundance across all relevant seasons of 290 birds at the site, displacement rates of 0.000 to 0.500 and a mortality rate of 1% (**Table 11-99**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.00% to 0.02%. The use of the upper 95% CI mean peak abundance in this calculation increases the mortality range to 1 to 3 individuals. This increases the annual mortality of the North Norfolk Coast SPA population by 0.01% to 0.03%. The use of model-based density estimates in these calculations produces a very similar outcome, though a maximum of two birds are predicted to die each year (**Table 11-100**).

400. The increase in mortality is very small, would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement at SEP and DEP combined year round is assessed as negligible. As Sandwich tern is considered to be of medium sensitivity to disturbance, the impact significance is **minor adverse**.

11.6.2.1.4.5 Summary and Confidence Assessment

401. The impact significance for autumn migration, spring migration, breeding season and year round Sandwich tern displacement during the operational phase of SEP and DEP combined is **minor adverse**.

402. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. A comparison between the encounter rates of this species within the different parts of DEP indicated that year round, the encounter rate for this species from the raw baseline survey data was 22.1% higher at DEP-N than DEP as a whole. This compares to a value of 16.5% calculated from the model-based density estimates that were produced for these species, though the differences are unlikely to be statistically significant, based on assessment of data presented in **Appendix 11.1 Offshore Ornithology Technical Report**. However, in the event that all of DEP's turbines were installed at DEP-N, the footprint of the OWF would be smaller than if turbines were installed across all of DEP, thereby resulting in smaller impacts than those presented here. Therefore, the assessment presented represents a suitably precautionary approach.

403. The confidence in the assessment is high for several reasons. Firstly, the evidence used to set the displacement rates presented at the start of this section is of high applicability and quality. Whilst there is limited available evidence to inform mortality rates, 1% is considered to be sufficiently precautionary based on expert opinion. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI mean peak abundances are used to calculate potential mortality and increases in the baseline mortality rate of the background population.

11.6.2.2 Impact 4: Collision Risk

11.6.2.2.1 Introduction

404. During the operational phase, offshore ornithology receptors flying through SEP and DEP may collide with the rotor blades of operational wind turbines. This would result in fatalities during migration, whilst foraging, or commuting between breeding sites and resting or foraging areas.

405. CRM (Band, 2012) has been used to estimate the theoretical collision risk to relevant offshore ornithology receptors flying through SEP and DEP when operational, both across biological seasons and annually. This focuses on birds recorded during the baseline surveys of SEP and DEP, and is detailed in **Section 11.6.2.2.2**.

406. Separately, an investigation into the theoretical collision risk posed by SEP and DEP to a range of migratory species recorded either infrequently, or in most cases not at all, by the baseline surveys was performed using the Strategic Ornithological Support Services Migration Assessment Tool (SOSSMAT) (Wright *et al*., 2012). This is presented in **Section 11.6.2.2.3**.

11.6.2.2.2 Band Model CRM

11.6.2.2.2.1 Overview

407. The approach to CRM is summarised here and further details are provided in **Appendix 11.1 Offshore Ornithology Technical Report**. On the basis of advice provided by Natural England (**Table 11-1**), deterministic CRM has been utilised. However, for each species screened into the assessment, multiple instances of CRM have been carried out in order to incorporate uncertainty around key parameter estimates. These parameters are monthly bird density, flight height, and where applicable, avoidance rate and nocturnal activity.

11.6.2.2.2.2 Band Model CRM Inputs

11.6.2.2.2.2.1 OWF Inputs

408. The OWF parameters that have been incorporated into the CRM are presented in **Table 11-2**. The mean annual rotation speed is approximately 12% greater than the rotation speed in the generic bird breeding season (April to August). During this period, this means that collision rates are overestimated by approximately 1.5%.

409. The proportion of time that turbines are operational by month, due to wind availability, is presented in **Table 11-3**. It should be noted that a further 2% to 3% of downtime over the lifetime of both OWFs would be anticipated due to operation and maintenance activities. This may occur either inside or outside the period when turbines are not turning due to wind resource constraints. This has not been factored into CRM, so the models assume no downtime other than that resulting from lack of wind resource.

410. In total therefore, monthly collision impacts may be overestimated by 0% to 3% between September to February, and 1.5% to 4.5% between April and August due to these parameters.

11.6.2.2.2.2.2 Baseline Survey Densities

411. The mean densities and 95% CIs of birds in flight within SEP and DEP were calculated as described in **Appendix 11.1 Offshore Ornithology Technical Report**.

412. CRM runs using the mean density value, as well as lower and upper 95% CI density values have been undertaken.

11.6.2.2.2.2.3 Flight Height Distribution

413. The assessment is largely based on collision risk for each key seabird species using Option 2 of the CRM. This was advised by Natural England during the ETG process (**Table 11-1**). This uses generic estimates of flight height for each species based on the percentage of birds flying at Potential Collision Height (PCH) derived from boat-based survey data from a number of locations in UK waters ("Corrigendum," 2014; Johnston *et al*., 2014).

414. CRM runs using the mean PCH value according to the Option 2 dataset, as well as lower and upper 95% CI flight height distribution values from the same dataset, have been undertaken.

415. For Sandwich tern, in addition to the Option 2 CRM, further models have been run using Option 1. This is because Sandwich tern was raised as a key concern during stakeholder consultation (**Table 11-1**), and has not been considered in detail by an OWF assessment in a number of years. Details are provided in the output section below.

416. **Appendix 11.1 Offshore Ornithology Technical Report** presents a comparison of available datasets which describe the flight height distributions of Sandwich tern within the Greater Wash area and beyond.

11.6.2.2.2.2.4 Avoidance Rates

417. The avoidance rates and variation about them recommended by the SNCBs using Option 2 of CRM (UK SNCBs, 2014) are presented in **Table 11-101**. These were recommended following the review of Cook *et al*. (2014), and are used by this assessment.

418. Avoidance rates based on more recent research are also presented in **Table 11-101**. A review of the latest evidence concerning avoidance rates for key seabird species considered by the assessment is provided in **Appendix 11.1 Offshore Ornithology Technical Report**.

Table 11-101: Avoidance Rates Used in CRM, and Alternative Rates Informed by more Recent Evidence

Species	UK SNCBs (2014) Recommended	Alternative Informed by Recent Evidence
Arctic tern	0.980	-
Black-headed gull	0.980	-
Common gull	0.980	-
Common tern	0.980	-
Cormorant	0.980	-

Species	UK SNCBs (2014) Recommended	Alternative Informed by Recent Evidence
Fulmar	0.980	-
Gannet	0.989 (+/- 0.002)	0.995 (Bowgen and Cook, 2018)
Great black-backed gull	0.995 (± 0.001)	0.995 (Bowgen and Cook, 2018)
Guillemot	0.980	-
Herring gull	0.995 (± 0.001)	0.995 (Bowgen and Cook, 2018)
Kittiwake	0.989 (+/- 0.002)	0.990 (Bowgen and Cook, 2018)
Lesser black-backed gull	0.995 (± 0.001)	0.995 (Bowgen and Cook, 2018)
Little gull	0.980	-
Razorbill	0.980	-
Red-throated diver	0.980	-
Sandwich tern	0.980	0.993 and 0.994 (Harwood *et al*., 2018) 0.9883 (DECC, 2012)

419. For all species except Sandwich tern, CRM has used the mean SNCB-recommended avoidance rate value, as well as the two standard deviation upper and lower limits where available (gannet, kittiwake and large gull species). For Sandwich tern, three avoidance rates, 0.980, 0.9883 and 0.993 have been selected for use, based on the evidence reviewed by the assessment.

11.6.2.2.2.2.5 Nocturnal Activity

420. The nocturnal activity parameter for CRM defines the level of nocturnal flight activity of each offshore ornithology receptor relative to daytime flight activity levels. For example, a value of 50% for the nocturnal activity factor is appropriate for a species which is half as active at night as during the day. This factor is used to enable estimation of theoretical nocturnal collision risk from survey data collected during daylight, with the total collision risk the sum of those for day and night. Values are derived from reviews of seabird activity reported in Garthe and Hüppop (2004), which 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 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’. Current nocturnal activity factors based on arbitrary conversions of Garthe and Hüppop (2004) scores into percentages are over-estimated, and consequently nocturnal CRM outputs are highly precautionary.

421. As the relative proportion of day to night 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 effect of 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 (MacArthur Green, 2015), which resulted in annual mortality estimate reductions of between 14.5% (lesser black-backed gull) and 27.7% (gannet).

422. The assessment uses the nocturnal activity factors presented in **Table 11-102**. Discussion regarding the use of updated, evidence-based avoidance rates for three species, which are presented alongside rates previously used by other OWF assessments, is presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

Table 11-102: Nocturnal Activity Factors used in CRM

Species	Nocturnal Activity Factor	Evidence-based Nocturnal Activity Factor
Arctic tern	1 (0%)	-
Black-headed gull	3 (50%)	-
Common gull	3 (50%)	-
Common tern	1 (0%)	-
Cormorant	1 (0%)	-
Fulmar	4 (75%)	-
Gannet	2 (25%)	8%
Great black-backed gull	3 (50%)	-
Guillemot	2 (25%)	-
Herring gull	3 (50%)	-
Kittiwake	3 (50%)	20%
Lesser black-backed gull	3 (50%)	-
Little gull	2 (25%)	-
Razorbill	1 (0%)	-
Red-throated diver	2 (25%)	-
Sandwich tern	1 (0%)	2%

11.6.2.2.2.2.6 Biometric Parameters

423. The biometric parameters of the offshore ornithology receptors screened into CRM are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

11.6.2.2.2.3 Screening

424. A screening exercise was undertaken to identify offshore ornithology receptors most likely to be at risk of significant impacts. CRM using Option 2 of Band (2012) was undertaken for all species recorded in flight at SEP or DEP. **Table 11-103** provides the annual predicted CRM and 95% CIs for density, flight height avoidance rate and nocturnal activity using SNCB-recommended avoidance rates (UK SNCBs, 2014) for SEP and DEP combined. Several species had very low predicted annual collision risk (i.e. mean annual collision rate of less than one). For these species, the impact magnitude was considered to be negligible. In the majority of cases, no further assessment is considered necessary for these species. They are therefore screened out of further assessment. The collision rates for these species by month are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

425. A number of relevant offshore ornithology receptors recorded within the aerial survey study area during the baseline surveys were not recorded within SEP and

DEP, and therefore are not at risk of collision. These are Arctic skua, common scoter, great skua, Manx shearwater, pomarine skua, puffin and shag.

426. A range of highly applicable existing information of high quality (encompassing peer-reviewed and other published research, along with previous OWF assessments) has been referred to during the literature review for the assessment of sensitivity of offshore ornithology receptors to collision risk (Black *et al*., 2019; Bowgen and Cook, 2018; Cook *et al*., 2014; Furness *et al*., 2013; Furness and Wade, 2012; Garthe and Hüppop, 2004; Skov *et al*., 2018; Tjørnløv *et al*., 2021; Wade *et al*., 2016). These sources consider factors such as percentage time spent flying at heights within the rotor diameter of OWFs, flight agility, the percentage of time flying overall, the extent of nocturnal flight activity and conservation importance. Confidence in the estimated sensitivity is also presented, and was considered to be medium for all species, due to the lack of widespread monitoring programmes deployed at operational OWFs to date producing empirical estimates of collision rates, meaning that expert opinion was largely relied upon for the classification of sensitivity.

Table 11-103: Collision Risk Screening for SEP and DEP (Option 2) (Shaded Rows are Species Screened in for Further Assessment)

Species	Estimated sensitivity to collision risk	Confidence in sensitivity estimate	Annual collision rate, SEP and DEP combined					Screening result
			Mean	95% CIs: density	95% CIs: flight height	2 x sd: avoidance rate	Evidence based nocturnal activity	
Arctic tern	Low	Medium	0.05	0.00 - 0.28	0.00 - 0.28	N/A	N/A	Out
Black-headed gull	Medium	Medium	1.69	0.00 - 8.17	0.54 - 3.83	N/A	N/A	In
Common gull	Medium	Medium	3.95	0.00 - 18.22	3.51 - 6.14	N/A	N/A	In
Common tern	Low	Medium	1.37	0.00 - 7.21	0.63 - 2.22	N/A	N/A	In
Cormorant	Low	Medium	0.01	0.00 - 0.04	0.00 - 0.37	N/A	N/A	Out
Fulmar	Low	Medium	0.01	0.00 - 0.08	0.00 - 0.06	N/A	N/A	Out
Gannet	Medium	Medium	5.79	0.11 - 16.95	2.28 - 10.48	4.74 - 6.84	4.86	In
Great black-backed gull	Medium	Medium	4.98	0.00 - 25.55	4.70 - 7.30	3.98 - 5.97	N/A	In
Guillemot	Low	Medium	0.02	0.00 - 0.10	0.00 - 2.42	N/A	N/A	Out
Herring gull	High	Medium	0.25	0.00 - 1.54	0.21 - 0.35	0.20 - 0.30	N/A	In
Kittiwake	Medium	Medium	17.07	1.72 - 47.41	12.26 - 20.60	16.70 - 20.17	13.93	In
Lesser black-backed gull	High	Medium	1.84	0.00 - 9.14	1.41 - 3.08	1.47 - 2.21	N/A	In
Little gull	Medium	Medium	4.71	0.00 - 19.77	1.54 - 12.68	N/A	N/A	In
Razorbill	Low	Medium	0.21	0.00 - 0.95	0.15 - 1.83	N/A	N/A	Out
Red-throated diver	Low	Medium	0.21	0.00 - 1.07	0.04 - 2.58	N/A	N/A	Out
Sandwich tern	Low	Medium	4.94	0.52 - 15.10	3.93 - 17.90	N/A	4.99	In

11.6.2.2.2.4 Band Model CRM Outputs

427. For each species screened into further assessment, (**Table 11-103**), a table has been produced which presents the outputs using Band model Option 2. These are arranged by month, and present the predicted collision risk for SEP, DEP, and SEP and DEP combined. CRM outputs based on mean values, and 95% CI values for density, flight height avoidance rate (two standard deviations rather than 95% CIs), and nocturnal activity are presented. Only a single model input was changed at a time, to avoid 'stacking' lower and upper limits into a single model run. Multiplying together the probability of two values which are both equal to or greater than the 95% upper CIs occurring (i.e. 0.025 x 0.025) is 0.06%, a scenario considered too unlikely as to represent a realistic worst-case scenario.

428. SNCB-recommended avoidance rates are applied throughout. For Sandwich tern, a greater range of outputs are presented to reflect the uncertainty around avoidance rates for this species, and the fact that an additional flight height distribution dataset has been made available.

429. Within the text accompanying each table, SEP and DEP are considered where the impacts are considered to be very small, and separately where impacts are larger. The text puts the predicted collision rates into the context of the wider population based on biologically relevant seasons (**Table 11-15**), and predicted mortality increases based on published mortality rates (**Table 11-17**). Where available, year round impacts are considered in the context of the biogeographic population with connectivity to UK waters.

430. The probability of the actual collision rate in a given month being equal to or greater than the upper 95% CI is 0.025; or 2.5%, a scenario considered to be unlikely. This becomes increasingly remote the more months are involved, as the probabilities are multiplied. It should also be noted that this probability is equal to the probability of the actual collision rate being equal to or lower than the 95% CI. In the case of the upper 95% CI, carrying out assessments based on this parameter is therefore considered extremely precautionary. For this reason, the assessment considers all outputs, not just the highest collision rate generated.

431. The Band spreadsheets used to calculate collision risk have been provided as part of the assessment and are available at **Appendix 11.1 Offshore Ornithology Technical Report**.

11.6.2.2.2.4.1 Black-Headed Gull

432. The mean annual collision rate for black-headed gull at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 1.23 (**Table 11-104**). This consisted of 0.29 birds per breeding season and 0.95 birds per non-breeding season. At SEP, the mean annual collision rate was zero during the non-breeding season, and 0.46 during the breeding season. In total, the annual mean collision rate for SEP and DEP combined was 1.69, of which 0.95 collisions were attributed to the non-breeding season, and 0.75 collisions to the breeding season.

433. Of the CRM input parameters that were varied, the one resulting in the largest effect on the predicted collision rate was the 95% CI for bird density. Using the upper 95% CI as a model input rather than the mean density estimate increased the non-breeding season collision rate for SEP and DEP combined to 4.48, and the breeding season collision rate to 3.70. Substituting the mean density with the lower 95% CI resulted in an annual collision rate of zero. Whilst the substitution of the mean flight height distribution for the respective 95% CIs also had an effect on predicted collision rates, the magnitude of the effect was less than when density estimates were varied.

434. Black-headed gull is not included in Furness (2015), and due to the fact that a substantial proportion of breeding does not occur in large colonies, it is not practical to accurately apportion breeding birds to particular colonies during the breeding season. As a result, the relevant background populations for this species are the latest Great Britain breeding (130,000 pairs) and non-breeding populations (2,200,000 individuals) (Woodward *et al*., 2020). Using the published 'all age-class' mortality rate of 17.5% (Horswill and Robinson, 2015), existing annual mortality in these populations would be 45,500 individuals and 385,000 individuals, respectively. In the case of both the breeding and non-breeding seasons, the predicted increase in mortality due to collision at SEP and DEP combined is 0.01% or less. This is also the case if the outputs from the upper 95% CI for density CRM are considered. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. The small sample size of flying birds recorded across DEP as a whole (10 birds) means that any differences in encounter rate between DEP and DEP-N are highly unlikely to be statistically significant for this species. Therefore, the collision rates presented here are a reasonable representation of the worst-case scenario for DEP.

435. For all seasons and year round, the increase in mortality of the relevant populations due to the mean predicted collision mortality at SEP and DEP is very small. It would not materially impact the existing mortality rate and since the predicted mortality increases in all relevant background populations are considerably below 1%, would be undetectable in the context of natural variation. The magnitude of effect of collision risk for this species at SEP and DEP combined is therefore assessed as negligible for the worst-case deployment scenario. Black-headed gull is considered to possess a medium sensitivity to collision risk. This is because it is not known to be displaced by operational OWFs (Dierschke *et al*., 2016), and occurs regularly at flight heights where collisions are possible ("Corrigendum," 2014; Johnston *et al*., 2014). However, it is not considered to be highly sensitive, as it did not occur in the aerial survey study aerial very frequently, or in large numbers. As a result, the impact significance is **minor adverse**.

436. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary

based on expert opinion to provide confidence that collision rates are not underestimated. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population.

Table 11-104: Black-Headed Gull CRM Outputs (Option 2, 0.980 Avoidance Rate) by Month

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.22	0.00	0.00	0.00	0.29	0.23	0.00	0.50	0.00	0.00	1.23
	Density	95% UCI	0.00	0.00	1.21	0.00	0.00	0.00	1.73	1.37	0.00	1.90	0.00	0.00	6.20
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.50	0.00	0.00	0.00	0.64	0.52	0.00	1.12	0.00	0.00	2.78
		95% LCI	0.00	0.00	0.07	0.00	0.00	0.00	0.09	0.07	0.00	0.16	0.00	0.00	0.39
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	Mean	-	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.46
	Density	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	1.97	0.00	0.00	0.00	0.00	0.00	1.97
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	1.05
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.14
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP and DEP	Mean	-	0.00	0.00	0.22	0.00	0.00	0.00	0.75	0.23	0.00	0.50	0.00	0.00	1.69
	Density	95% UCI	0.00	0.00	1.21	0.00	0.00	0.00	3.70	1.37	0.00	1.90	0.00	0.00	8.17
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
	Flight Height	95% UCI	0.00	0.00	0.50	0.00	0.00	0.00	1.70	0.52	0.00	1.12	0.00	0.00	3.83
		95% LCI	0.00	0.00	0.07	0.00	0.00	0.00	0.24	0.07	0.00	0.16	0.00	0.00	0.54
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-

11.6.2.2.2.4.2 Common Gull

437. The mean annual collision rate for common gull at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 1.88 collisions (**Table 11-105**). This consisted of 1.67 during the non-breeding season and 0.21 during the breeding season. At SEP, the mean annual collision rate was 2.07 during the non-breeding season and zero during the breeding season. In total, the annual mean collision rate for SEP and DEP combined was 3.95 collisions, of which 3.74 were attributed to the non-breeding season and 0.21 were attributed to the breeding season.

438. Of the CRM input parameters that were varied, the one resulting in the largest effect on the predicted collision rate was the 95% CI for bird density. Using the upper 95% CI as a model input rather than the mean density estimate increased the non-breeding season collision rate for SEP and DEP combined to 16.68, and the breeding season collision rate to 1.54. Substituting the mean density with the lower 95% CI resulted in an annual collision rate of zero. Whilst the substitution of 95% CIs for flight height distribution in place of the mean flight height distribution had an effect on predicted collision rates, the magnitude of the effect was less than when density estimates were varied.

439. Common gull is not included in Furness (2015), and due to the fact that a substantial proportion of breeding does not occur in large colonies, it is not practical to accurately apportion breeding birds to particular colonies during the breeding season. As a result, the relevant background populations for this species are the latest Great Britain non-breeding (700,000 individuals) and breeding (48,000 pairs) populations (Woodward *et al*., 2020). Using the published 'all age class' mortality rate of 17.2% (Horswill and Robinson, 2015), existing annual mortality in these populations would be 120,400 individuals and 16,512 individuals, respectively. In the case of both the non-breeding and breeding seasons, the mean collision mortality at SEP and DEP combined would increase existing annual mortality in the relevant populations by less than 0.01%. If the upper 95% CI for density is considered instead, the predicted increase in annual mortality in the relevant populations would be 0.01%. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. The small sample size of flying birds recorded across DEP as a whole (five birds) means that any differences in encounter rate between DEP and DEP-N are highly unlikely to be statistically significant for this species. Therefore, the collision rates presented here are a reasonable representation of the worst-case scenario for DEP.

440. For all seasons, and on a year-round basis, the increase in existing mortality of the relevant common gull populations due to the mean predicted collision mortality at SEP and DEP is very small. It would not materially impact the existing mortality rate and since the predicted mortality increases in all relevant background populations are considerably below 1%, would be undetectable in the context of natural variation. The magnitude of effect of collision risk for this species at SEP and DEP combined is therefore assessed as negligible for the worst-case deployment

scenario. Common gull is considered to possess a medium sensitivity to collision risk. This is because it is not known to be displaced by operational OWFs (Dierschke *et al*., 2016), and occurs regularly at flight heights where collisions are possible ("Corrigendum," 2014; Johnston *et al*., 2014). However, it is not considered to be highly sensitive, as it did not occur in the aerial survey study aerial very frequently, or in large numbers. As a result, the impact significance is **minor adverse**.

441. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population.

Table 11-105: Common Gull CRM Outputs (Option 2, 0.980 Avoidance Rate) by Month

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.00	0.16	0.21	0.00	0.00	0.00	0.00	1.51	0.00	0.00	1.88
	Density	95% UCI	0.00	0.00	0.00	1.37	1.54	0.00	0.00	0.00	0.00	6.80	0.00	0.00	9.71
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.25	0.33	0.00	0.00	0.00	0.00	2.34	0.00	0.00	2.91
		95% LCI	0.00	0.00	0.00	0.14	0.19	0.00	0.00	0.00	0.00	1.34	0.00	0.00	1.67
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	Mean	-	0.44	0.00	0.48	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.81	0.00	2.07
	Density	95% UCI	2.47	0.00	1.80	0.00	0.00	0.00	0.00	1.95	0.00	0.00	2.29	0.00	8.51
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.69	0.00	0.75	0.00	0.00	0.00	0.00	0.53	0.00	0.00	1.25	0.00	3.23
		95% LCI	0.39	0.00	0.43	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.72	0.00	1.84
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP and DEP	Mean	-	0.44	0.00	0.48	0.16	0.21	0.00	0.00	0.34	0.00	1.51	0.81	0.00	3.95
	Density	95% UCI	2.47	0.00	1.80	1.37	1.54	0.00	0.00	1.95	0.00	6.80	2.29	0.00	18.22
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
	Flight Height	95% UCI	0.69	0.00	0.75	0.25	0.33	0.00	0.00	0.53	0.00	2.34	1.25	0.00	6.14
		95% LCI	0.39	0.00	0.43	0.14	0.19	0.00	0.00	0.30	0.00	1.34	0.72	0.00	3.51
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-

11.6.2.2.2.4.3 Common Tern

442. The mean annual collision rate for common tern at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 1.00 collision (**Table 11-106**). This consisted of 0.24 during the autumn migration season, 0.40 during the spring migration season and 0.36 during the breeding season. At SEP, the mean annual collision rate was 0.37 collisions, which consisted of 0.01 during the autumn migration season, zero during the spring migration seasons and 0.36 during the breeding season. In total, the annual mean collision rate for SEP and DEP combined was 1.37 collisions, of which 0.25 were attributed to the autumn migration season, 0.40 to the spring migration season and 0.73 to the breeding season.

443. Of the CRM input parameters that were varied, the one resulting in the largest effect on the predicted collision rate was the 95% CI for bird density. Using the upper 95% CI as a model input rather than the mean density estimate increased the autumn migration season collision rate for SEP and DEP combined to 1.85, the spring migration season collision rate to 2.12 and the breeding season collision rate to 3.25. Substituting the mean density with the lower 95% CI resulted in an annual collision rate of zero. Whilst the substitution of 95% CIs for flight height distribution in place of the mean flight height distribution had an effect on predicted collision rates, the magnitude of the effect was less than when density estimates were varied.

444. During the autumn and spring migration seasons, the relevant background common tern population is the UK North Sea and Channel BDMPS, which consists of 144,911 individuals. Using the published ‘all age class’ mortality rate of 21.5% (**Table 11-17**), existing annual mortality in this population would be 31,156 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality during each migration season by less than 0.01%. If the upper 95% CI for density is considered instead, the predicted increase in annual mortality would be 0.01%.

445. During the breeding season, the relevant background population is the breeding adult population of the North Norfolk Coast SPA (232 pairs from colonies at Blakeney Point, Scolt Head, Holkham and Titchwell Marshes) (JNCC, 2020a). Using the published adult mortality rate of 11.7% (**Table 11-17**), existing annual mortality in this population would be 54 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality by 1.34%. If the upper 95% CI for density is considered instead, the predicted increase in annual mortality would be 5.98%.

446. With regard to placing overall annual mortality in context, the number of common terns expected to die annually that are members of the largest relevant BDMPS (UK North Sea and Channel, autumn / spring migration) is 31,156 (based on the published ‘all age class’ mortality rate of 21.5% (**Table 11-17**)). The biogeographic population of this species with connectivity to UK waters is 480,000 individuals (Furness, 2015). The number of individuals expected to die annually from this population is 103,200 (based on the same mortality rate). The addition of the annual mean and upper 95% CI collision mortalities at SEP and DEP combined (from all seasons) would increase the BDMPS annual mortality by between 0.00% and

0.02%, and would increase the biogeographic population annual mortality by between 0.00% and 0.01%.

447. During the autumn and spring migration seasons, and on a year-round basis, the increase in existing mortality of the relevant populations due to the mean predicted collision mortality at SEP and DEP would be very small. It would not materially impact the existing mortality rate and would be undetectable in the context of natural variation. The magnitude of effect of collision risk for this species at SEP and DEP combined is therefore assessed as negligible for the worst-case deployment scenario. Although the predicted increase in annual mortality is somewhat higher during the breeding season than the rest of the year, the modelled collision rate during the breeding season is driven principally by collisions during the months of May and August (**Table 11-106**). During those months, the relevant background population (i.e. the North Norfolk Coast SPA breeding population) would be supplemented by additional birds migrating to and from other breeding colonies. As such, it is likely that a proportion of individuals present at SEP and DEP are likely not birds from the North Norfolk Coast SPA. Therefore the increase in annual mortality within this population is likely to be considerably lower than if all birds at SEP and DEP are apportioned to the breeding adult population of the North Norfolk Coast SPA. This is reinforced by the fact that the mean maximum foraging range of common terns (18.0 +/- 8.9km; Woodward *et al*. 2019) is smaller than the distance between the North Norfolk Coast SPA and SEP or DEP. Whilst the latter is within the mean maximum foraging range plus one standard deviation, this is considered to be a poor measure of typical foraging behaviour within a population.

448. Based on the above observations, the magnitude of effect of collision risk for this species at SEP and DEP combined is assessed as negligible for the worst-case deployment scenario. Common tern is considered to possess a low sensitivity to collision risk. This is because it is not known to be displaced by operational OWFs (Dierschke *et al*., 2016), and does not occur regularly at flight heights where collisions are possible ("Corrigendum," 2014; Johnston *et al*., 2014). As a result, the impact significance is **minor adverse**.

449. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. In total, 36 flying birds were observed across DEP (of which 29 were within DEP-N, and seven within DEP-S). When corrected for the different survey transect lengths in both regions of DEP this means that encounter rate was 32.2% higher at DEP-N than in DEP as a whole. An increase in the predicted collision rate of this magnitude would not change the conclusions of the assessment, which is considered to be reasonable representation of the worst-case scenario for DEP.

450. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Whilst the conclusion of the assessment could result in a higher

impact magnitude being assigned if the 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population, the distance between SEP, DEP and the North Norfolk Coast SPA breeding colonies provides sufficient confidence that impacts are overestimated.

Table 11-106: Common Tern CRM Outputs (Option 2, 0.980 Avoidance Rate) by Month

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.00	0.40	0.19	0.05	0.00	0.13	0.20	0.04	0.00	0.00	1.00
	Density	95% UCI	0.00	0.00	0.00	2.12	0.77	0.34	0.00	0.50	1.61	0.22	0.00	0.00	5.55
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.65	0.30	0.08	0.00	0.21	0.32	0.06	0.00	0.00	1.62
		95% LCI	0.00	0.00	0.00	0.18	0.09	0.02	0.00	0.06	0.09	0.02	0.00	0.00	0.46
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	Mean	-	0.00	0.00	0.00	0.00	0.10	0.15	0.00	0.10	0.01	0.00	0.00	0.00	0.37
	Density	95% UCI	0.00	0.00	0.00	0.00	0.75	0.28	0.00	0.61	0.02	0.00	0.00	0.00	1.66
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.00	0.17	0.25	0.00	0.17	0.01	0.00	0.00	0.00	0.60
		95% LCI	0.00	0.00	0.00	0.00	0.05	0.07	0.00	0.05	0.00	0.00	0.00	0.00	0.17
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP and DEP	Mean	-	0.00	0.00	0.00	0.40	0.29	0.20	0.00	0.23	0.21	0.04	0.00	0.00	1.37
	Density	95% UCI	0.00	0.00	0.00	2.12	1.52	0.62	0.00	1.11	1.63	0.22	0.00	0.00	7.21
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.65	0.47	0.32	0.00	0.38	0.34	0.06	0.00	0.00	2.22
		95% LCI	0.00	0.00	0.00	0.18	0.13	0.09	0.00	0.11	0.10	0.02	0.00	0.00	0.63
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-

11.6.2.2.2.4.4 Gannet

451. The mean annual collision rate for gannet at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 4.88 (**Table 11-107**). This consisted of 1.84 collisions per breeding season, 2.84 collisions per autumn migration season, and 0.20 collisions per spring migration season. At SEP, the mean annual collision rate under the worst-case scenario was 0.91. This consisted of 0.25 collisions per breeding season, 0.66 collisions per autumn migration season, and zero collisions per spring migration season. In total, the annual mean collision rate for SEP and DEP combined under the worst-case scenario was 5.79, of which 2.08 collisions were attributed to the breeding season, 3.50 to the autumn migration season, and 0.20 to the spring migration season.

452. Of the CRM input parameters that were varied (**Table 11-107**), the one resulting in the largest effect on the predicted collision rate was the 95% CI for bird density. Using the upper 95% CI density estimate as a model input rather than the mean density estimate increased the annual collision rate for DEP to 14.21 (of which 5.84 collisions were during the breeding season, 7.56 during the autumn migration season, and 0.81 during the spring migration season). At SEP, the annual collision rate when the upper 95% CI of bird density was substituted for the mean density was 2.75 (of which 1.27 collisions were during the breeding season, 1.48 during the autumn migration season, and zero during the spring migration season). Substituting the mean density with the lower 95% CI resulted in an annual collision rate of zero at SEP and 0.11 at DEP. Whilst the substitution of the mean flight height distribution for the respective 95% CIs, or plus/minus two standard deviations of avoidance rate also had an effect on predicted collision rates, the magnitude of the differences compared to the mean was substantially less than when density estimates were varied.

453. During the autumn and spring migration seasons, the relevant background gannet population is the UK North Sea and Channel BDMPS, which consist of 456,298 and 248,385 individuals respectively. Using the published all age class mortality rate of 19.1% (**Table 11-17**), the number of birds expected to die annually from each population would be 87,153 and 47,442 respectively. The mean collision mortality of SEP and DEP combined during the respective seasons in question would result in a mortality increase of 0.00%, or 0.01% in autumn if the outputs obtained using models where the upper 95% CI density estimate was an input parameter are considered.

454. During the breeding season, the relevant background population is the breeding adult population of the Flamborough and Filey Coast SPA (26,874 birds as per Aitken *et al*. (2017)). Using the published adult mortality rate of 8.8% (**Table 11-17**), the number of birds expected to die annually from this population would be 2,357. Collision mortality from DEP would increase existing mortality within this population by 0.08% and 0.25%, if mean and upper 95% CI bird densities are used as input parameters. The corresponding mortality increases for collision rates at SEP are 0.01% and 0.05%. For SEP and DEP combined, the mean collision rate during the breeding season increases the existing mortality within the breeding adult

population of the Flamborough and Filey Coast SPA by 0.09% using the mean CRM outputs, or 0.30% using the upper 95% CI density outputs.

455. With regard to placing annual mortality in context, the number of birds expected to die annually that are members of the largest relevant BDMPS (autumn UK North Sea BDMPS) is 87,153 (based on the published all age class mortality rate of 19.1% (**Table 11-17**)). The biogeographic population of this species with connectivity to UK waters is 1,180,000 (Furness, 2015). The number of individuals expected to die annually from this population based on the same published mortality rate is 225,380. The addition of the annual mean and upper 95% CI collision mortalities for SEP and DEP combined to existing levels of mortality from these populations increases the autumn UK North Sea BDMPS annual mortality by between 0.01% and 0.02%, and the biogeographic population mortality rate by between 0.00% and 0.01%.

456. The increase in existing mortality of the relevant gannet populations due to predicted collision mortality at SEP and DEP is very small during the migration seasons and year round, and small during the breeding season. Collision mortality due to SEP and DEP combined would not materially impact existing mortality levels and would be undetectable in the context of natural variation. The magnitude of effect of collision risk for this species at SEP and DEP combined for all seasons, and year round is therefore assessed as negligible.

457. Gannet is considered to possess a medium sensitivity to collision risk. This is because whilst it occurs regularly at flight heights where collisions are possible ("Corrigendum," 2014; Johnston *et al*., 2014), it is known to be displaced by operational OWFs (Dierschke *et al*., 2016). As a result, the impact significance is **minor adverse**.

458. Recently, it has been suggested by Natural England that the application of correction factors to CRM outputs of 0.600 to 0.800 to account for macro-avoidance may be appropriate for this species. This would further reduce collision risk. This is not explored quantitatively here since the conclusions would not be affected, but is considered in the **RIAA** (document reference 5.4) for impacts on the gannet population of the Flamborough and Filey Coast SPA.

459. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. In total, 59 flying birds were observed across DEP (of which 41 were within DEP-N, and 18 within DEP-S). This means that encounter rate was 14.0% higher at DEP-N than in DEP as a whole. An increase in the predicted collision rate of this magnitude would not change the conclusions of the assessment, which is considered to be reasonable representation of the worst-case scenario for DEP.

460. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Finally, the conclusion of the assessment is the same irrespective

of whether the mean or 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population.

Table 11-107: Gannet CRM Outputs (Option 2, 0.989 Avoidance Rate) by Month

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.24	0.83	0.11	0.10	0.10	0.09	0.37	1.32	1.51	0.20	4.88
	Density	95% UCI	0.00	0.00	1.11	1.93	0.46	0.57	0.43	0.39	0.95	4.55	3.01	0.81	14.21
		95% LCI	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
	Flight Height	95% UCI	0.00	0.00	0.43	1.51	0.20	0.17	0.18	0.17	0.66	2.39	2.74	0.37	8.82
		95% LCI	0.00	0.00	0.09	0.33	0.04	0.04	0.04	0.04	0.15	0.52	0.60	0.08	1.93
	Avoidance Rate	-2 SD	0.00	0.00	0.28	0.99	0.13	0.11	0.12	0.11	0.43	1.57	1.79	0.24	5.77
		+2 SD	0.00	0.00	0.19	0.68	0.09	0.08	0.08	0.08	0.30	1.08	1.24	0.17	3.99
	Noct. Act.	EB	0.00	0.00	0.20	0.75	0.10	0.09	0.09	0.09	0.32	1.11	1.20	0.16	4.11
SEP	Mean	-	0.00	0.00	0.00	0.12	0.00	0.00	0.04	0.04	0.05	0.00	0.66	0.00	0.91
	Density	95% UCI	0.00	0.00	0.00	0.46	0.00	0.00	0.26	0.25	0.31	0.00	1.48	0.00	2.75
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.21	0.00	0.00	0.07	0.07	0.10	0.00	1.21	0.00	1.66
		95% LCI	0.00	0.00	0.00	0.05	0.00	0.00	0.02	0.02	0.02	0.00	0.26	0.00	0.36
	Avoidance Rate	-2 SD	0.00	0.00	0.00	0.14	0.00	0.00	0.05	0.05	0.06	0.00	0.78	0.00	1.08
		+2 SD	0.00	0.00	0.00	0.09	0.00	0.00	0.03	0.03	0.04	0.00	0.54	0.00	0.75
	Noct. Act.	EB	0.00	0.00	0.00	0.10	0.00	0.00	0.04	0.04	0.05	0.00	0.53	0.00	0.75
SEP and DEP	Mean	-	0.00	0.00	0.24	0.95	0.11	0.10	0.14	0.13	0.42	1.32	2.18	0.20	5.79
	Density	95% UCI	0.00	0.00	1.11	2.39	0.46	0.57	0.69	0.63	1.26	4.55	4.49	0.81	16.95
		95% LCI	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
	Flight Height	95% UCI	0.00	0.00	0.43	1.72	0.20	0.17	0.25	0.24	0.76	2.39	3.94	0.37	10.48
		95% LCI	0.00	0.00	0.09	0.37	0.04	0.04	0.05	0.05	0.17	0.52	0.86	0.08	2.28
	Avoidance Rate	-2 SD	0.00	0.00	0.28	1.12	0.13	0.11	0.16	0.16	0.50	1.57	2.57	0.24	6.84
		+2 SD	0.00	0.00	0.19	0.78	0.09	0.08	0.11	0.11	0.34	1.08	1.78	0.17	4.74
	Noct. Act.	EB	0.00	0.00	0.20	0.85	0.10	0.09	0.13	0.12	0.37	1.11	1.73	0.16	4.86

11.6.2.2.2.4.5 Great Black-Backed Gull

461. The mean annual collision rate for great black-backed gull at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 1.30 collisions (**Table 11-108**). This consisted of 1.08 collisions during the non-breeding season and 0.23 during the breeding season. At SEP, the mean annual collision rate was 3.67, with all of these collisions predicted during the non-breeding season. In total, the annual mean collision rate for SEP and DEP combined was 4.98 collisions, of which 0.23 were attributed to the breeding season, and 4.75 to the non-breeding season.

462. Of the CRM input parameters that were varied, the one resulting in the largest effect on the predicted collision rate was the 95% CI for bird density. Using the upper 95% CI as a model input rather than the mean density estimate increased the breeding season collision rate for SEP and DEP combined to 1.67, the non-breeding season collision rate for SEP and DEP to 23.88, and the total annual collision rate to 25.55. Substituting the mean density with the lower 95% CI resulted in an annual collision rate of zero. Whilst the substitution of 95% CIs for flight height distribution in place of the mean had an effect on predicted collision rates, as did substitution of the avoidance rate to include plus / minus two SDs, the magnitude of the effects were less than when density estimates were varied.

463. During the non-breeding season, the relevant background great black-backed gull population is the UK North Sea BDMPS, which consists of 91,399 individuals. Using the published 'all age class' mortality rate of 18.5% (**Table 11-17**), existing annual mortality in this population would be 16,909 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality by 0.03%. The upper 95% CI collision mortality would increase the existing annual mortality by 0.14% (of which SEP would be responsible for 0.12%).

464. There are no known breeding colonies of this species within the published mean maximum foraging range (73km) (Woodward *et al*., 2019) from which birds could originate. During the breeding season, the relevant background population is therefore considered to be the non-breeding component of the UK North Sea BDMPS, which consists of 59,329 immature birds. Using the published 'all age class' mortality rate of 18.5% (**Table 11-17**), existing annual mortality in this population would be 10,976 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality by less than 0.01%. The upper 95% CI collision mortality would increase the existing annual mortality by 0.02%.

465. With regard to placing annual mortality in context, the number of great black-backed gulls expected to die annually that are members of the largest relevant BDMPS (UK North Sea, non-breeding) is 16,909 (based on the published 'all age class' mortality rate of 18.4% (**Table 11-17**)). The biogeographic population of this species with connectivity to UK waters is 235,000 individuals (Furness, 2015). The number of individuals expected to die annually from this population is 43,475 (based on the same mortality rate). The addition of the annual mean and upper 95% CI collision mortalities at SEP and DEP combined (from all seasons) would increase the BDMPS annual mortality by 0.03%, and the biogeographic population annual

mortality by 0.01%. The upper 95% CI collision mortality would increase the existing annual mortality of these background populations by 0.16% and 0.06% respectively.

466. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. The small sample size of flying birds recorded across DEP as a whole (six birds) means that any differences in encounter rate between DEP and DEP-N are highly unlikely to be statistically significant for this species. Therefore, the collision rates presented here are a reasonable representation of the worst-case scenario for DEP. Therefore, the assessment presented represents a suitably precautionary approach.

467. During both the breeding and non-breeding season, and on a year-round basis, the increase in existing mortality of the relevant populations due to the mean predicted collision mortality at SEP and DEP is very small. It would not materially impact the existing mortality rate and since the predicted mortality increases in all relevant background populations are considerably below 1%, would be undetectable in the context of natural variation. The magnitude of effect of collision risk for this species at SEP and DEP combined is therefore assessed as negligible for the worst-case deployment scenario.

468. Great black-backed gull is considered to possess a high sensitivity to collision risk. This is because it is not known to be displaced by operational OWFs (Dierschke *et al*., 2016), and occurs regularly at flight heights where collisions are possible (“Corrigendum,” 2014; Johnston *et al*., 2014). However, it did not occur in the aerial survey study aerial very frequently, or in large numbers, which limits the sensitivity of this species to collision at SEP and DEP. As a result, the impact significance is **minor adverse**.

469. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population.

Table 11-108: Great Black-Backed Gull CRM Outputs (Option 2, 0.995 Avoidance Rate) by Month

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.25	0.00	0.00	0.09	0.00	0.00	0.13	0.00	0.56	0.00	0.26	1.30
	Density	95% UCI	0.00	1.33	0.00	0.00	0.84	0.00	0.00	0.83	0.00	1.60	0.00	1.48	6.09
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.37	0.00	0.00	0.13	0.00	0.00	0.20	0.00	0.82	0.00	0.38	1.91
		95% LCI	0.00	0.24	0.00	0.00	0.09	0.00	0.00	0.13	0.00	0.53	0.00	0.25	1.24
	Avoidance Rate	-2 SD	0.00	0.30	0.00	0.00	0.11	0.00	0.00	0.16	0.00	0.68	0.00	0.31	1.57
		+2 SD	0.00	0.20	0.00	0.00	0.07	0.00	0.00	0.11	0.00	0.45	0.00	0.21	1.04
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	Mean	-	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.70	2.49	3.67
	Density	95% UCI	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	1.33	15.28	19.46
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	1.03	3.66	5.39
		95% LCI	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.66	2.36	3.47
	Avoidance Rate	-2 SD	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.84	2.99	4.41
		+2 SD	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.56	2.00	2.94
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP and DEP	Mean	-	0.24	0.25	0.00	0.00	0.09	0.00	0.00	0.13	0.00	0.80	0.70	2.76	4.98
	Density	95% UCI	1.34	1.33	0.00	0.00	0.84	0.00	0.00	0.83	0.00	3.11	1.33	16.77	25.55
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.35	0.37	0.00	0.00	0.13	0.00	0.00	0.20	0.00	1.17	1.03	4.04	7.30
		95% LCI	0.23	0.24	0.00	0.00	0.09	0.00	0.00	0.13	0.00	0.76	0.66	2.60	4.70
	Avoidance Rate	-2 SD	0.29	0.30	0.00	0.00	0.11	0.00	0.00	0.16	0.00	0.96	0.84	3.31	5.97
		+2 SD	0.19	0.20	0.00	0.00	0.07	0.00	0.00	0.11	0.00	0.64	0.56	2.20	3.98
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-

11.6.2.2.2.4.6 Herring Gull

470. The mean annual collision rate for herring gull at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 0.25 collisions (**Table 11-109**). This consisted of zero during the non-breeding season and 0.25 during the breeding season. At SEP, the mean annual collision rate was zero during both the breeding and non-breeding season. In total, the annual mean collision rate for SEP and DEP combined was 0.25 collisions, of which all were attributed to the breeding season.

471. Of the CRM input parameters that were varied, the one resulting in the largest effect on the predicted collision rate was the 95% CI for bird density. Using the upper 95% CI as a model input rather than the mean density estimate increased the breeding season collision rate for SEP and DEP combined to 1.54 (the non-breeding season collision rate remained zero). Substituting the mean density with the lower 95% CI resulted in an annual collision rate of zero. Whilst the substitution of 95% CIs for flight height distribution in place of the mean had an effect on predicted collision rates, as did substitution of the avoidance rate to include plus / minus two SDs, the magnitude of the effects were less than when density estimates were varied.

472. During the non-breeding season, the relevant background herring gull population is the UK North Sea and Channel BDMPS, which consists of 466,511 individuals. Using the published 'all age class' mortality rate of 18.4% (**Table 11-17**), existing annual mortality in this population would be 85,838 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality by less than 0.01%. This would also be the case if the upper 95% CI for density is considered instead.

473. During the breeding season, the relevant background population is the breeding adult population from the North Norfolk Coast (1,225 pairs from colonies at Blakeney Point, Holkham, Outer Trial Bank, Titchwell Marsh and Hunstanton) (JNCC, 2020a). Using the published adult mortality rate of 16.6% (**Table 11-17**), existing annual mortality in this population would be 407 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality by 0.06%. If the upper 95% CI for density is considered instead, the predicted increase in mortality is 0.38%.

474. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. The small sample size of flying birds recorded across DEP as a whole (a single bird) means that any differences in encounter rate between DEP and DEP-N are highly unlikely to be statistically significant for this species. Therefore, the collision rates presented here are a reasonable representation of the worst-case scenario for DEP.

475. With regard to placing annual mortality in context, the number of herring gulls expected to die annually that are members of the largest relevant BDMPS (UK North Sea and Channel, non-breeding) is 85,838 (based on the published 'all age class' mortality rate of 18.4% (**Table 11-17**)). The biogeographic population of this species

with connectivity to UK waters is 1,098,000 individuals (Furness, 2015). The number of individuals expected to die annually from this population is 202,032 (based on the same mortality rate). The addition of the annual mean and upper 95% CI collision mortalities at SEP and DEP combined (from all seasons) would increase the BDMPS annual mortality and the biogeographic population annual mortality by less than 0.01%.

476. During both the breeding and non-breeding season, and on a year-round basis, the increase in existing mortality of the relevant populations due to the mean predicted collision mortality at SEP and DEP is very small. It would not materially impact the existing mortality rate and would be undetectable in the context of natural variation since predicted increases in the annual mortality of the relevant background populations are substantially below 1%. The magnitude of effect of collision risk for this species at SEP and DEP combined is therefore assessed as negligible for the worst-case deployment scenario.

477. Herring gull is considered to possess a high sensitivity to collision risk. This is because it is not known to be displaced by operational OWFs (Dierschke *et al*., 2016), and occurs regularly at flight heights where collisions are possible (“Corrigendum,” 2014; Johnston *et al*., 2014). However, it did not occur in the aerial survey study aerial very frequently, or in large numbers, which limits the sensitivity of this species to collision at SEP and DEP. As a result, the impact significance is **minor adverse**.

478. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population.

Table 11-109: Herring Gull CRM Outputs (Option 2, 0.995 Avoidance Rate) by Month

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.14	0.07	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.25
	Density	95% UCI	0.00	0.00	0.69	0.67	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	1.54
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.19	0.10	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.35
		95% LCI	0.00	0.00	0.11	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.21
	Avoidance Rate	-2 SD	0.00	0.00	0.17	0.09	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.30
		+2 SD	0.00	0.00	0.11	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.20
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	Mean	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Density	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Avoidance Rate	-2 SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		+2 SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP and DEP	Mean	-	0.00	0.00	0.14	0.07	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.25
	Density	95% UCI	0.00	0.00	0.69	0.67	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	1.54
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.19	0.10	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.35
		95% LCI	0.00	0.00	0.11	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.21
	Avoidance Rate	-2 SD	0.00	0.00	0.17	0.09	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.30
		+2 SD	0.00	0.00	0.11	0.06	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.20
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-

11.6.2.2.2.4.7 Kittiwake

479. The mean annual collision rate for kittiwake at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 15.04 (**Table 11-110**). This consisted of 9.10 collisions per breeding season, 4.64 collisions per autumn migration season, and 1.30 collisions per spring migration season. At SEP, the mean annual collision rate under the worst-case scenario was 2.03. This consisted of 0.83 collisions per breeding season, 1.20 collisions per autumn migration season, and zero collisions per spring migration season. In total, the annual mean collision rate for SEP and DEP combined under the worst-case scenario was 17.07, of which 9.93 collisions were attributed to the breeding season, 5.84 to the autumn migration season, and 1.30 to the spring migration season.

480. Of the CRM input parameters that were varied (**Table 11-110**), the one resulting in the largest effect on the predicted collision rate was the 95% CI for bird density. Using the upper 95% CI density estimate as a model input rather than the mean density estimate increased the annual collision rate for DEP to 38.25 (of which 22.42 collisions were during the breeding season, 12.66 during the autumn migration season, and 3.17 during the spring migration season). At SEP, the annual collision rate when the upper 95% CI of bird density was substituted for the mean density was 9.16 (of which 4.05 collisions were during the breeding season, 5.11 during the autumn migration season, and zero during the spring migration season). Substituting the mean density with the lower 95% CI resulted in an annual collision rate of 1.72 at DEP, and zero at SEP. Whilst the substitution of the mean flight height distribution for the respective 95% CIs, or plus/minus two standard deviations of avoidance rate also had an effect on predicted collision rates, the magnitude of the differences compared to the mean was substantially less than when density estimates were varied.

481. During the autumn and spring migration seasons, the relevant background kittiwake population is the UK North Sea BDMPS, which consist of 829,937 and 627,816 individuals respectively. Using the published all age class mortality rate of 15.6% (**Table 11-17**), the number of birds expected to die annually from each population would be 129,470 and 97,939 respectively. The mean collision mortality of SEP and DEP combined would result in a mortality increase of 0.00% in spring, or 0.01% in autumn if the outputs obtained using the upper 95% CI density estimate are considered.

482. During the breeding season, the relevant background population is the breeding adult population of the Flamborough and Filey Coast SPA (103,070 birds as per Aitken *et al*. (2017)). Using the published adult mortality rate of 14.6% (**Table 11-17**), the number of birds expected to die annually from this population would be 15,048. Collision mortality from DEP would increase existing mortality within this population by 0.06% and 0.15%, if mean and upper 95% CI bird densities are used as input parameters. The corresponding mortality increases for collision rates at SEP are 0.01% and 0.03%. For SEP and DEP combined, the mean collision rate during the breeding season increases the existing mortality within the breeding adult

population of the Flamborough and Filey Coast SPA by 0.07% using the mean CRM outputs, or 0.18% using the upper 95% CI density outputs.

483. With regard to placing annual mortality in context, the number of birds expected to die annually that are members of the largest relevant BDMPS (autumn UK North Sea BDMPS) is 129,470 (based on the published all age class mortality rate of 15.6% (**Table 11-17**)). The biogeographic population of this species with connectivity to UK waters is 5,100,000 (Furness, 2015). The number of individuals expected to die annually from this population based on the same published mortality rate is 795,600. The addition of the annual mean and upper 95% CI collision mortalities for SEP and DEP combined, to existing levels of mortality from these populations, increases the autumn UK North Sea BDMPS annual mortality by between 0.01% and 0.04%, and the biogeographic population mortality rate by between 0.00% and 0.01%.

484. The increase in existing mortality of the relevant kittiwake populations due to predicted collision mortality at SEP and DEP is very small during the migration seasons and year round, and small during the breeding season. Collision mortality due to SEP and DEP combined would not materially impact existing mortality levels and would be undetectable in the context of natural variation. The magnitude of effect of collision risk for this species at SEP and DEP combined for all seasons, and year round is therefore assessed as negligible.

485. Kittiwake is considered to possess a medium sensitivity to collision risk. This is because it is not known to be displaced by operational OWFs (Dierschke *et al*., 2016), and occurs quite regularly at flight heights where collisions are possible ("Corrigendum," 2014; Johnston *et al*., 2014). As a result, the impact significance is **minor adverse**.

486. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. In total, 205 flying birds were observed across DEP (of which 158 were within DEP-N, and 47 within DEP-S). When corrected for the different survey transect lengths in both regions of DEP, this means that encounter rate was 26.5% higher at DEP-N than in DEP as a whole. An increase in the predicted collision rate of this magnitude would not change the conclusions of the assessment, which is considered to be reasonable representation of the worst-case scenario for DEP.

487. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population.

Table 11-110: Kittiwake CRM Outputs (Option 2) by Month

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.78	0.52	0.29	5.42	1.58	0.15	0.49	1.17	2.65	1.18	0.13	0.67	15.04
	Density	95% UCI	1.91	1.26	1.11	9.87	5.22	0.81	1.30	4.12	7.87	2.70	0.75	1.34	38.25
		95% LCI	0.00	0.00	0.00	1.47	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	1.72
	Flight Height	95% UCI	0.94	0.63	0.35	6.54	1.90	0.18	0.60	1.41	3.20	1.42	0.16	0.81	18.15
		95% LCI	0.56	0.37	0.21	3.90	1.13	0.11	0.36	0.84	1.91	0.85	0.10	0.48	10.81
	Avoidance Rate	-2 SD	0.92	0.61	0.35	6.41	1.86	0.17	0.58	1.38	3.14	1.39	0.16	0.80	17.78
		+2 SD	0.64	0.43	0.24	4.44	1.29	0.12	0.40	0.96	2.17	0.96	0.11	0.55	12.31
	Noct. Act.	EB	0.55	0.39	0.23	4.56	1.38	0.13	0.44	1.00	2.17	0.91	0.10	0.46	12.32
SEP	Mean	-	0.00	0.00	0.00	0.74	0.00	0.08	0.00	0.00	0.57	0.00	0.28	0.36	2.03
	Density	95% UCI	0.00	0.00	0.00	3.56	0.00	0.49	0.00	0.00	2.20	0.00	1.06	1.85	9.16
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.90	0.00	0.10	0.00	0.00	0.68	0.00	0.33	0.43	2.45
		95% LCI	0.00	0.00	0.00	0.53	0.00	0.06	0.00	0.00	0.41	0.00	0.20	0.26	1.45
	Avoidance Rate	-2 SD	0.00	0.00	0.00	0.88	0.00	0.10	0.00	0.00	0.67	0.00	0.33	0.42	2.39
		+2 SD	0.00	0.00	0.00	0.61	0.00	0.07	0.00	0.00	0.46	0.00	0.23	0.29	1.66
	Noct. Act.	EB	0.00	0.00	0.00	0.62	0.00	0.08	0.00	0.00	0.46	0.00	0.20	0.25	1.61
	Mean	-	0.78	0.52	0.29	6.16	1.58	0.23	0.49	1.17	3.22	1.18	0.41	1.03	17.07

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
SEP and DEP	Density	95% UCI	1.91	1.26	1.11	13.43	5.22	1.30	1.30	4.12	10.08	2.70	1.80	3.19	47.41
		95% LCI	0.00	0.00	0.00	1.47	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	1.72
	Flight Height	95% UCI	0.94	0.63	0.35	7.44	1.90	0.28	0.60	1.41	3.89	1.42	0.50	1.24	20.60
		95% LCI	0.56	0.37	0.21	4.43	1.13	0.17	0.36	0.84	2.31	0.85	0.29	0.74	12.26
	Avoidance Rate	-2 SD	0.92	0.61	0.35	7.28	1.86	0.27	0.58	1.38	3.81	1.39	0.49	1.22	20.17
		+2 SD	0.78	0.52	0.29	6.03	1.58	0.22	0.49	1.17	3.12	1.18	0.36	0.97	16.70
	Noct. Act.	EB	0.55	0.39	0.23	5.18	1.38	0.21	0.44	1.00	2.63	0.91	0.30	0.71	13.93

11.6.2.2.2.4.8 Lesser Black-Backed Gull

488. The mean annual collision rate for lesser black-backed gull at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 1.31 collisions (**Table 11-111**). This consisted of 0.09 during the autumn migration season, 0.19 during the winter season, zero during the spring migration season and 1.03 during the breeding season. At SEP, the mean annual collision rate was 0.53 collisions during the breeding season and zero during the autumn migration, winter and spring migration seasons. In total, the annual mean collision rate for SEP and DEP combined was 1.84 collisions, of which 0.09 were attributed to the autumn migration season, 0.19 to the winter season, zero to the spring migration season and 1.56 to the breeding season.

489. Of the CRM input parameters that were varied, the one resulting in the largest effect on the predicted collision rate was the 95% CI for bird density. Using the upper 95% CI as a model input rather than the mean density estimate increased the autumn migration season collision rate for SEP and DEP combined to 0.53, the winter season collision rate to 1.02 and the breeding season collision rate to 7.59, (the spring migration season collision rate remained zero). Substituting the mean density with the lower 95% CI resulted in an annual collision rate of zero. Whilst the substitution of 95% CIs for flight height distribution in place of the mean had an effect on predicted collision rates, as did substitution of the avoidance rate to include plus / minus two SDs, the magnitude of the effects were less than when density estimates were varied.

490. During the autumn migration season, the relevant background lesser black-backed gull population is the UK North Sea and Channel BDMPS, which consists of 209,007 individuals. Using the published ‘all age class’ mortality rate of 12.6% (**Table 11-17**), existing annual mortality in this population would be 26,335 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality by less than 0.01%. This would also be the case if the upper 95% CI for density is considered instead.

491. During the winter season, the relevant background population is the UK North Sea and Channel BDMPS, which consists of 39,314 individuals. Using the published ‘all age class’ mortality rate of 12.6% (**Table 11-17**), existing annual mortality in this population would be 4,954 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality by less than 0.01%. If the upper 95% CI for density is considered instead, the predicted increase in mortality would be 0.02%.

492. During the spring migration season, the relevant background population is the UK North Sea and Channel BDMPS, which consists of 197,483 individuals. Using the published ‘all age class’ mortality rate of 12.6% (**Table 11-17**), existing annual mortality in this population would be 24,883 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality by less than 0.01%. This would also be the case if the upper 95% CI for density is considered instead.

493. During the breeding season, the relevant background population is the breeding adult population from the North Norfolk Coast (1,330 pairs from colonies at Blakeney Point, Holkham, Berney Marshes, Outer Trial Bank and Hunstanton) (JNCC, 2020a). Using the published adult mortality rate of 11.5% (**Table 11-17**), existing annual mortality in this population would be 306 individuals. The mean collision mortality at SEP and DEP combined would increase the existing annual mortality by 0.51%. If the upper 95% CI for density is considered instead, the predicted increase in mortality would be 2.48%.

494. With regard to placing annual mortality in context, the number of lesser black-backed gulls expected to die annually that are members of the largest relevant BDMPS (UK North Sea and Channel, autumn migration) is 26,335 (based on the published 'all age class' mortality rate of 12.6% (**Table 11-17**)). The biogeographic population of this species with connectivity to UK waters is 1,707,000 (Furness, 2015). The number of individuals expected to die annually from this population is 215,082 (based on the same mortality rate). The addition of the annual mean and upper 95% CI collision mortalities at SEP and DEP combined (from all seasons) would increase the BDMPS annual mortality by between 0.00% and 0.03%, and the biogeographic population annual mortality by less than 0.01%.

495. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. The small sample size of flying birds recorded across DEP as a whole (16 birds) means that any differences in encounter rate between DEP and DEP-N are highly unlikely to be statistically significant for this species. Therefore, the collision rates presented here are a reasonable representation of the worst-case scenario for DEP.

496. During the autumn migration, winter and spring migration seasons, and on a year-round basis, the increase in existing mortality of the relevant populations due to the mean predicted collision mortality at SEP and DEP is very small. During the breeding season, the increase in existing mortality due to the mean predicted collision mortality would be small. In all seasons, the predicted increase would not materially impact the existing mortality rate and would be undetectable in the context of natural variation, since the predicted mortality increases in all relevant background populations are below 1%. The magnitude of effect of collision risk for this species at SEP and DEP combined is therefore assessed as negligible for the worst-case deployment scenario.

497. Lesser black-backed gull is considered to possess a high sensitivity to collision risk. This is because it is not known to be displaced by operational OWFs (Dierschke *et al*., 2016), and occurs regularly at flight heights where collisions are possible ("Corrigendum," 2014; Johnston *et al*., 2014). However, it did not occur in the aerial survey study aerial very frequently, or in large numbers, which may limit the sensitivity of this species to collision at SEP and DEP. As a result, the impact significance is **minor adverse**.

498. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Whilst the conclusion of the assessment could result in a higher impact magnitude being assigned if the 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population, this is considered to be a highly unlikely impact magnitude to occur in multiple years.

Table 11-111: Lesser Black-Backed Gull CRM Outputs (Option 2, 0.995 Avoidance Rate) by Month

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.00	0.06	0.00	0.41	0.52	0.03	0.09	0.00	0.00	0.19	1.31
	Density	95% UCI	0.00	0.00	0.00	0.41	0.00	2.17	2.43	0.15	0.53	0.00	0.00	1.02	6.70
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.10	0.00	0.69	0.87	0.05	0.15	0.00	0.00	0.31	2.18
		95% LCI	0.00	0.00	0.00	0.05	0.00	0.32	0.40	0.02	0.07	0.00	0.00	0.14	1.00
	Avoidance Rate	-2 SD	0.00	0.00	0.00	0.07	0.00	0.49	0.63	0.04	0.11	0.00	0.00	0.22	1.57
		+2 SD	0.00	0.00	0.00	0.05	0.00	0.33	0.42	0.03	0.07	0.00	0.00	0.15	1.05
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	Mean	-	0.00	0.00	0.00	0.00	0.00	0.06	0.27	0.21	0.00	0.00	0.00	0.00	0.53
	Density	95% UCI	0.00	0.00	0.00	0.00	0.00	0.48	1.28	0.68	0.00	0.00	0.00	0.00	2.44
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.00	0.00	0.10	0.45	0.34	0.00	0.00	0.00	0.00	0.90
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.05	0.21	0.16	0.00	0.00	0.00	0.00	0.41
	Avoidance Rate	-2 SD	0.00	0.00	0.00	0.00	0.00	0.07	0.32	0.25	0.00	0.00	0.00	0.00	0.64
		+2 SD	0.00	0.00	0.00	0.00	0.00	0.05	0.22	0.16	0.00	0.00	0.00	0.00	0.43
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP and DEP	Mean	-	0.00	0.00	0.00	0.06	0.00	0.47	0.79	0.24	0.09	0.00	0.00	0.19	1.84
	Density	95% UCI	0.00	0.00	0.00	0.41	0.00	2.65	3.71	0.83	0.53	0.00	0.00	1.02	9.14
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.10	0.00	0.79	1.33	0.40	0.15	0.00	0.00	0.31	3.08
		95% LCI	0.00	0.00	0.00	0.05	0.00	0.36	0.61	0.18	0.07	0.00	0.00	0.14	1.41
	Avoidance Rate	-2 SD	0.00	0.00	0.00	0.07	0.00	0.57	0.95	0.29	0.11	0.00	0.00	0.22	2.21
		+2 SD	0.00	0.00	0.00	0.05	0.00	0.38	0.64	0.19	0.07	0.00	0.00	0.15	1.47
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-

11.6.2.2.2.4.9 Little Gull

499. The mean annual collision rate for little gull at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 4.71 (**Table 11-112**). All predicted collisions occurred in October, which falls in the non-breeding season. At SEP, the mean annual collision rate was 1.06 during the non-breeding season, and zero during the breeding season. In total, the annual mean collision rate for SEP and DEP combined was 5.78, of which all collisions were attributed to the non-breeding season.

500. Of the CRM input parameters that were varied, the one resulting in the largest effect on the predicted collision rate was the 95% CI for bird density. Using the upper 95% CI as a model input rather than the mean density estimate increased the non-breeding season (and therefore annual) collision rate for SEP and DEP combined to 19.77. Substituting the mean density with the lower 95% CI resulted in an annual collision rate of zero. Whilst the substitution of the mean flight height distribution for the respective 95% CIs also had an effect on predicted collision rates, the magnitude of the effect was less than when density estimates were varied.

501. This species is not included in Furness (2015), and is a passage period visitor to UK waters. The relevant background population for this species is the North Sea flyway population (75,000 individuals) (Stienen *et al*., 2007). Using the published adult mortality for this species (20.0%; **Table 11-17**), the number of birds expected to die annually from this population would be 15,000. The predicted increase in mortality due to collision at SEP and DEP combined is 0.04% if CRM outputs derived from mean model inputs are considered, or 0.13% if outputs derived from models using the 95% upper CI density as inputs are considered.

502. As explained in **Appendix 11.1 Offshore Ornithology Technical Report**, it was not considered possible to produce reliable and precise design-based density estimates for offshore ornithology receptors for DEP-N and DEP-S, only DEP as a whole. The small sample size of flying birds recorded across DEP as a whole (25 birds) means that any differences in encounter rate between DEP and DEP-N are highly unlikely to be statistically significant for this species. Therefore, the collision rates presented here are a reasonable representation of the worst-case scenario for DEP.

503. For all seasons and year round, the increase in existing mortality of the relevant populations due to the mean predicted collision mortality at SEP and DEP is very small. It would not materially impact the existing mortality rate and would be undetectable in the context of natural variation, since predicted annual mortality increases in the background population are less than 1%. The magnitude of effect of collision risk for this species at SEP and DEP combined is therefore assessed as negligible for the worst-case deployment scenario.

504. Little gull is considered to possess a medium sensitivity to collision risk. This is because whilst it occurs quite regularly at flight heights where collisions are possible (“Corrigendum,” 2014; Johnston *et al*., 2014), it is known to be displaced by operational OWFs (Dierschke *et al*., 2016). As a result, the impact significance is **minor adverse**.

505. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population.

Table 11-112: Little Gull CRM Outputs (Option 2, 0.980 Avoidance Rate) by Month

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.71	0.00	0.00	4.71
	Density	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.16	0.00	0.00	16.16
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.32	0.00	0.00	10.32
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26	0.00	0.00	1.26
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP	Mean	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.17	0.81	0.00	1.06
	Density	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.83	2.38	0.00	3.61
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.37	1.80	0.00	2.36
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.21	0.00	0.28
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-
SEP and DEP	Mean	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	4.88	0.81	0.00	5.78
	Density	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	16.99	2.38	0.00	19.77
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Flight Height	95% UCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	10.69	1.80	0.00	12.68
		95% LCI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	1.31	0.21	0.00	1.54
	Avoidance Rate	-2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
		+2 SD	-	-	-	-	-	-	-	-	-	-	-	-	-
	Noct. Act.	EB	-	-	-	-	-	-	-	-	-	-	-	-	-

11.6.2.2.2.4.10 Sandwich tern

Overview

506. Sandwich tern is a key receptor for the assessment. A wide range of potential CRM input parameters were available, which has resulted in a large number of CRM iterations being presented. These are:

- Two sets of density estimates (design-based density estimates of birds in flight, and model-based density estimates of all birds as requested by Natural England). CRM outputs produced using the mean and 95% CIs from both datasets are presented. In addition, for model-based density estimation it was possible to produce outputs for both DEP as a whole, and DEP-N only. This has been presented despite the assessment of density estimation methods in **Appendix 11.1 Offshore Ornithology Technical Report** concluding that differences in Sandwich tern density between DEP and DEP-N are not statistically significant.
- Two flight height distributions, enabling the production of Option 1 (Harwood, 2021) and Option 2 ("Corrigendum," 2014; Johnston *et al*., 2014) CRMs. Model outputs produced using both datasets are presented.
- Three flight speed estimates. Two of these are from published material. The first has historically been used for Sandwich tern CRM (Christensen and Hounisen, 2005, 2004). The second (Fijn and Gyimesi, 2018) is considered to be the most robust published data, and was obtained from GPS tagging of birds at a Dutch colony. The third (Fijn and Collier, 2020), which was produced specifically for this assessment, uses very similar methods to the second study, but was carried out on birds breeding at Scolt Head. This is considered by the Applicant to represent the best available data. Natural England requested further information on the calculation of these flight speeds before they could be accepted (**Table 11-1**), this information has therefore been provided in **Appendix 11.1 Offshore Ornithology Technical Report**. CRMs using the mean flight speeds of both Fijn and Gyimesi (2018) and Fijn and Collier (2020) are presented.
- Two nocturnal activity estimates. The first (0%) is an estimate from published material (Stienen *et al*., 2000), which has previously been used in Sandwich tern CRM at other OWFs. The second, slightly higher value (2%) was estimated from GPS tag data collected from birds breeding at Scolt Head (the same dataset used to estimate flight speed). The value represents the average nocturnal activity occurring within seven OWFs in The Wash, and is considered to represent the best available data. As a result, all CRMs utilise the nocturnal activity of 2%.

507. The background to all of these parameters is explained in detail in **Appendix 11.1 Offshore Ornithology Technical Report**.

508. CRMs presented in the sections that precede the "Realistic Worst-case Scenario" section below incorporate input parameters that were agreed during the stakeholder consultation process. As well as providing collision estimates for Sandwich tern, an assessment of the sensitivity of the CRM to different parameters is also provided.

509. The "Realistic Worst-case Scenario" section provides what are considered to be the most realistic CRM outputs, and are the models on which population modelling and assessment conclusions are based.

CRM Results and Discussion of Model Sensitivity

510. Using the input parameters recommended by Natural England, Option 1 of the Band Model with the flight height distribution calculated by Harwood (2021), the flight speeds of Fijn and Gyimesi (2018), and design-based density estimates (**Table 11-113**), the mean annual collision rate for Sandwich tern at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 9.09. At SEP, the mean annual collision rate under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 2.25. In total, the annual mean collision rate for SEP and DEP combined under the worst-case scenario was 11.34. Using the upper 95% CI density estimate as a model input rather than the mean density estimate increased the annual collision rate for DEP to 27.18, a 199% increase from the CRM which used the mean density estimate. At SEP, the equivalent change to input parameters resulted in an annual collision rate of 7.50, or a 233% increase from the CRM which used the mean density estimate. Substituting the mean density estimate with the lower 95% CI density estimate resulted in an annual collision rate of 1.08 at DEP, and 0.10 at SEP, or reductions from the mean density estimate CRM of 88% and 96% respectively.

511. Using the same input parameters but with model-based density estimates (**Table 11-114**), the mean annual collision rate for Sandwich tern at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 10.70, assuming turbines will be deployed across the northern and southern areas of DEP. The model-based density estimates enabled density estimates for DEP-N and DEP-S to be produced, and also CRMs. If it is assumed that all turbines are in fact installed in DEP-N only, rather than across both DEP array areas, the year round collision risk for Sandwich tern using these parameters increases to 14.46 (95% CIs 7.59 to 24.13). This represents an increase in predicted collision risk of approximately 30%. It should be noted that the assessment of density estimation methods in **Appendix 11.1 Offshore Ornithology Technical Report** concluded that differences in Sandwich tern density between DEP and DEP-N are not statistically significant.

512. At SEP, the mean annual collision rate under the worst-case scenario was 3.38. In total, the annual mean collision rate for SEP and DEP combined under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 14.08. Using the upper 95% CI density estimate as a model input rather than the mean density estimate increased the annual collision rate for DEP to 18.43, a 72% increase from the CRM which used the mean density estimate. At SEP, the equivalent change resulted in an annual collision rate of 6.32, or an 87% increase. Substituting the mean density estimate with the lower 95% CI density estimate resulted in an annual collision rate of 5.88

at DEP, and 1.87 at SEP, or reductions from the mean density estimate CRM of 45%.

513. At DEP, the mean annual CRM collision rate using the model-based densities was approximately 20% higher than the equivalent model outputs using design-based densities. At SEP, CRMs using the mean model-based density estimate resulted in the prediction of 50% more annual collisions than the equivalent design-based density estimate CRM. The CRMs using the 95% CI density estimates were considerably closer to the mean density estimate CRMs in the model-based density estimate CRMs than the design-based equivalents. When CRMs were produced using model-based density estimates, the 95% lower CIs were larger (around 400% larger in the case of DEP, and 1,800% larger at SEP), and the 95% upper CIs were smaller (around 30% smaller in the case of DEP, and 15% smaller at SEP).

514. Much of the differences between the two sets of density estimates (and particularly the tighter CIs of the model-based density estimates) are a result of the different methodologies used to calculate them. Whilst there is no clear pattern of one method consistently producing higher or lower density estimates at SEP or DEP across all surveys, the model-based estimates tended to produce considerably higher density estimates on several occasions across both OWFs. This caused an increase in the annual collision rate.

515. In order to generate model-based densities for any given survey, certain conditions within the dataset must be satisfied, one of which relates to numbers of observations. Model-based density estimates cannot be produced if too few observations exist in a particular survey dataset. Therefore, two surveys where fewer Sandwich tern observations were made (in this case the surveys in August 2018, September 2018) have been omitted from the model-based density estimation process. Conversely, design-based density estimates were able to be produced for these surveys. This results in larger mean density estimates being produced, and therefore increased numbers of predicted collisions. However, these months were not the main contributors to annual collision risk for Sandwich tern. It should also be noted that the dataset used to produce the model-based densities included all birds, whilst the design-based density estimates omitted birds on the water from the calculations. Of the 1,710 Sandwich tern observations made during the SEP and DEP baseline surveys, 1,676 (98%) were of birds in flight. The inclusion of the extra birds is not considered to materially affect the assessment, but will increase densities, and therefore predicted collisions, slightly.

516. The use of the flight speed of Fijn and Collier (2020) reduced the collision rate by approximately 17% compared with models that used the flight speed estimate of Fijn and Gyimesi (2018). The Harwood (2021) dataset did not include 95% CI distributions which were appropriate to include in separate CRM runs.

Table 11-113: Sandwich Tern CRM Outputs (Option 1) by Month using Design-Based Density Estimates

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.00	2.14	3.57	0.85	1.75	0.48	0.31	0.00	0.00	0.00	9.09
	Density	95% UCI	0.00	0.00	0.00	9.02	7.66	2.26	5.22	1.53	1.50	0.00	0.00	0.00	27.18
		95% LCI	0.00	0.00	0.00	0.00	0.96	0.11	0.00	0.00	0.00	0.00	0.00	0.00	1.08
	Flight Height	95% UCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
		95% LCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	1.79	2.98	0.71	1.46	0.40	0.25	0.00	0.00	0.00	7.58
SEP	Mean	-	0.00	0.00	0.00	0.03	0.74	0.46	0.87	0.11	0.04	0.00	0.00	0.00	2.25
	Density	95% UCI	0.00	0.00	0.00	0.19	1.60	1.11	3.95	0.40	0.25	0.00	0.00	0.00	7.50
		95% LCI	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
	Flight Height	95% UCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
		95% LCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	0.02	0.62	0.39	0.72	0.09	0.03	0.00	0.00	0.00	1.88
SEP and DEP	Mean	-	0.00	0.00	0.00	2.17	4.31	1.31	2.62	0.59	0.35	0.00	0.00	0.00	11.34
	Density	95% UCI	0.00	0.00	0.00	9.21	9.26	3.37	9.17	1.93	1.75	0.00	0.00	0.00	34.68
		95% LCI	0.00	0.00	0.00	0.00	1.06	0.11	0.00	0.00	0.00	0.00	0.00	0.00	1.18
	Flight Height	95% UCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
		95% LCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	1.81	3.6	1.1	2.18	0.49	0.28	0.00	0.00	0.00	9.46

Table 11-114: Sandwich Tern CRM Outputs (Option 1) by Month using Model-Based Density Estimates

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.00	2.44	3.14	1.41	2.64	0.32	0.75	0.00	0.00	0.00	10.70
	Density	95% UCI	0.00	0.00	0.00	4.75	4.77	2.57	3.85	0.72	1.77	0.00	0.00	0.00	18.43
		95% LCI	0.00	0.00	0.00	1.08	1.95	0.70	1.77	0.12	0.26	0.00	0.00	0.00	5.88
	Flight Height	95% UCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
		95% LCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	2.04	2.62	1.18	2.20	0.26	0.63	0.00	0.00	0.00	8.92
SEP	Mean	-	0.00	0.00	0.00	0.05	0.80	0.87	1.41	0.13	0.13	0.00	0.00	0.00	3.38
	Density	95% UCI	0.00	0.00	0.00	0.22	1.39	1.92	2.07	0.37	0.35	0.00	0.00	0.00	6.32
		95% LCI	0.00	0.00	0.00	0.01	0.45	0.34	1.00	0.03	0.04	0.00	0.00	0.00	1.87
	Flight Height	95% UCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
		95% LCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	0.05	0.67	0.72	1.18	0.10	0.10	0.00	0.00	0.00	2.82
SEP and DEP	Mean	-	0.00	0.00	0.00	2.49	3.94	2.28	4.05	0.45	0.88	0.00	0.00	0.00	14.08
	Density	95% UCI	0.00	0.00	0.00	4.97	6.16	4.49	5.92	1.09	2.12	0.00	0.00	0.00	24.75
		95% LCI	0.00	0.00	0.00	1.09	2.40	1.04	2.77	0.15	0.30	0.00	0.00	0.00	7.75
	Flight Height	95% UCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
		95% LCI	-	-	-	-	-	-	-	-	-	-	-	-	0.00
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	2.09	3.29	1.9	3.38	0.36	0.73	0.00	0.00	0.00	11.74

517. Using the input parameters recommended by Natural England, Option 2 of the Band Model ("Corrigendum," 2014; Johnston *et al*., 2014), the flight speeds of Fijn and Gyimesi (2018), and design-based density estimates (**Table 11-115**), the mean annual collision rate for Sandwich tern at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 3.98. At SEP, the mean annual collision rate under the worst-case scenario (**Table 11-2** and **Table 11-3**) was 1.01. In total, the annual mean collision rate for SEP and DEP combined under the worst-case scenario was 4.99.

518. The use of the Option 2 flight height distribution reduces the predicted annual collisions by approximately 55% for all model iterations when compared with CRMs produced using the flight height distribution of Harwood (2021).

519. Variations in the Option 2 CRM outputs due to the use of 95% CI density estimates, model-based density estimates, and the more recently calculated flight speed for Sandwich tern were as per the Option 1 CRMs.

Table 11-115: Sandwich Tern CRM Outputs (Option 2) by Month using Design-Based Density Estimates

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.00	0.94	1.56	0.37	0.77	0.21	0.13	0.00	0.00	0.00	3.98
	Density	95% UCI	0.00	0.00	0.00	3.95	3.35	0.99	2.29	0.67	0.66	0.00	0.00	0.00	11.90
		95% LCI	0.00	0.00	0.00	0.00	0.42	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.47
	Flight Height	95% UCI	0.00	0.00	0.00	3.26	5.42	1.29	2.66	0.72	0.46	0.00	0.00	0.00	13.82
		95% LCI	0.00	0.00	0.00	0.75	1.24	0.30	0.61	0.17	0.11	0.00	0.00	0.00	3.17
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	0.78	1.30	0.31	0.64	0.17	0.11	0.00	0.00	0.00	3.32
SEP	Mean	-	0.00	0.00	0.00	0.01	0.33	0.21	0.39	0.05	0.02	0.00	0.00	0.00	1.01
	Density	95% UCI	0.00	0.00	0.00	0.09	0.72	0.50	1.78	0.18	0.11	0.00	0.00	0.00	3.37
		95% LCI	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
	Flight Height	95% UCI	0.00	0.00	0.00	0.05	1.17	0.73	1.37	0.18	0.06	0.00	0.00	0.00	3.56
		95% LCI	0.00	0.00	0.00	0.01	0.26	0.17	0.31	0.04	0.01	0.00	0.00	0.00	0.80
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	0.01	0.28	0.17	0.33	0.04	0.02	0.00	0.00	0.00	0.84
SEP and DEP	Mean	-	0.00	0.00	0.00	0.95	1.89	0.58	1.16	0.26	0.15	0.00	0.00	0.00	4.99
	Density	95% UCI	0.00	0.00	0.00	4.04	4.07	1.49	4.07	0.85	0.77	0.00	0.00	0.00	15.27
		95% LCI	0.00	0.00	0.00	0.00	0.48	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.53
	Flight Height	95% UCI	0.00	0.00	0.00	3.31	6.59	2.02	4.03	0.90	0.52	0.00	0.00	0.00	17.38
		95% LCI	0.00	0.00	0.00	0.76	1.50	0.47	0.92	0.21	0.12	0.00	0.00	0.00	3.97
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	0.79	1.58	0.48	0.97	0.21	0.13	0.00	0.00	0.00	4.16

Table 11-116: Sandwich Tern CRM Outputs (Option 2) by Month using Model-Based Density Estimates

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean	-	0.00	0.00	0.00	1.07	1.37	0.62	1.15	0.14	0.33	0.00	0.00	0.00	4.69
	Density	95% UCI	0.00	0.00	0.00	2.11	2.11	1.14	1.70	0.32	0.79	0.00	0.00	0.00	8.17
		95% LCI	0.00	0.00	0.00	0.47	0.86	0.30	0.77	0.05	0.12	0.00	0.00	0.00	2.58
	Flight Height	95% UCI	0.00	0.00	0.00	3.71	4.77	2.15	4.01	0.48	1.15	0.00	0.00	0.00	16.26
		95% LCI	0.00	0.00	0.00	0.85	1.09	0.49	0.92	0.11	0.26	0.00	0.00	0.00	3.73
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	0.89	1.15	0.52	0.96	0.12	0.28	0.00	0.00	0.00	3.90
SEP	Mean	-	0.00	0.00	0.00	0.02	0.36	0.39	0.64	0.06	0.06	0.00	0.00	0.00	1.52
	Density	95% UCI	0.00	0.00	0.00	0.10	0.62	0.86	0.93	0.17	0.16	0.00	0.00	0.00	2.84
		95% LCI	0.00	0.00	0.00	0.00	0.20	0.15	0.45	0.01	0.02	0.00	0.00	0.00	0.84
	Flight Height	95% UCI	0.00	0.00	0.00	0.09	1.26	1.37	2.23	0.20	0.20	0.00	0.00	0.00	5.34
		95% LCI	0.00	0.00	0.00	0.02	0.29	0.31	0.50	0.04	0.04	0.00	0.00	0.00	1.21
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	0.02	0.30	0.32	0.53	0.05	0.05	0.00	0.00	0.00	1.27
SEP and DEP	Mean	-	0.00	0.00	0.00	1.09	1.73	1.01	1.79	0.20	0.39	0.00	0.00	0.00	6.21
	Density	95% UCI	0.00	0.00	0.00	2.21	2.73	2.00	2.63	0.49	0.95	0.00	0.00	0.00	11.01
		95% LCI	0.00	0.00	0.00	0.47	1.06	0.45	1.22	0.06	0.14	0.00	0.00	0.00	3.42
	Flight Height	95% UCI	0.00	0.00	0.00	3.80	6.03	3.52	6.24	0.68	1.35	0.00	0.00	0.00	21.60
		95% LCI	0.00	0.00	0.00	0.87	1.38	0.80	1.42	0.15	0.30	0.00	0.00	0.00	4.94
	Flight Speed	Fijn/Collier (2020)	0.00	0.00	0.00	0.91	1.45	0.84	1.49	0.17	0.33	0.00	0.00	0.00	5.17

520. During the autumn and spring migration seasons, the relevant background Sandwich tern population is the UK North Sea and Channel BDMPS, which consist of 38,051 individuals. Using the published all age class mortality rate of 24.0% (**Table 11-17**), the number of birds expected to die annually from this population would be 9,132. Using Option 1 CRMs produced with design-based density estimates, the mean collision mortality of SEP and DEP combined during the respective seasons in question (i.e. autumn only, since Sandwich terns were absent from SEP and DEP in spring) would result in a mortality increase of 0.00%, or 0.02% if the outputs obtained using the upper 95% CI density estimate were considered. For CRMs produced using model-based density estimates, the equivalent mortality increases are 0.01% and 0.02%. Using Option 2 CRMs produced with design-based or model-based density estimates, the mean collision mortality of SEP and DEP combined during the respective seasons in question (i.e. autumn only, since Sandwich terns were absent from SEP and DEP in spring) would result in a mortality increase of 0.00%, or 0.01% if the outputs obtained using the upper 95% CI density estimate were considered.

521. During the breeding season, the relevant background population is the breeding adult population of the North Norfolk Coast SPA (9,443 birds on average during 2018 and 2019, when the baseline surveys were carried out). Using the published adult mortality rate of 10.2% (**Table 11-17**), the number of birds expected to die annually from this population would be 963.

522. Collision mortality from DEP would increase existing mortality within this population by 0.91% and 2.67%, when Option 1 CRMs using mean and upper 95% CI design-based densities are used as CRM input parameters. Mortality rate increases of 0.40% and 1.17% result from the use of the same parameters using Option 2 of the Band model. Using the corresponding model-based densities as CRM inputs results in mortality increases of 1.03% (mean density estimates) and 1.73% (upper 95% CI density estimate) when Option 1 CRM is used, and 0.45% (mean density estimates) and 0.77% (upper 95% CI density estimate) when Option 2 CRM is used. Using Option 1, and assuming that all turbines at DEP will be installed in DEP-N (rather than across both DEP array areas), breeding season collision risk is predicted to increase existing mortality levels by 1.38% (mean collision rate) or 2.23% (upper 95% CI collision rate).

523. Collision mortality from SEP would increase existing mortality within this population by 0.23% and 0.75%, when Option 1 CRMs using mean and upper 95% CI design-based densities are used as CRM input parameters. Mortality rate increases of 0.10% and 0.34% result from the use of the same parameters using Option 2 of the Band model. Using the corresponding model-based densities as CRM inputs results in mortality increases of 0.34% (mean density estimates) and 0.62% (upper 95% CI density estimate) using Option 1 of the Band model, and 0.15% (mean density estimates) and 0.28% (upper 95% CI density estimate) when Option 2 CRM is used.

524. Using Option 1 CRMs, collision mortality from SEP and DEP would increase existing mortality within this population by 1.14% when mean design-based densities are used as CRM input parameters, or 1.37% when the corresponding model-based densities are used as CRM inputs (or 1.61% if it is assumed all of DEP's turbines will be installed within DEP-N). Using Option 2 of the Band model, collision mortality

from SEP and DEP would increase existing mortality within this population by 0.50% when mean design-based densities are used as CRM input parameters, or 0.60% when the corresponding model-based densities are used as CRM inputs.

525. With regard to placing annual mortality in context, two populations are considered. Firstly, the autumn and spring migration UK North Sea and Channel BDMPS of 38,051 individuals (with an annual mortality rate of 9,132 based on the published all age class mortality rate of 24.0% (**Table 11-17**)). Secondly, the biogeographic population of this species with connectivity to UK waters, which consists of 148,000 birds (Furness, 2015), with an annual mortality of 35,520 based on the published all age class mortality rate of 24.0% (**Table 11-17**).

526. For Option 1 CRMs, the addition of the annual mean and upper 95% CI collision mortalities for SEP and DEP combined to existing levels of mortality from these populations, increases the autumn UK North Sea and Channel BDMPS annual mortality by between 0.12% and 0.38% (using CRMs calculated using design-based density estimates) or 0.15% to 0.27% (using CRMs calculated using model-based density estimates). If it is presumed that all of DEP's turbines are installed within DEP-N, the predicted mortality increases are 0.17% to 0.30%. Mortality within the biogeographic population would increase by between 0.03% and 0.10% (using CRMs calculated using design-based density estimates). or 0.04% to 0.07% (using CRMs calculated using model-based density estimates).

527. For Option 2 CRMs, the addition of the annual mean and upper 95% CI collision mortalities for SEP and DEP combined to existing levels of mortality from these populations, increases the autumn UK North Sea and Channel BDMPS annual mortality by between 0.05% and 0.17% (using CRMs calculated using design-based density estimates) or 0.07% to 0.12% (using CRMs calculated using model-based density estimates). Mortality within the biogeographic population would increase by between 0.01% and 0.04% (using CRMs calculated using design-based density estimates). or 0.02% to 0.03% (using CRMs calculated using model-based density estimates).

Realistic Worst-Case Scenario

528. This section contains a set of what are considered to be realistic worst-case model outputs. Many of the model input parameters (e.g. OWF design, most biometric parameters and avoidance rate) remain unchanged from those presented earlier in this section. Of the parameters for which multiple iterations were available, the following have been selected for the realistic worst-case scenario CRM:

- CRMs using both design-based and model-based density estimates are included, since the precision of both sets of density estimates is similar.

- For reasons discussed in **Appendix 11.1 Offshore Ornithology Technical Report**, it is considered that the flight height distribution dataset produced by Harwood (2021) represents the best available evidence for North Norfolk Coast SPA Sandwich tern flight height distribution during the breeding season. The data are relatively recent, were collected in the same geographical area in which SEP and DEP are located, and recorded birds from the colony that will be impacted, at the time of year during which collision risk is predicted to be greatest. This flight height distribution has therefore been incorporated into all CRMs presented in this section. The Option 2 CRM flight height distribution ("Corrigendum," 2014; Johnston *et al*., 2014) indicates that during passage seasons, birds may fly at lower heights, which could lead to potential overestimation of collision risk during September in the CRMs presented below. However, given that collision risk is greatest during the breeding season this is unlikely to materially change the conclusions of the assessment.
- The mean Sandwich tern flight speed of Fijn and Collier (2020) is considered to represent the best available data, and is therefore used by the CRMs presented in this section. Further detail on the methodology used to calculate this flight speed is provided in **Appendix 11.1 Offshore Ornithology Technical Report**. The mean value calculated by this study was 8.2 m/s, which was calculated from mean foraging flight speeds of 7.9 m/s, and commuting flight speeds of 8.5 m/s. It should be noted that the use of the mean flight speed will result in collision risk being overestimated in areas such as DEP, where foraging has been shown to be the most commonly undertaken activity, by 2.8% (**Appendix 11.1 Offshore Ornithology Technical Report**).
- The nocturnal activity factor of 2%, calculated from the DOW OMP data (**Appendix 11.1 Offshore Ornithology Technical Report**), is included in all realistic worst-case calculations, again because it represents the best available evidence.

529. Finally, whilst the avoidance rate remains 0.980, outputs incorporating macro-avoidance correction factors of 0.250 and 0.500 are presented to account for potential operational phase displacement, alongside uncorrected collision estimates. This range has been selected due to information presented in the DOW OMP (which suggests a range of zero to 0.50 might be appropriate depending on the behaviour associated with a particular area), Cook *et al*. (2014), Krijgsveld *et al*. (2011) (which suggested a macro-avoidance rate of 0.28 based on three years of radar data, though this rate was not species-specific), and Harwood *et al*. (2018) (which suggested a species-specific macro-avoidance rate of 0.31 to 0.42 based on one year of baseline and three years of operational phase boat-based survey data from SOW). In addition, assessment of the model-based density estimates for Sandwich tern (**Appendix 11.1 Offshore Ornithology Technical Report**) indicates that during the baseline surveys, there was a potentially strong displacement effect at SOW (between 0.70 to 1.00 when compared with the area surrounding the OWF), and DOW (between 0.36 to 1.00 when compared with the area surrounding the

OWF, though the OWF contained more birds than the surrounding area on two of the nine surveys included in the analysis). However, due to the relatively small numbers of birds involved, no statistical significance could be attached to these observations.

530. The annual collisions rate for Sandwich tern at SEP, SEP and DEP and DEP combined under the worst-case scenario (**Table 11-2** and **Table 11-3**) are presented in **Table 11-117** for CRMs using design-based density estimates, and **Table 11-118** for CRMs using model-based density estimates. These models assumed that turbines will be installed across both DEP array areas. Finally, the collision rates presented in **Table 11-119** have been calculated using model-based density estimates, if it is assumed that within DEP, turbines are installed at DEP-N only. The CRMs using mean density estimates and 95% CIs are presented separately with their respective collision rates with macro-avoidance correction factors applied.

Table 11-117: Realistic Worst-Case Sandwich Tern CRM Outputs at SEP and DEP by Month, using Design-Based Density Estimates

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean density	No MA	0.00	0.00	0.00	1.79	2.98	0.71	1.46	0.40	0.25	0.00	0.00	0.00	7.58
		25% MA	0.00	0.00	0.00	1.34	2.23	0.53	1.09	0.30	0.19	0.00	0.00	0.00	5.69
		50% MA	0.00	0.00	0.00	0.89	1.49	0.35	0.73	0.20	0.13	0.00	0.00	0.00	3.79
	95% up. CI density	No MA	0.00	0.00	0.00	7.52	6.38	1.88	4.35	1.28	1.25	0.00	0.00	0.00	22.66
		25% MA	0.00	0.00	0.00	5.64	4.79	1.41	3.26	0.96	0.94	0.00	0.00	0.00	17.00
		50% MA	0.00	0.00	0.00	3.76	3.19	0.94	2.18	0.64	0.62	0.00	0.00	0.00	11.33
	95% lower CI density	No MA	0.00	0.00	0.00	0.00	0.80	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.90
		25% MA	0.00	0.00	0.00	0.00	0.60	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.67
		50% MA	0.00	0.00	0.00	0.00	0.40	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.45
SEP	Mean density	No MA	0.00	0.00	0.00	0.02	0.62	0.39	0.72	0.09	0.03	0.00	0.00	0.00	1.88
		25% MA	0.00	0.00	0.00	0.02	0.46	0.29	0.54	0.07	0.03	0.00	0.00	0.00	1.41
		50% MA	0.00	0.00	0.00	0.01	0.31	0.19	0.36	0.05	0.02	0.00	0.00	0.00	0.94
	95% up. CI density	No MA	0.00	0.00	0.00	0.16	1.33	0.93	3.29	0.33	0.21	0.00	0.00	0.00	6.25
		25% MA	0.00	0.00	0.00	0.12	1.00	0.70	2.47	0.25	0.16	0.00	0.00	0.00	4.69

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
		50% MA	0.00	0.00	0.00	0.08	0.67	0.46	1.65	0.16	0.10	0.00	0.00	0.00	3.13
	95% lower CI density	No MA	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
		25% MA	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
		50% MA	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
SEP and DEP	Mean density	No MA	0.00	0.00	0.00	1.81	3.59	1.09	2.18	0.49	0.29	0.00	0.00	0.00	9.46
		25% MA	0.00	0.00	0.00	1.36	2.69	0.82	1.64	0.37	0.22	0.00	0.00	0.00	7.09
		50% MA	0.00	0.00	0.00	0.91	1.80	0.55	1.09	0.25	0.14	0.00	0.00	0.00	4.73
	95% up. CI density	No MA	0.00	0.00	0.00	7.68	7.72	2.81	7.64	1.61	1.46	0.00	0.00	0.00	28.91
		25% MA	0.00	0.00	0.00	5.76	5.79	2.11	5.73	1.21	1.09	0.00	0.00	0.00	21.68
		50% MA	0.00	0.00	0.00	3.84	3.86	1.41	3.82	0.80	0.73	0.00	0.00	0.00	14.46
	95% lower CI density	No MA	0.00	0.00	0.00	0.00	0.91	0.10	0.00	0.00	0.00	0.00	0.00	0.00	1.00
		25% MA	0.00	0.00	0.00	0.00	0.68	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.75
		50% MA	0.00	0.00	0.00	0.00	0.45	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.50

Table 11-118: Realistic Worst-Case Sandwich Tern CRM Outputs at SEP and DEP by Month, using Model-Based Density Estimates

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean density	No MA	0.00	0.00	0.00	2.04	2.62	1.18	2.20	0.26	0.63	0.00	0.00	0.00	8.92
		25% MA	0.00	0.00	0.00	1.53	1.96	0.88	1.65	0.20	0.47	0.00	0.00	0.00	6.69
		50% MA	0.00	0.00	0.00	1.02	1.31	0.59	1.10	0.13	0.31	0.00	0.00	0.00	4.46
	95% up. CI density	No MA	0.00	0.00	0.00	4.01	4.02	2.16	3.24	0.61	1.51	0.00	0.00	0.00	15.55
		25% MA	0.00	0.00	0.00	3.01	3.01	1.62	2.43	0.45	1.13	0.00	0.00	0.00	11.66
		50% MA	0.00	0.00	0.00	2.01	2.01	1.08	1.62	0.30	0.75	0.00	0.00	0.00	7.77
	95% lower CI density	No MA	0.00	0.00	0.00	0.90	1.63	0.58	1.48	0.10	0.22	0.00	0.00	0.00	4.90
		25% MA	0.00	0.00	0.00	0.67	1.22	0.44	1.11	0.08	0.16	0.00	0.00	0.00	3.68
		50% MA	0.00	0.00	0.00	0.45	0.81	0.29	0.74	0.05	0.11	0.00	0.00	0.00	2.45
SEP	Mean density	No MA	0.00	0.00	0.00	0.05	0.67	0.72	1.18	0.10	0.10	0.00	0.00	0.00	2.82
		25% MA	0.00	0.00	0.00	0.03	0.50	0.54	0.88	0.08	0.08	0.00	0.00	0.00	2.11
		50% MA	0.00	0.00	0.00	0.02	0.33	0.36	0.59	0.05	0.05	0.00	0.00	0.00	1.41
	95% up. CI density	No MA	0.00	0.00	0.00	0.18	1.16	1.60	1.73	0.31	0.29	0.00	0.00	0.00	5.27
		25% MA	0.00	0.00	0.00	0.14	0.87	1.20	1.30	0.23	0.22	0.00	0.00	0.00	3.95

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
		50% MA	0.00	0.00	0.00	0.09	0.58	0.80	0.86	0.16	0.15	0.00	0.00	0.00	2.63
	95% lower CI density	No MA	0.00	0.00	0.00	0.01	0.37	0.28	0.84	0.03	0.03	0.00	0.00	0.00	1.56
		25% MA	0.00	0.00	0.00	0.00	0.28	0.21	0.63	0.02	0.02	0.00	0.00	0.00	1.17
		50% MA	0.00	0.00	0.00	0.00	0.19	0.14	0.42	0.01	0.01	0.00	0.00	0.00	0.78
SEP and DEP	Mean density	No MA	0.00	0.00	0.00	2.08	3.28	1.90	3.38	0.37	0.73	0.00	0.00	0.00	11.74
		25% MA	0.00	0.00	0.00	1.56	2.46	1.43	2.53	0.28	0.55	0.00	0.00	0.00	8.81
		50% MA	0.00	0.00	0.00	1.04	1.64	0.95	1.69	0.18	0.37	0.00	0.00	0.00	5.87
	95% up. CI density	No MA	0.00	0.00	0.00	4.20	5.18	3.76	4.97	0.92	1.80	0.00	0.00	0.00	20.82
		25% MA	0.00	0.00	0.00	3.15	3.88	2.82	3.73	0.69	1.35	0.00	0.00	0.00	15.61
		50% MA	0.00	0.00	0.00	2.10	2.59	1.88	2.49	0.46	0.90	0.00	0.00	0.00	10.41
	95% lower CI density	No MA	0.00	0.00	0.00	0.91	2.00	0.86	2.31	0.13	0.25	0.00	0.00	0.00	6.46
		25% MA	0.00	0.00	0.00	0.68	1.50	0.65	1.73	0.09	0.19	0.00	0.00	0.00	4.85
		50% MA	0.00	0.00	0.00	0.45	1.00	0.43	1.16	0.06	0.12	0.00	0.00	0.00	3.23

Table 11-119: Realistic Worst-Case Sandwich Tern CRM Outputs at SEP and DEP by Month, using Model-Based Density Estimates and Assuming that at DEP, Maximum Number of Turbines Installed in DEP-N Only

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
DEP	Mean density	No MA	0.00	0.00	0.00	2.63	3.12	1.67	2.99	0.18	0.92	0.00	0.00	0.00	11.51
		25% MA	0.00	0.00	0.00	1.98	2.34	1.26	2.24	0.13	0.69	0.00	0.00	0.00	8.63
		50% MA	0.00	0.00	0.00	1.32	1.56	0.84	1.50	0.09	0.46	0.00	0.00	0.00	5.76
	95% up. CI density	No MA	0.00	0.00	0.00	5.22	4.82	3.04	4.36	0.51	2.18	0.00	0.00	0.00	20.12
		25% MA	0.00	0.00	0.00	3.91	3.61	2.28	3.27	0.38	1.63	0.00	0.00	0.00	15.09
		50% MA	0.00	0.00	0.00	2.61	2.41	1.52	2.18	0.25	1.09	0.00	0.00	0.00	10.06
	95% lower CI density	No MA	0.00	0.00	0.00	1.15	1.93	0.83	2.04	0.05	0.32	0.00	0.00	0.00	6.33
		25% MA	0.00	0.00	0.00	0.87	1.45	0.62	1.53	0.03	0.24	0.00	0.00	0.00	4.75
		50% MA	0.00	0.00	0.00	0.58	0.97	0.42	1.02	0.02	0.16	0.00	0.00	0.00	3.16
SEP	Mean density	No MA	0.00	0.00	0.00	0.05	0.67	0.72	1.18	0.10	0.10	0.00	0.00	0.00	2.82
		25% MA	0.00	0.00	0.00	0.03	0.50	0.54	0.88	0.08	0.08	0.00	0.00	0.00	2.11
		50% MA	0.00	0.00	0.00	0.02	0.33	0.36	0.59	0.05	0.05	0.00	0.00	0.00	1.41
	95% up. CI density	No MA	0.00	0.00	0.00	0.18	1.16	1.60	1.73	0.31	0.29	0.00	0.00	0.00	5.27
		25% MA	0.00	0.00	0.00	0.14	0.87	1.20	1.30	0.23	0.22	0.00	0.00	0.00	3.95

Site	Variable		J	F	M	A	M	J	J	A	S	O	N	D	Total
		50% MA	0.00	0.00	0.00	0.09	0.58	0.80	0.86	0.16	0.15	0.00	0.00	0.00	2.63
	95% lower CI density	No MA	0.00	0.00	0.00	0.01	0.37	0.28	0.84	0.03	0.03	0.00	0.00	0.00	1.56
		25% MA	0.00	0.00	0.00	0.00	0.28	0.21	0.63	0.02	0.02	0.00	0.00	0.00	1.17
		50% MA	0.00	0.00	0.00	0.00	0.19	0.14	0.42	0.01	0.01	0.00	0.00	0.00	0.78
SEP and DEP	Mean density	No MA	0.00	0.00	0.00	2.68	3.79	2.39	4.17	0.28	1.02	0.00	0.00	0.00	14.33
		25% MA	0.00	0.00	0.00	2.01	2.84	1.80	3.12	0.21	0.77	0.00	0.00	0.00	10.74
		50% MA	0.00	0.00	0.00	1.34	1.89	1.20	2.09	0.14	0.51	0.00	0.00	0.00	7.16
	95% up. CI density	No MA	0.00	0.00	0.00	5.40	5.98	4.64	6.09	0.82	2.47	0.00	0.00	0.00	25.39
		25% MA	0.00	0.00	0.00	4.05	4.48	3.48	4.57	0.61	1.85	0.00	0.00	0.00	19.05
		50% MA	0.00	0.00	0.00	2.70	2.99	2.32	3.04	0.41	1.24	0.00	0.00	0.00	12.70
	95% lower CI density	No MA	0.00	0.00	0.00	1.16	2.30	1.11	2.88	0.08	0.35	0.00	0.00	0.00	7.89
		25% MA	0.00	0.00	0.00	0.87	1.73	0.83	2.16	0.05	0.26	0.00	0.00	0.00	5.91
		50% MA	0.00	0.00	0.00	0.58	1.16	0.56	1.44	0.03	0.17	0.00	0.00	0.00	3.93

531. At DEP, the mean annual collision rate obtained from the design-based density estimate CRMs was 7.58 (95% CIs 0.90 to 22.66) assuming no macro-avoidance, 5.69 (95% CIs 0.67 to 17.00) assuming 25% macro-avoidance, and 3.79 (95% CIs 0.45 to 11.33) assuming 50% macro-avoidance. The mean collision rate obtained from the model-based density estimate CRMs was 8.92 (95% CIs 4.90 to 15.55) assuming no macro-avoidance, 6.69 (95% CIs 3.68 to 11.66) assuming 25% macro-avoidance, and 4.46 (95% CIs 2.45 to 7.77) assuming 50% macro-avoidance, assuming that turbines will be installed across both DEP-N and DEP-S. If it is assumed that all turbines will be installed at DEP-N, the mean collision rate was 11.51 (95% CIs 6.33 to 20.12) assuming no macro-avoidance, 8.63 (95% CIs 4.75 to 15.09) assuming 25% macro-avoidance, and 5.76 (95% CIs 3.16 to 10.06) assuming 50% macro-avoidance. If all turbines were installed at DEP-N rather than across DEP as a whole, collision risk for this species would increase by approximately 30%.

532. At SEP, the mean annual collision rate obtained from the design-based density estimate CRMs was 1.88 (95% CIs 0.10 to 6.25) assuming no macro-avoidance, 1.41 (95% CIs 0.08 to 4.69) assuming 25% macro-avoidance, and 0.94 (95% CIs 0.05 to 3.13) assuming 50% macro-avoidance. The mean collision rate obtained from the model-based density estimate CRMs was 2.82 (95% CIs 1.56 to 5.27) assuming no macro-avoidance, 2.11 (95% CIs 1.17 to 3.95) assuming 25% macro-avoidance, and 1.41 (95% CIs 0.78 to 2.63) assuming 50% macro-avoidance.

533. At SEP and DEP combined, the mean collision rate obtained from the design-based density estimate CRMs was 9.46 (95% CIs 1.00 to 28.91) assuming no macro-avoidance, 7.09 (95% CIs 0.75 to 21.68) assuming 25% macro-avoidance, and 4.73 (95% CIs 0.50 to 14.46) assuming 50% macro-avoidance. The mean collision rate obtained from the model-based density estimate CRMs (assuming that turbines will be installed across both DEP-N and DEP-S) was 11.74 (95% CIs 6.46 to 20.82) assuming no macro-avoidance, 8.81 (95% CIs 4.85 to 15.61) assuming 25% macro-avoidance, and 5.87 (95% CIs 3.23 to 10.41) assuming 50% macro-avoidance. If it is assumed that all turbines will be installed at DEP-N, the mean collision rate was 14.33 (95% CIs 7.89 to 25.39) assuming no macro-avoidance, 10.74 (95% CIs 5.91 to 19.05) assuming 25% macro-avoidance, and 7.16 (95% CIs 3.93 to 7.16) assuming 50% macro-avoidance. If all turbines were installed at DEP-N rather than across DEP as a whole, collision risk for this species would increase by approximately 22%.

534. During the autumn and spring migration seasons, the relevant background Sandwich tern population is the UK North Sea and Channel BDMPS, which consist of 38,051 individuals. Using the published all age class mortality rate of 24.0% (**Table 11-17**), the number of birds expected to die annually from this population would be 8,371. The collision mortality of SEP and DEP combined during the respective seasons in question (i.e. autumn only, since Sandwich terns were absent from SEP and DEP in spring) would result in a mortality increase of no more than 0.03% under any combination of density estimate or macro-avoidance.

535. During the breeding season, the relevant background population to which 100% of impacts are apportioned is the breeding adult population of the North Norfolk Coast SPA (9,443 birds on average during 2018 and 2019, when the baseline surveys

were carried out). Using the published adult mortality rate of 10.2% (**Table 11-17**), the number of birds expected to die annually from this population would be 963. In addition to the impacts predicted during the breeding season, approximately 21.73% of impacts during the spring and autumn migration seasons will also impact birds belonging to this population (Furness, 2015). The percentage increases in this population's annual mortality as a result of predicted collision mortality at SEP and DEP under the scenarios presented in **Table 11-117** and **Table 11-118** is presented in **Table 11-120**.

Table 11-120: Effect of Predicted Realistic Worst-Case Sandwich Tern Collision Rates at SEP and DEP on Existing Annual Mortality of North Norfolk Coast SPA Breeding Population. Numbers in Red Denote Scenarios where the Increase in Existing Annual Mortality is Predicted to be >1%.

Site	Variable		Design-based density CRMs		Model-based density CRMs, assuming turbines across all of DEP		Model-based density CRMs, assuming turbines across DEP-N only	
			Mort.	% mort. inc.[1]	Mort.	% mort. inc.[1]	Mort.	% mort. inc.[1]
DEP	Mean density	No MA	7.38	0.77%	8.43	0.88%	10.79	1.12%
		25% MA	5.54	0.57%	6.32	0.66%	8.10	0.84%
		50% MA	3.69	0.38%	4.22	0.44%	5.40	0.56%
	95% up. CI density	No MA	21.69	2.25%	14.37	1.49%	18.42	1.91%
		25% MA	16.26	1.69%	10.78	1.12%	13.81	1.43%
		50% MA	10.84	1.13%	7.19	0.75%	9.21	0.96%
	95% lower CI density	No MA	0.90	0.09%	4.73	0.49%	6.07	0.63%
		25% MA	0.67	0.07%	3.55	0.37%	4.56	0.47%
		50% MA	0.45	0.05%	2.37	0.25%	3.04	0.32%
SEP	Mean density	No MA	1.85	0.19%	2.74	0.28%	2.74	0.28%
		25% MA	1.39	0.14%	2.05	0.21%	2.05	0.21%
		50% MA	0.93	0.10%	1.37	0.14%	1.37	0.14%
	95% up. CI density	No MA	6.09	0.63%	5.04	0.52%	5.04	0.52%
		25% MA	4.57	0.47%	3.78	0.39%	3.78	0.39%
		50% MA	3.04	0.32%	2.52	0.26%	2.52	0.26%
	95% lower CI density	No MA	0.10	0.01%	1.53	0.16%	1.53	0.16%
		25% MA	0.08	0.01%	1.15	0.12%	1.15	0.12%
		50% MA	0.05	0.01%	0.77	0.08%	0.77	0.08%
SEP and DEP	Mean density	No MA	9.23	0.96%	11.17	1.16%	13.54	1.41%
		25% MA	6.92	0.72%	8.38	0.87%	10.14	1.05%
		50% MA	4.62	0.48%	5.58	0.58%	6.76	0.70%
	95% up. CI density	No MA	27.77	2.88%	19.41	2.02%	23.46	2.44%
		25% MA	20.83	2.16%	14.56	1.51%	17.60	1.83%
		50% MA	13.89	1.44%	9.71	1.01%	11.73	1.22%
	95% lower CI density	No MA	1.00	0.10%	6.27	0.65%	7.61	0.79%
		25% MA	0.75	0.08%	4.70	0.49%	5.70	0.59%
		50% MA	0.50	0.05%	3.13	0.33%	3.80	0.39%

Site	Variable	Design-based density CRMs		Model-based density CRMs, assuming turbines across all of DEP		Model-based density CRMs, assuming turbines across DEP-N only	
		Mort.	% mort. inc.[1]	Mort.	% mort. inc.[1]	Mort.	% mort. inc.[1]

Notes
1. Assumes existing mortality is 963 birds per year, based on population of 9,443 birds and a published annual adult mortality of 0.102 (Horswill and Robinson, 2015)

536. Impacts of DEP in isolation and SEP and DEP combined result in increases of >1% in the existing annual mortality of the North Norfolk Coast SPA Sandwich tern population during the breeding season if the upper 95% CI CRMs are used in conjunction with all macro-avoidance rates in the case of the design-based density estimate CRMs, and the 0% and 25% macro-avoidance rates in the case of the model-based density estimate CRMs. In addition, the mean model-based density CRM for SEP and DEP combined also results in an increase of >1% in the existing annual mortality of the North Norfolk Coast SPA Sandwich tern population at macro-avoidance rates of 0% and 25%.

537. With regard to placing annual mortality in context, two populations are considered. Firstly, the autumn and spring migration UK North Sea and Channel BDMPS of 38,051 individuals (with an annual mortality rate of 9,132 based on the published all age class mortality rate of 24.0% (**Table 11-17**)). Secondly, the biogeographic population of this species with connectivity to UK waters, which consists of 148,000 birds (Furness, 2015), with an annual mortality of 35,520 based on the published all age class mortality rate of 24.0% (**Table 11-17**). The annual collision mortality of SEP and DEP combined would result in a mortality increase of no more than 0.32% of the BDMPS population, or 0.07% of the biogeographic population, under any combination of density estimate or macro-avoidance.

Summary and Impact Assessment

538. Three sets of CRMs have been produced for Sandwich tern using both design-based and model-based density estimates, each using a different set of input parameters. The first two sets of CRMs used parameters agreed with Natural England during the ETG process, with the sole difference between the two the flight height distribution data used. The first set of CRMs used a flight height distribution consisting entirely of observations collected in the same area as SEP and DEP and of birds from the North Norfolk Coast SPA (Harwood, 2021). The second set utilised generic flight height distributions which have been widely used in CRMs carried out at other UK OWFs ("Corrigendum," 2014; Johnston *et al*., 2014), and are included in the assessment for comparative purposes. The predicted number of collisions using the second set of CRMs are considerably lower (by approximately 55%) than the first set. However, since the data of Harwood (2021) is considered the best available, only CRMs produced using this flight height distribution are used to make conclusions by the impact assessment.

539. The third set of CRMs are very similar to those agreed with Natural England, but include a recently calculated flight speed consisting entirely of observations

collected in the same area as SEP and DEP and of birds from the North Norfolk Coast SPA. The predicted number of collisions using the third set of CRMs are considerably lower (by approximately 17%) than the first set. Three different macro-avoidance rates were incorporated into the realistic worst-case CRM. These were selected on the basis of the range of macro-avoidance recorded at operational OWFs in the literature. In addition, consideration has been given to a scenario where all of the turbines at DEP are placed in DEP-N, rather than across DEP as a whole.

540. At DEP, the mean annual collision rate obtained from the design-based density estimate CRMs was 7.58 (95% CIs 0.90 to 22.66) assuming no macro-avoidance, 5.69 (95% CIs 0.67 to 17.00) assuming 25% macro-avoidance, and 3.79 (95% CIs 0.45 to 11.33) assuming 50% macro-avoidance. The mean collision rate obtained from the model-based density estimate CRMs was 8.92 (95% CIs 4.90 to 15.55) assuming no macro-avoidance, 6.69 (95% CIs 3.68 to 11.66) assuming 25% macro-avoidance, and 4.46 (95% CIs 2.45 to 7.77) assuming 50% macro-avoidance. If all turbines were installed at DEP-N rather than across DEP as a whole, collision risk for this species would increase by approximately 30%.

541. At SEP, the mean annual collision rate obtained from the design-based density estimate CRMs was 1.88 (95% CIs 0.10 to 6.25) assuming no macro-avoidance, 1.41 (95% CIs 0.08 to 4.69) assuming 25% macro-avoidance, and 0.94 (95% CIs 0.05 to 3.13) assuming 50% macro-avoidance. The mean collision rate obtained from the model-based density estimate CRMs was 2.82 (95% CIs 1.56 to 5.27) assuming no macro-avoidance, 2.11 (95% CIs 1.17 to 3.95) assuming 25% macro-avoidance, and 1.41 (95% CIs 0.78 to 2.63) assuming 50% macro-avoidance.

542. At SEP and DEP combined, the mean collision rate obtained from the design-based density estimate CRMs was 9.46 (95% CIs 1.00 to 28.91) assuming no macro-avoidance, 7.09 (95% CIs 0.75 to 21.68) assuming 25% macro-avoidance, and 4.73 (95% CIs 0.50 to 14.46) assuming 50% macro-avoidance. The mean collision rate obtained from the model-based density estimate CRMs was 11.74 (95% CIs 6.46 to 20.82) assuming no macro-avoidance, 8.81 (95% CIs 4.85 to 15.61) assuming 25% macro-avoidance, and 5.87 (95% CIs 3.23 to 10.41) assuming 50% macro-avoidance. If all turbines were installed at DEP-N rather than across DEP as a whole, collision risk for this species would increase by approximately 22%.

543. The collision mortality of SEP and DEP combined during the autumn migration season (since Sandwich terns were absent from SEP and DEP in spring) would result in a mortality increase of no more than 0.03% under any combination of density estimate or macro-avoidance.

544. The percentage increases in the breeding adult population of the North Norfolk Coast SPA annual mortality as a result of predicted collision mortality at SEP and DEP under the scenarios presented in **Table 11-115** and **Table 11-116** is presented in **Table 11-120**.

545. Predicted mortality increases of greater than 1% due to collision impacts of SEP and DEP combined are possible, depending on the use of mean density estimates or 95% upper CI density estimates (particularly with respect to design-based density estimates), or the incorporation of a macro-avoidance correction factors.

546. PVA has been used to investigate the population-level effects of a range of scenarios presented in **Table 11-121**. Details of the models are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

Table 11-121: PVA Outputs for Breeding Adult North Norfolk Coast SPA Sandwich Terns Incorporating Collision Impacts of DEP, and SEP and DEP Combined

OWF	Avoidance rate	Macro-avoidance rate	Density estimate	Annual mortality[1]	Increase in existing mortality rate[2,3]	Median CGR[4]	Median CPS[4]
DEP	0.980	0%	Design-based, 95% UCI	21.69	0.0025912226	0.997	0.888
DEP	0.980	25%	Design-based, 95% UCI	16.26	0.0019434170	0.998	0.914
DEP	0.980	50%	Design-based, 95% UCI	10.84	0.0012956113	0.999	0.942
SEP and DEP	0.980	0%	Design-based, mean	9.23	0.0011032521	0.999	0.950
SEP and DEP	0.980	25%	Design-based, mean	6.92	0.0008274391	0.999	0.963
SEP and DEP	0.980	50%	Design-based, mean	4.62	0.0005516261	0.999	0.975
SEP and DEP	0.980	0%	Design-based, 95% UCI	27.77	0.0033185613	0.996	0.858
SEP and DEP	0.980	25%	Design-based, 95% UCI	20.83	0.0024889210	0.997	0.892
SEP and DEP	0.980	50%	Design-based, 95% UCI	13.89	0.0016592806	0.998	0.926
DEP	0.980	0%	Model-based, 95% UCI	14.37	0.0017171023	0.998	0.924
DEP	0.980	25%	Model-based, 95% UCI	10.78	0.0012878267	0.999	0.943
SEP and DEP	0.980	0%	Model-based, mean	11.17	0.0013344332	0.998	0.940
SEP and DEP	0.980	25%	Model-based, mean	8.38	0.0010008249	0.999	0.955

OWF	Avoidance rate	Macro-avoidance rate	Density estimate	Annual mortality[1]	Increase in existing mortality rate[2,3]	Median CGR[4]	Median CPS[4]
SEP and DEP	0.980	50%	Model-based, mean	5.58	0.0006672166	0.999	0.969
SEP and DEP	0.980	0%	Model-based, 95% UCI	19.41	0.0023195447	0.997	0.898
SEP and DEP	0.980	25%	Model-based, 95% UCI	14.56	0.0017396585	0.998	0.923
SEP and DEP	0.980	50%	Model-based, 95% UCI	9.71	0.0011597723	0.999	0.948

Notes

1. Assumes that 100% of impacts during breeding season (April to August), plus 21.73% of impacts during the spring and autumn migration seasons (Furness, 2015), are apportioned to the North Norfolk Coast SPA breeding adult Sandwich tern population
2. This is a key input into PVA, and is provided to ten decimal places to enable the model to be reproduced
3. Background population is North Norfolk Coast SPA breeding adults (8,369 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015)
4. CGR = Counterfactual of Growth Rate, CPS = Counterfactual of Population Size, after 40 years of operation

547. The PVAs investigating the population-level effects of potential collision impacts for DEP alone, and SEP and DEP, produced median CGRs ranging from 0.996 to 0.999, and median CPSs ranging from 0.858 to 0.975 (**Table 11-121**). All of the PVAs assume that turbines will be installed across all of DEP.

548. All scenarios involving collision rates calculated using mean density estimates resulted in CGRs of at least 0.998, and CPSs of at least 0.940. This means that during the operational phase, the annual growth rate of the population would be reduced by no more than 0.2% due to predicted collision impacts when compared with the unimpacted baseline model. After 40 years of operation, the predicted collision impacts would reduce the overall population by no more than 6% when compared with the unimpacted baseline model. If it is assumed that 25% macro-avoidance will occur (which is not an unreasonable assumption, given the available evidence for this at other OWFs), the impacts reduce; the CGR becomes at least 0.999 (i.e. 0.1% change in annual population growth compared to the unimpacted baseline model), and the CPS at least 0.955 (i.e. 4.5% change in population after 40 years compared to the unimpacted baseline model). To put these values in context, the annual rate of change in the North Norfolk Coast SPA breeding Sandwich tern population is -2.3%, 0.8%, -0.5% and 2.9% when measured over the last 40, 30, 20 and 10 years respectively. The CGRs presented in **Table 11-121** indicate that the change in annual growth rate of the population compared with the baseline, unimpacted scenario would be less than the annual changes observed at the colony in previous years. Compared to the 2019 count, the population increase at the North Norfolk Coast SPA has been 21.6%, 27.7%, 7.5% and 22.4% over the last 40, 30, 20 and 10 years respectively. The CPSs presented in **Table 11-121** indicate that the change in the population size after 40 years of operation at SEP and DEP when compared with the baseline, unimpacted scenario would be considerably less than the annual changes observed at the colony in many previous years.

549. Greater impacts are predicted to occur at the population level if CRMs that used the upper 95% CI as input parameters are considered. However, even the largest of the predicted impacts results in a CGR of 0.996, and a CPS of 0.858. This means that the change to the annual growth rate (0.4%) and population size after 40 years of operation (14.2%) are within the range of variation experienced by the North Norfolk Coast SPA Sandwich tern population over the last 40 years. In addition, the probability of this impact occurring is extremely small.

550. Whilst PVAs have not been run for scenarios where the turbines at DEP are all installed in DEP-N, it is anticipated that the slightly increased predicted impacts (approximately 30% more collisions for DEP alone, and 22% for SEP and DEP) would not produce substantially different PVA outputs, and the conclusions presented above also apply to these scenarios.

551. In summary, the project alone collision impacts of SEP, DEP, and SEP and DEP on the breeding adult Sandwich tern population of the North Norfolk Coast SPA are predicted to result in an effect at the population level that is unlikely to be distinguishable from the natural variation of population trends.

552. For all seasons and year round, the increase in existing mortality of the relevant Sandwich tern populations due to the mean predicted collision mortality at SEP and

DEP is small. It would not materially impact the existing mortality rate and would be undetectable in the context of natural variation. During the migration seasons and year round, predicted annual mortality increases in the background population are less than 1%. Whilst the predicted annual mortality increases in the background population are greater than 1% during the breeding season in particular scenarios, population models have demonstrated the impact at the population level to be small relative to the natural variation recorded in the population in the last 40 years.

553. The magnitude of effect of collision risk for this species at SEP and DEP combined for all seasons, and year round is therefore assessed as low. As Sandwich tern is considered to possess a medium sensitivity to collision risk, the impact significance is **minor adverse**.

554. The confidence in the assessment is high. The evidence used to define the CRM input parameters presented at the start of this section is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Finally, the conclusion of the assessment is the same irrespective of whether the mean or 95% upper CI flying bird densities are used to calculate collision rates and increases in the baseline mortality rate of the background population, or as inputs into PVAs. Furthermore, the PVA does not incorporate density dependence, which means the outputs of the model are likely to be precautionary, and the North Norfolk Coast SPA Sandwich tern population is modelled as a closed population, with no emigration or immigration occurring, further increasing the precaution in the population models presented.

11.6.2.2.3 SOSSMAT Assessment

11.6.2.2.3.1 SOSSMAT Inputs

555. The potential collision risk posed by SEP and DEP to a range of non-breeding waterbirds included in the review of migration activity by Wright *et al*. (2012) has been investigated using SOSSMAT.

556. Non-breeding waterbird species were screened into the assessment that are named as qualifying features of SPAs and/or Ramsar sites within 100km of SEP and DEP. These are North Norfolk Coast, Breydon Water, The Wash, Gibraltar Point, Humber Estuary, Broadland, Ouse Washes, Minsmere-Walberswick and Nene Washes. It is considered that the potential sensitivity of these receptors to collision is medium. Confidence in this prediction however is low, as potential collision impacts of operational OWFs on migrating non-breeding waterbirds has not been extensively studied.

557. Population sizes and migration routes were obtained from Wright *et al*. (2012). To select the migration routes relevant to SEP and DEP, the OWF boundaries were overlaid on the SOSSMAT migration route dataset in GIS. Any migration routes intersecting either or both site boundaries were included in each respective assessment. Relevant migrant route crossings included those from named sections of coastline which included a start or end point bordering the southern North Sea, which could also have resulted in a crossing intersecting either SEP or DEP. From

this, SOSSMAT generated a percentage of birds migrating through the southern North Sea which could encounter SEP and/or DEP during migration. To generate the number of birds passing through each OWF, the relevant population size presented in Wright *et al*. (2012) was multiplied by the relevant percentage of birds passing through each site.

558. The avoidance rate was set at 0.980 for all species, which was considered to be a precautionary figure.

559. The "migrant collision risk" element of the Band (2012) CRM spreadsheet was utilised for the calculation of collision risk for each species. Input parameters with regard to biometric parameters and PCH are presented in **Table 11-122**.

560. OWF parameters were as for CRM carried out for seabirds. These are presented in **Section 11.3.2**.

Table 11-122: Biometric Parameters for Offshore Ornithology Receptors Screened into SOSSMAT Assessment for SEP and DEP

Species	Flight Type	Body Length (m)	Wingspan (m)	Flight Speed (m/s)	% PCH
Avocet *Recurvirostra avosetta*	Flapping	0.44	0.78	11.1	25
Bar-tailed godwit *Limosa lapponica*	Flapping	0.38	0.75	18.3	25
Bewick's swan *Cygnus columbianus*	Flapping	1.21	1.96	18.5	50
Bittern *Botaurus stellaris*	Flapping	0.75	1.3	8.8	50
Black-tailed godwit *Limosa limosa*	Flapping	0.42	0.76	14.4	25
Common scoter	Flapping	0.49	0.84	17.7	30
Curlew *Numenius arquata*	Flapping	0.55	0.9	22.1	1
Dark-bellied brent goose *Branta bernicla (bernicla)*	Flapping	0.58	1.15	17.7	30
Dunlin *Calidris alpina*	Flapping	0.18	0.4	15.3	25
Gadwall *Anas strepera*	Flapping	0.51	0.9	16.9	15
Golden plover	Flapping	0.28	0.72	17.9	25
Goldeneye *Bucephala clangula*	Flapping	0.46	0.72	21.2	15
Grey plover *Pluvialis squatarola*	Flapping	0.28	0.77	17.9	25
Knot	Flapping	0.24	0.59	20.1	25
Lapwing	Flapping	0.3	0.84	11.9	25
Mallard *Anas platyrhynchos*	Flapping	0.58	0.90	19.7	15
Oystercatcher	Flapping	0.42	0.83	13.9	25
Pink-footed goose *Anser brachyrhynchus*	Flapping	0.68	1.52	15.0	50
Pintail *Anas acuta*	Flapping	0.58	0.88	16.6	15
Pochard *Aythya ferina*	Flapping	0.46	0.77	21.2	15
Redshank *Tringa totanus* (*britannica*)	Flapping	0.28	0.62	18.3	25
Redshank (*robusta*)	Flapping	0.28	0.62	18.3	25

Species	Flight Type	Body Length (m)	Wingspan (m)	Flight Speed (m/s)	% PCH
Redshank (*totanus*)	Flapping	0.28	0.62	18.3	25
Ringed plover *Charadrius hiaticula*	Flapping	0.19	0.52	10.6	25
Ruff *Calidris pugnax*	Flapping	0.25	0.53	16.9	25
Sanderling *Calidris alba*	Flapping	0.2	0.42	17.7	25
Shelduck *Tadorna tadorna*	Flapping	0.62	1.12	15.4	15
Shoveler *Spatula clypeata*	Flapping	0.48	0.77	16.9	15
Teal *Anas crecca*	Flapping	0.36	0.61	16.9	15
Tufted duck *Aythya fuligula*	Flapping	0.44	0.7	21.2	15
Turnstone *Arenaria interpres*	Flapping	0.23	0.54	17.7	25
Whooper swan *Cygnus cygnus*	Flapping	1.52	2.3	17.3	50
Wigeon *Anas penelope*	Flapping	0.48	0.8	18.5	25

11.6.2.2.3.2 SOSSMAT Outputs

561. Potential annual collision mortality for migrating non-breeding waterbirds at SEP, DEP, and SEP and DEP combined, as estimated by SOSSMAT, is presented in **Table 11-123**. The national non-breeding populations of the species (as per Wright *et al*. (2012)) is also presented, along with the number of annual collisions expressed as a percentage of the national population.

Table 11-123: SOSSMAT-Derived Annual Collision Mortality for Non-Breeding Waterbirds that are Qualifying Features of SPAs within 100km of SEP and DEP, Based on 15MW Deployment Scenario

Species	National Population (Wright *et al*., 2012)	Annual Collision Rate, 0.980 Avoidance Rate			SEP and DEP Collisions as % of National Population
		DEP	SEP	SEP and DEP	
Avocet	7,500	0.05	0.04	0.09	0.001
Bar-tailed godwit	54,280	0.33	0.20	0.54	0.001
Bewick's swan	7,380	0.14	0.12	0.26	0.004
Bittern	600	0.01	0.01	0.02	0.003
Black-tailed godwit	56,880	0.30	0.18	0.48	0.001
Common scoter	123,190	0.82	0.51	1.33	0.001
Curlew	191,650	0.05	0.03	0.07	0.000
Dark-bellied brent goose	91,000	0.87	0.80	1.67	0.002
Dunlin	438,480	2.27	1.82	4.09	0.001
Gadwall	25,630	0.09	0.07	0.17	0.001
Golden plover	400,000	2.64	1.71	4.34	0.001

Species	National Population (Wright *et al*., 2012)	Annual Collision Rate, 0.980 Avoidance Rate			SEP and DEP Collisions as % of National Population
		DEP	SEP	SEP and DEP	
Goldeneye	29,665	0.10	0.06	0.16	0.001
Grey plover	49,315	0.27	0.17	0.43	0.001
Knot	338,970	1.75	1.08	2.83	0.001
Lapwing	465,000	3.49	2.17	5.66	0.001
Mallard	718,250	2.50	1.54	4.03	0.001
Oystercatcher	320,000	1.82	1.12	2.94	0.001
Pink-footed Goose	360,000	2.41	1.19	3.59	0.001
Pintail	30,235	0.11	0.06	0.17	0.001
Pochard	75,780	0.07	0.00	0.07	0.000
Redshank (*britannica*)	38,800	0.26	0.16	0.41	0.001
Redshank (*robusta*)	400,000	2.58	1.58	4.16	0.001
Redshank (*totanus*)	25,000	0.14	0.09	0.23	0.001
Ringed plover	34,000	0.11	0.07	0.18	0.001
Ruff	800	0.00	0.00	0.01	0.001
Sanderling	22,680	0.11	0.07	0.18	0.001
Shelduck	75,610	0.29	0.18	0.47	0.001
Shoveler	20,545	0.07	0.05	0.12	0.001
Teal	255,010	0.81	0.50	1.31	0.001
Tufted duck	146,610	0.42	0.26	0.67	0.000
Turnstone	59,810	0.30	0.19	0.49	0.001
Whooper swan	23,730	0.53	0.30	0.83	0.003
Wigeon	522,370	1.74	1.07	2.81	0.001

562. Less than one annual collision due to SEP and DEP combined is predicted for the majority of species included in the assessment (**Table 11-123**). Less than six annual collisions are predicted for any species.

563. When assessed as a proportion of the national population, the collision rates for migrating non-breeding waterbirds are very small for all species; <0.004% of the national population based on information presented in Wright *et al*. (2012). The magnitude of effect of collision risk for migrating non-breeding waterbird species at SEP and DEP in isolation and combined is therefore assessed as negligible. As all non-breeding waterbird species included in the collision assessment are assumed to be of medium sensitivity to collision, the impact significance is **minor adverse**.

564. Whilst extensive information exists on the responses of waterbirds to onshore OWFs, there is substantial uncertainty regarding waterbird movements at sea. The confidence level assigned to this section of the assessment is therefore medium.

11.6.2.3 Combined Operational Displacement and Collision Risk

565. Gannet and Sandwich tern have been scoped into the assessments for combined operational disturbance, displacement and barrier effects, and collision risk. Whilst these impacts would not act on the same individuals, as birds which do not enter an OWF cannot collide with its turbines, the impacts could combine to adversely affect the relevant populations of these species.

566. For operational phase displacement, the relevant impact predictions have been taken from the appropriate tables in **Section 11.6.2.1.1** for gannet, and **Section 11.6.2.1.3.5** for Sandwich tern. The estimated mortality of birds based on mean peak densities is considered, at the upper, lower, and where applicable, additional evidence-based estimates of mortality, based on species-specific displacement and mortality rates. Mortality estimates derived from the use of upper and lower 95% CIs of the mean peak are not presented, since the mean peak itself is considered to be a sufficiently precautionary input parameter.

567. For collision, the mean collision rate, along with the upper and lower 95% CIs that produced the largest range of values has been included. These have been taken from the appropriate tables in **Section 11.6.2.1.1**.

568. The predicted impacts from displacement and collision are combined to produce a total potential impact. When considering impacts of both OWFs combined, the mean value is a more representative measurement of potential impact, though 95% CIs are also included. Impacts are presented by biologically relevant season (**Table 11-15**). Since the displacement impacts in **Section 11.6.2.1** are also calculated in this way, it is not possible to present the combined impacts of displacement and collision by month.

11.6.2.3.1 Gannet

569. The mean annual mortality rate for gannet at DEP under the worst-case scenario (**Table 11-2** and **Table 11-3**) due to both displacement and collision was 10.52. (**Table 11-124**). This consisted of 4.75 birds lost per breeding season, 5.24 per autumn migration season, and 0.53 per spring migration season. At SEP, the mean annual mortality rate under the worst-case scenario was 3.21. This consisted of 0.41 birds lost per breeding season, 2.73 per autumn migration season, and 0.07 per spring migration season. In total, the annual mean mortality rate for SEP and DEP combined under the worst-case scenario was 13.73, of which 5.16 deaths were attributed to the breeding season, 7.96 to the autumn migration season, and 0.60 to the spring migration season.

Table 11-124: Gannet Combined Operational Displacement and Collision Mortality by Season for SEP, DEP, and SEP and DEP Combined

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
DEP	Mean collision mortality (95% CIs of density)	2.84 (0.00 - 7.56)	0.20 (0.00 - 0.81)	1.84 (0.11 - 5.84)	4.88 (0.11 - 14.21)

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
	Mean peak displacement mortality	2.40 (2.06 - 2.40)	0.33 (0.28 - 0.37)	2.92 (2.50 - 3.34)	5.65 (4.84 - 6.45)
	Total mortality	5.24 (2.06 - 10.30)	0.53 (0.28 - 1.18)	4.75 (2.61 - 9.17)	10.52 (4.95 - 20.66)
SEP	Mean collision mortality (95% CIs of density)	0.66 (0.00 - 1.48)	0.00 (0.00 - 0.00)	0.25 (0.00 - 1.27)	0.91 (0.00 - 2.75)
	Mean peak displacement mortality	2.06 (1.77 - 2.36)	0.07 (0.06 - 0.08)	0.16 (0.14 - 0.18)	2.30 (1.97 - 2.62)
	Total mortality	2.73 (1.77 - 3.84)	0.07 (0.06 - 0.08)	0.41 (0.14 - 1.45)	3.21 (1.97 - 5.37)
SEP and DEP	Mean collision mortality (95% CIs of density)	3.50 (0.00 - 9.04)	0.20 (0.00 - 0.81)	2.08 (0.11 - 7.10)	5.79 (0.11 - 16.95)
	Mean peak displacement mortality	4.46 (3.83 - 5.10)	0.40 (0.34 - 0.46)	3.08 (2.64 - 3.52)	7.94 (6.81 - 9.08)
	Total mortality	7.96 (3.83 - 14.14)	0.60 (0.34 - 1.26)	5.16 (2.75 - 10.62)	13.73 (6.92 - 26.03)

570. Using the upper 95% CI density estimate as a CRM model input rather than the mean density estimate, and the upper estimate of displacement mortality, increased the annual mortality rate for DEP to 20.66 (of which 9.17 deaths were during the breeding season, 10.30 during the autumn migration season, and 1.18 during the spring migration season). At SEP, the annual mortality rate when the corresponding parameters were used was 5.37 (of which 1.45 deaths were during the breeding season, 3.84 during the autumn migration season, and 0.08 during the spring migration season). Substituting the mean density with the lower 95% CI in CRM, in conjunction with the use of the lower estimate for displacement mortality, resulted in an annual mortality rate of 4.95 at DEP, and 1.97 at SEP.

571. During the autumn and spring migration seasons, the relevant background gannet population is the UK North Sea and Channel BDMPS. In autumn and spring respectively, this consists of 456,298 and 248,385 individuals. Using the published all age class mortality rate of 19.1% (**Table 11-17**), the number of birds expected to die annually from each population would be 87,153 and 47,442 respectively. The mean mortality of SEP and DEP combined during the respective seasons in question would increase existing annual mortality by 0.01% in the autumn BDMPS population, and 0.00% in the spring BDMPS population. The upper 95% CRM outputs in conjunction with the upper limit of displacement mortality increases this to 0.02% in autumn, with no change in spring.

572. During the breeding season, the relevant background population is the breeding adult population of the Flamborough and Filey Coast SPA (26,874 birds as per Aitken *et al*. (2017)). Using the published adult mortality rate of 8.8% (**Table 11-17**), the number of birds expected to die annually from this population would be 2,357. Combined annual breeding season collision and displacement mortality from DEP

would increase existing mortality within this population by 0.20% and 0.39%, if mean and upper 95% CI bird densities/upper displacement mortalities are used as input parameters respectively. The corresponding mortality increases in the wider population due to the combined displacement and collision impacts at SEP are 0.02% and 0.06%. For SEP and DEP combined, the mean combined displacement and collision mortality during the breeding season increases the existing mortality within the breeding adult population of the Flamborough and Filey Coast SPA by 0.22% using the mean outputs, or 0.45% using the upper 95% CI density outputs for CRM and the upper predicted displacement mortalities.

573. With regard to placing annual mortality in context, two populations are considered. Firstly, the largest relevant BDMPS (autumn UK North Sea BDMPS), which has an annual mortality of 87,153 (based on the published all age class mortality rate of 19.1% (**Table 11-17**)). Secondly, the biogeographic population of this species with connectivity to UK waters is considered. The population size is 1,180,000 (Furness, 2015), and the annual mortality (based on the published all age class mortality rate of 19.1% (**Table 11-17**)) is 225,380. The addition of the annual mean and upper 95% CI CRM and upper limit of displacement mortalities for SEP and DEP combined to existing levels of mortality from these populations increases the autumn UK North Sea BDMPS annual mortality by between 0.02% and 0.03%, and the biogeographic population mortality rate by 0.01%.

574. The increase in existing mortality of the relevant gannet populations due to predicted combined displacement and collision mortality at SEP and DEP is very small during the migration seasons and year round. Whilst slightly larger during the breeding season, the increase in annual mortality is still considered to be small. Mortality due to SEP and DEP combined would not materially impact existing mortality levels and would be undetectable in the context of natural variation. The magnitude of effect of combined displacement and collision for this species at SEP and DEP combined for all seasons, and year round is therefore assessed as negligible. As gannet is considered to possess a medium sensitivity to displacement and collision risk, the impact significance is **minor adverse**.

575. The confidence in the assessment is high. The evidence used to define the displacement (**Section 11.6.2.1.1**) and CRM (**Section 11.6.2.1.1**) input parameters is of high applicability and quality. Whilst there is uncertainty around some of the input parameters (e.g. avoidance rate), the rates selected are considered to be sufficiently precautionary based on expert opinion to provide confidence that collision rates are not underestimated. Finally, the conclusion of the assessment is the same irrespective of whether the mean or upper limits of mortality are used to calculate increases in the baseline mortality rate of the background population.

11.6.2.3.2 Sandwich Tern

576. The avoidance rate used to calculate collision risk for this species (0.980), which is recommended for use by Natural England, does not include a correction for birds displaced by OWFs. Whilst there is uncertainty around the level of macro-avoidance (i.e. displacement) that will actually occur, evidence discussed in **Section 11.6.2.1.3.5** indicates that this will likely be greater than zero. This is why the displacement assessment considered a range of displacement rates from 0.000 to

0.500, which covered the range presented in all identified evidence. The combined assessment takes the approach of considering the potential combined impact of displacement and collision at three different displacement rates. These are 0.000 (**Table 11-125** and **Table 11-126**), 0.250 (**Table 11-127** and **Table 11-128**), and 0.500 (**Table 11-129** and **Table 11-130**).

577. The assessment outputs using both design-based and model-based density estimates (means and 95% CIs) are presented. The collision rates are taken from the "realistic worst-case scenario" CRMs for Sandwich tern. The displacement rates selected are those calculated at each relevant macro-avoidance rate, using mean peak densities, and the upper and lower 95% CIs of these densities.

Table 11-125: Sandwich Tern Combined Operational Displacement and Collision Mortality by Season for SEP, DEP, and SEP and DEP Combined, Calculated using Design-Based Density Estimates, and Assuming a Macro-Avoidance Rate of 0.000

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
DEP	Mean collision mortality (95% CIs of density)	0.25 (0.00 - 1.25)	0	7.33 (0.90 - 21.41)	7.58 (0.90 - 22.66)
	Mean peak displacement mortality	0	0	0	0
	Total mortality	0.25 (0.00 - 1.25)	0	7.33 (0.90 - 21.41)	7.58 (0.90 - 22.66)
SEP	Mean collision mortality (95% CIs of density)	0.03 (0.00 - 0.21)	0	1.84 (0.10 - 6.04)	1.88 (0.10 - 6.25)
	Mean peak displacement mortality	0	0	0	0
	Total mortality	0.03 (0.00 - 0.21)	0	1.84 (0.10 - 6.04)	1.88 (0.10 - 6.25)
SEP and DEP	Mean collision mortality (95% CIs of density)	0.29 (0.00 - 1.46)	0	9.17 (1.00 - 27.46)	9.46 (1.00 - 28.91)
	Mean peak displacement mortality	0	0	0	0
	Total mortality	0.29 (0.00 - 1.46)	0	9.17 (1.00 - 27.46)	9.46 (1.00 - 28.91)

Table 11-126: Sandwich Tern Combined Operational Displacement and Collision Mortality by Season for SEP, DEP, and SEP and DEP Combined, Calculated using Model-Based Density Estimates, and Assuming a Macro-Avoidance Rate of 0.000

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
DEP	Mean collision mortality (95% CIs of density)	0.63 (0.22 - 1.51)	0	8.29 (4.68 - 14.04)	8.92 (4.90 - 15.55)

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
	Mean peak displacement mortality	0	0	0	0
	Total mortality	0.63 (0.22 - 1.51)	0	8.29 (4.68 - 14.04)	8.92 (4.90 - 15.55)
SEP	Mean collision mortality (95% CIs of density)	0.10 (0.03 - 0.29)	0	2.71 (1.53 - 4.98)	2.82 (1.56 - 5.27)
	Mean peak displacement mortality	0	0	0	0
	Total mortality	0.10 (0.03 - 0.29)	0	2.71 (1.53 - 4.98)	2.82 (1.56 - 5.27)
SEP and DEP	Mean collision mortality (95% CIs of density)	0.73 (0.25 - 1.80)	0	11.01 (6.21 - 19.02)	11.74 (6.46 – 20.72)
	Mean peak displacement mortality	0	0	0	0
	Total mortality	0.73 (0.25 - 1.80)	0	11.01 (6.21 - 19.02)	11.74 (6.46 - 20.72)

Table 11-127: Sandwich Tern Combined Operational Displacement and Collision Mortality by Season for SEP, DEP, and SEP and DEP Combined, Calculated using Design-Based Density Estimates, and Assuming a Macro-Avoidance Rate of 0.250

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
DEP	Mean collision mortality (95% CIs of density)	0.19 (0.00 - 0.94)	0	5.49 (0.67 - 16.06)	5.69 (0.67 - 17.00)
	Mean peak displacement mortality	0.04 (0.00 - 0.10)	0	0.51 (0.20 - 0.98)	0.54 (0.20 - 1.07)
	Total mortality	0.23 (0.00 - 1.04)	0	6.00 (0.87 - 16.04)	6.23 (0.87 - 18.07)
SEP	Mean collision mortality (95% CIs of density)	0.03 (0.00 - 0.16)	0	1.38 (0.08 - 4.53)	1.41 (0.08 - 4.69)
	Mean peak displacement mortality	0.01 (0.00 - 0.02)	0	0.18 (0.05 - 0.32)	0.19 (0.05 - 0.34)
	Total mortality	0.04 (0.00 - 0.18)	0	1.57 (0.14 - 4.88)	1.60 (0.13 - 5.03)
SEP and DEP	Mean collision mortality (95% CIs of density)	0.22 (0.00 - 1.09)	0	6.88 (0.75 - 20.59)	7.09 (0.75 - 21.68)

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
	Mean peak displacement mortality	0.04 (0.00 - 0.12)	0	0.68 (0.25 - 1.30)	0.73 (0.25 - 1.41)
	Total mortality	0.27 (0.00 - 1.22)	0	7.52 (0.96 - 21.81)	7.82 (1.00 - 23.10)

Table 11-128: Sandwich Tern Combined Operational Displacement and Collision Mortality by Season for SEP, DEP, and SEP and DEP Combined, Calculated using Model-Based Density Estimates, and Assuming a Macro-Avoidance Rate of 0.250

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
DEP	Mean collision mortality (95% CIs of density)	0.47 (0.16 - 1.13)	0	6.22 (3.51 - 10.53)	6.69 (3.68 - 11.66)
	Mean peak displacement mortality	0.09 (0.03 - 0.21)	0	0.50 (0.30 - 0.82)	0.59 (0.33 - 1.03)
	Total mortality	0.56 (0.19 - 1.34)	0	6.72 (3.81 - 11.35)	7.28 (4.01 - 12.69)
SEP	Mean collision mortality (95% CIs of density)	0.08 (0.02 - 0.22)	0	2.04 (1.15 - 3.73)	2.11 (1.17 - 3.95)
	Mean peak displacement mortality	0.02 (0.01 - 0.05)	0	0.26 (0.20 - 0.37)	0.28 (0.21 - 0.42)
	Total mortality	0.10 (0.03 - 0.27)	0	2.30 (1.35 - 4.10)	2.40 (1.38 - 4.37)
SEP and DEP	Mean collision mortality (95% CIs of density)	0.22 (0.00 - 1.09)	0	6.88 (0.75 - 20.59)	7.09 (0.75 - 21.68)
	Mean peak displacement mortality	0.10 (0.04 - 0.25)	0	0.76 (0.51 - 1.19)	0.86 (0.55 - 1.44)
	Total mortality	0.32 (0.04 - 1.34)	0	7.64 (1.26 - 21.78)	7.96 (1.30 - 23.12)

Table 11-129: Sandwich Tern Combined Operational Displacement and Collision Mortality by Season for SEP, DEP, and SEP and DEP Combined, Calculated using Design-Based Density Estimates, and Assuming a Macro-Avoidance Rate of 0.500

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
DEP	Mean collision mortality (95% CIs of density)	0.13 (0.00 - 0.62)	0	3.66 (0.45 - 11.33)	3.79 (0.45 - 11.33)
	Mean peak displacement mortality	0.07 (0.00 - 0.19)	0	1.01 (0.40 - 1.96)	1.08 (0.40 - 2.15)

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
	Total mortality	0.20 (0.00 - 0.81)	0	4.67 (0.85 - 13.29)	4.94 (0.85 - 14.10)
SEP	Mean collision mortality (95% CIs of density)	0.02 (0.00 - 0.10)	0	0.92 (0.05 - 3.02)	0.94 (0.05 - 3.13)
	Mean peak displacement mortality	0.02 (0.00 - 0.04)	0	0.36 (0.11 - 0.64)	0.38 (0.11 - 0.68)
	Total mortality	0.04 (0.00 - 0.14)	0	1.28 (0.16 - 3.66)	1.32 (0.16 - 3.80)
SEP and DEP	Mean collision mortality (95% CIs of density)	0.14 (0.00 - 0.73)	0	4.59 (0.50 - 13.73)	4.73 (0.75 - 21.68)
	Mean peak displacement mortality	0.09 (0.00 - 0.23)	0	1.37 (0.51 - 2.60)	1.46 (0.51 - 2.83)
	Total mortality	0.24 (0.00 - 0.95)	0	5.95 (1.01 - 16.95)	6.19 (1.01 - 17.90)

Table 11-130: Sandwich Tern Combined Operational Displacement and Collision Mortality by Season for SEP, DEP, and SEP and DEP Combined, Calculated using Model-Based Density Estimates, and Assuming a Macro-Avoidance Rate of 0.500

Site	Parameter	Autumn migration	Spring migration	Breeding	Year round
DEP	Mean collision mortality (95% CIs of density)	0.31 (0.11 - 0.75)	0	4.15 (2.34 - 7.02)	4.46 (2.45 - 7.77)
	Mean peak displacement mortality	0.17 (0.06 - 0.41)	0	1.01 (0.61 - 1.64)	1.18 (0.67 - 2.05)
	Total mortality	0.48 (0.17 - 1.16)	0	5.16 (2.95 - 8.66)	5.64 (3.12 - 9.82)
SEP	Mean collision mortality (95% CIs of density)	0.05 (0.01 - 0.15)	0	1.36 (0.76 - 2.49)	1.41 (0.78 - 2.63)
	Mean peak displacement mortality	0.04 (0.01 - 0.10)	0	0.51 (0.40 - 0.74)	0.55 (0.41 - 0.84)
	Total mortality	0.09 (0.02 - 0.25)	0	1.87 (1.16 - 3.23)	1.96 (1.18 - 3.48)
SEP and DEP	Mean collision mortality (95% CIs of density)	0.37 (0.12 - 0.90)	0	5.50 (3.11 - 9.51)	5.87 (3.23 - 10.41)
	Mean peak displacement mortality	0.21 (0.07 - 0.51)	0	1.52 (1.01 - 2.37)	1.73 (1.08 - 2.88)
	Total mortality	0.58 (0.19 - 1.41)	0	7.02 (4.12 - 11.88)	7.60 (4.31 - 13.29)

578. Of the scenarios presented, the highest mortality rates are obtained when macro-avoidance is 0% (i.e. displacement is not predicted to occur). This means that the worst-case scenario for combined displacement and collision is the same as for collision risk only (**Section 11.6.2.2.2.4**). The PVAs that were produced for collision risk only (**Table 11-121** and **Appendix 11.1 Offshore Ornithology Technical Report**) are therefore also applicable to the combined impact of collision and displacement.

579. For all seasons and year round, the increase in existing mortality of the relevant Sandwich tern populations due to the mean predicted collision mortality at SEP and DEP is small. It would not materially impact the existing mortality rate and would be undetectable in the context of natural variation. During the migration seasons and year round, predicted annual mortality increases in the background population are less than 1%. Whilst the predicted annual mortality increases in the background population are greater than 1% during the breeding season in particular scenarios, population models have demonstrated the impact at the population level to be small relative to the natural variation recorded in the population in the last 40 years.

580. The magnitude of effect of collision risk for this species at SEP and DEP combined for all seasons, and year round is therefore assessed as low. As Sandwich tern is considered to possess a medium sensitivity to collision risk and displacement, the impact significance is **minor adverse**.

581. The confidence in the assessment is high, for the reasons discussed in **Section 11.6.2.1.3.5** and **Section 11.6.2.2.2.4** respectively.

11.6.2.4 Impact 5: Indirect Effects Through Effects on Habitats and Prey Species during the Operational Phase

582. Indirect effects on offshore ornithology receptors may occur during the operational phase of SEP and DEP if there are impacts on prey species and/or their habitats.

583. These effects include those resulting from the production of underwater noise (e.g. from the turning of the wind turbines), electromagnetic fields (EMF) and the generation of suspended sediments (e.g. due to scour or maintenance activities) that may alter the behaviour or availability of 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 particular areas and may smother and hide immobile benthic prey. All of these indirect effects could result in less prey being available within the SEP and DEP offshore site to foraging seabirds. Changes in fish and invertebrate communities due to changes in presence of hard substrate (resulting in colonisation by epifauna) may also occur, and changes in fishing activity could influence the communities present.

584. Potential effects on benthic invertebrates and fish have been assessed in **Chapter 8 Benthic Ecology** and **Chapter 9 Fish and Shellfish Ecology** and the conclusions of those assessments inform this assessment of indirect effects on offshore ornithology receptors.

585. With regard to noise impacts, **Chapter 9 Fish and Shellfish Ecology** discusses the potential impacts of the operational phase of SEP and DEP upon fish relevant to ornithology as prey species (e.g. species such as herring, sprat and sandeel, which are key prey items of seabirds such as Sandwich tern, kittiwake, gannet and auks). Underwater noise impacts (physical injury or behavioural changes) during operation are considered to be of minor impact significance. All offshore ornithology receptors are considered to possess a medium sensitivity to this potential impact. It is therefore concluded that the impact significance on all offshore ornithology receptors occurring in or around SEP and DEP during the operational phase due to this impact is **minor adverse**.

586. With regard to EMF effects, these are identified as highly localised with the majority of cables being buried, (**Chapter 8 Benthic Ecology**). The impact significance is considered minor adverse on benthic invertebrates and fish (elasmobranchs). All offshore ornithology receptors are considered to possess a medium sensitivity to this potential impact. It is therefore concluded that the impact significance on all offshore ornithology receptors occurring in or around SEP and DEP during the operational phase due to this impact is **minor adverse**.

587. Little is known about potential long-term changes in invertebrate and fish communities due to colonisation of hard substrate and changes in fishing pressures in OWFs. Whilst the impact of the colonisation of introduced hard substrate is seen as a **minor adverse** impact in terms of benthic ecology (as it is a change from the baseline conditions), the consequences for seabirds may be positive or negative locally, but are not predicted to be significant (either positively or negatively) in EIA terms, at a wider scale.

588. **Chapter 6 Marine Geology, Oceanography and Physical Processes** and **Chapter 8 Benthic Ecology** discuss the nature of any change and impacts on the sea bed and benthic habitats during the operational phase of SEP and DEP. The indirect impact magnitude on fish through habitat loss is considered to be minor or negligible for species such as herring, sprat and sandeel which are the main prey items of seabirds such as Sandwich tern, kittiwake, gannet and auks. All offshore ornithology receptors are considered to possess a medium sensitivity to this potential impact. It is therefore concluded that the impact significance on all offshore ornithology receptors occurring in or around SEP and DEP during the operational phase due to this impact is **minor adverse**.

589. The confidence of this prediction is high. This is primarily because the other chapters of the assessment have used the best available evidence, and best practice methodologies, in assessing potential impacts and drawing conclusions. Therefore, the assessment of these potential effects on offshore ornithology receptors is robust. In addition, though difficult to measure, no effects have been recorded due to these impact pathways at other OWFs to date.

11.6.3 Potential Impacts During Decommissioning

11.6.3.1 Impact 6: Disturbance, Displacement and Barrier Effects

590. Disturbance and displacement is likely to occur due to the presence of working vessels and the movement, noise and light associated with these.

The impact of such activities have already been assessed on relevant offshore ornithology receptors during construction (**Section 11.6.1.1**) and have been found to be of negligible to **minor adverse** impact significance.

591. Any impacts generated during the decommissioning phase of SEP and DEP are expected to be similar, but likely of reduced magnitude compared to those generated during the construction phase. The magnitude of impact is therefore 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** impact significance.

11.6.3.2 Impact 7: Indirect Effects Through Effects on Habitats and Prey Species during the Decommissioning Phase

592. Indirect effects such as displacement of seabird prey species are likely to occur during the decommissioning phase of SEP and DEP as structures are removed. The impact of such activities have already been assessed on relevant offshore ornithology receptors during construction (**Section 11.6.1.2**) and have been found to be of minor to negligible impact significance.

593. Any impacts generated during the decommissioning phase of SEP and / or DEP are expected to be similar, but likely of reduced magnitude compared to those generated during the construction phase. The magnitude of effect is therefore 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 for SEP, DEP, and SEP and DEP combined.

594. The confidence of this prediction is high. This is primarily because the other chapters of the assessment have used the best available evidence, and best practice methodologies, in assessing potential impacts and drawing conclusions. Therefore, the assessment of these potential effects offshore ornithology receptors is robust. In addition, though difficult to measure, no effects have been recorded due to these impact pathways at other OWFs during the construction phase, which is expected to be similar to impacts resulting from similar activities during the decommissioning phase.

11.7 Cumulative Impacts

11.7.1 Identification of Potential Cumulative Impacts

595. **Table 11-131** sets out which residual impacts assessed for SEP and / or DEP on their own have the potential for a cumulative impact with other plans, projects and activities ("impact screening"). In addition, consideration of the confidence in the data that is available to inform a detailed assessment and the associated rationale is presented. Potential impacts assessed in **Section 11.6** as negligible or above are included in the CIA. Those assessed as 'no impact' are not taken forward as there is no potential for them to contribute to a cumulative impact.

596. Impacts that occur during the construction phase are screened out of the CIA. This is because the existence of a cumulative impact would be dependent on a temporal and spatial coincidence of similar impacts from other plans or projects. No such impacts or projects have been identified. However, the potential for cumulative

impacts on offshore ornithology receptors exists for disturbance, displacement and barrier effects during the operational phase, and collision risk.

Table 11-131: Potential Cumulative Impacts (Impact Screening)

Impact	Potential for cumulative impact	Confidence	Rationale
Construction			
Disturbance, displacement and barrier effects	No	High	Likelihood of a cumulative impact is low because the impacts are temporary, reversible, spatially limited, and unlikely to occur simultaneously with the same impacts at other OWFs.
Indirect effects	No	High	
Operation			
Disturbance, displacement and barrier effects	Yes	High	Likelihood of a cumulative impact is sufficiently high to justify a detailed assessment.
Collision risk	Yes	High	Likelihood of a cumulative impact is sufficiently high to justify a detailed assessment.
Indirect effects	No	High	Likelihood of a cumulative impact is low because the significance of this impact is extremely small.
Decommissioning			
Disturbance, displacement and barrier effects	No	High	Likelihood of a cumulative impact is low because the impacts are temporary, reversible, spatially limited, and unlikely to occur simultaneously with the same impacts at other OWFs.
Indirect effects	No	High	

11.7.2 Other Plans, Projects and Activities

597. **Table 11-132** presents the identification of the other plans, projects and activities that may result in cumulative impacts for inclusion in the CIA ("project screening"). Relevant details of each project are also presented. These include current status, planned construction period, closest distance to SEP and DEP (and whether the closest distance involves a land crossing) and the status of available data. Finally, the rationale for including or excluding from the assessment is provided.

598. The project screening has been informed by the development of a CIA Project List which forms an exhaustive list of plans, projects and activities relevant to SEP and DEP. The classes of projects that could potentially be considered for the cumulative assessment of offshore ornithology receptors include OWFs, marine aggregate extraction areas, mariculture, oil and gas exploration and extraction, subsea cables and pipelines and commercial shipping. Of these, only OWFs are considered to have potential to contribute to cumulative operational displacement and collision risk, which are the only effects screened in for cumulative assessment. Thus, the cumulative assessment is focused on OWFs.

599. OWFs included in the cumulative impact assessment of offshore ornithology receptors have been assigned to tiers following the approach proposed by Natural

England and JNCC (Scottish Power Renewables, 2016) and with consideration of PINS Advice Note Seventeen (PINS, 2019) as follows:

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

600. Quantitative information is available for OWFs in tiers 1 to 4, which have been included in the assessment. Whilst OWFs in tiers 5 and 6 are included in lists of projects to be considered (see **Chapter 5 EIA Methodology**), they cannot be qualitatively considered with respect to the offshore ornithology assessment since no information at the required level of detail is publicly available (e.g. seabird densities, CRM results etc). The cut off for inclusion of other OWFs into the CIA was May 2022. This means that for projects in Examination at that point (i.e. Hornsea Project Four), and those submitted for Examination more recently (i.e. Awel Y Mor), updates to the assessment will be required during the Examination for SEP and DEP.

Table 11-132: Summary of Projects Considered for the CIA

Tier	Project	Minimum distance to SEP (km)	Minimum distance to DEP (km)	Land crossing in measured minimum distance?
1	Beatrice	603	594	SEP and DEP
1	Beatrice Demonstrator	603	594	SEP and DEP
1	Blyth Demonstration	261	255	No
1	Dudgeon	12	0	No
1	East Anglia ONE	119	115	No
1	European Offshore Wind Deployment Centre (EOWDC)	482	473	No
1	Galloper	131	133	SEP and DEP
1	Greater Gabbard	131	134	SEP and DEP
1	Gunfleet Sands	148	157	SEP and DEP
1	Hornsea Project One	90	66	No
1	Humber Gateway	67	64	No
1	Hywind	494	485	No
1	Kentish Flats and Extension	180	188	SEP and DEP
1	Kincardine	455	446	No
1	Lincs	34	46	No
1	Lynn and Inner Dowsing	37	51	No
1	London Array	155	161	SEP and DEP
1	Methil	448	436	SEP and DEP
1	Moray Firth East	591	582	SEP and DEP
1	Race Bank	10	19	No
1	Rampion	284	296	SEP and DEP
1	Scroby Sands	58	58	No
1	Sheringham Shoal	0	16	No
1	Teesside	210	205	SEP and DEP
1	Thanet	182	188	SEP and DEP

Tier	Project	Minimum distance to SEP (km)	Minimum distance to DEP (km)	Land crossing in measured minimum distance?
1	Westermost Rough	85	81	No
2	Dogger Bank A and B (formerly Creyke Beck A and B)	168	149	No
2	Forth (Seagreen) Alpha and Bravo	411	403	No
2	Hornsea Project Two	85	66	No
2	Neart na Gaoithe	391	383	No
2	Triton Knoll	19	13	No
3	Dogger Bank C (formerly Teesside A) and Sofia (formerly Teesside B)	214	194	No
3	East Anglia ONE North	101	98	No
3	East Anglia TWO	104	103	SEP
3	East Anglia THREE	107	95	No
3	Hornsea Project Three	106	83	No
3	Inch Cape	409	401	No
3	Moray Firth West	592	584	SEP and DEP
3	Norfolk Boreas	99	83	No
3	Norfolk Vanguard	103	89	No
4	Hornsea Project Four	66	52	No

11.7.3 Assessment of Cumulative Impacts

601. The following sections provide an assessment of the level of impact that may arise for the residual impacts from SEP and/or DEP with the potential for a cumulative impact.

602. For each of the impacts included in the CIA, the confidence in the conclusions is the same as for the project alone impacts detailed in this chapter. This is because the evidence used to define the input parameters for either displacement assessment or CRM is generally the same as was used for the project alone impact assessment. These inputs incorporate appropriate levels of precaution to ensure that impacts are unlikely to be underestimated. The mean cumulative impacts are used to estimate total potential impact levels. 95% CIs are not used, as to do so would produce hugely overestimated (in the case of upper 95% CIs) or underestimated (in the case of lower 95% CIs) predicted impacts.

11.7.3.1 Cumulative Impact 1: Operational Disturbance, Displacement and Barrier Effects

603. The species assessed for project alone operational displacement impacts were gannet (autumn migration, breeding season and spring migration), guillemot (breeding season and non-breeding season), razorbill (autumn migration, winter, spring migration and breeding season), red-throated diver (autumn migration, winter and spring migration), and Sandwich tern (autumn migration, spring migration and breeding season).

604. A review of the BDMPS regions for each species indicated that for gannet, guillemot, razorbill and Sandwich tern, all OWFs identified for inclusion in the CIA in **Table 11-132** and **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment** have the potential to contribute a cumulative effect during the non-breeding season.

605. For red-throated diver, the relevant BDMPS is the southwest North Sea. Thus, OWFs located from the Northumbria coast northwards, and in the English Channel were not considered likely to contribute to a cumulative displacement effect for this species. In addition, as the species tends to be found in estuarine and nearshore shallow waters during the non-breeding season, OWFs further from the coast were also excluded. Many OWF assessments have previously not quantitatively considered red-throated diver impacts. This means that the standard approach of extracting quantitatively expressed impacts from the assessments of other OWFs may lead to underestimated cumulative impacts. For this reason, an approach to examining the potential for cumulative impact has been followed using alternative data sources (Bradbury *et al*., 2014).

606. For Sandwich tern, no previous OWF assessment that has quantitatively assessed potential displacement effects during operation was identified. Given the internationally important conservation status of the North Norfolk Coast SPA breeding Sandwich tern population, and the identification of evidence that suggests the existence of such an effect (**Section 11.6.2.1.3.5**), additional assessment to quantify the potential for mortality within this population during the breeding season has been undertaken. A review of other UK North Sea OWF assessments indicates

that the potential for substantial impacts outside the breeding season is very low. At the majority of OWFs situated beyond the Greater Wash area, Sandwich terns were either not recorded, or were recorded in numbers insufficient for CRM to be carried out.

607. The primary source of information for predicted impacts at other OWFs was the post-Examination update of cumulative and in-combination collision risk and displacement produced for the East Anglia ONE North and TWO OWFs (MacArthur Green and Royal HaskoningDHV, 2021b). The Hornsea Project Four ES Chapter has been published since the publication of the above document. However, relevant representations of Natural England (Natural England, 2021d) make it clear that apportioning of gannet, guillemot and razorbill (and therefore the apportioning of impacts) has not occurred according to their recommended methodology. For this reason, the estimated mortality for displacement due to Hornsea Four is taken from that project's PEIR. This assessment will be updated to reflect the final outcome of the Hornsea Four examination.

11.7.3.1.1 Gannet

608. The number of birds at risk of displacement from all OWFs in the UK North Sea and Channel BDMPS is included by development in **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**. The seasonal totals by tier, along with the contribution made by SEP and DEP, is presented in **Table 11-133**. Whilst 2km was the preferred buffer where it was available, the buffer zones included in this assessment varied between 0-4km depending on the data available. The displacement matrix for annual cumulative gannet mortality is presented in **Table 11-134**.

Table 11-133: Summary of Cumulative Numbers of Gannet Potentially at Risk of Displacement for All OWFs Included in CIA

Tiers	Autumn migration	Spring migration	Breeding	Annual
1 to 3 (i.e. consented, under construction or operational)	20,544	5,011	20,367	45,922
Hornsea Project Four (PEIR)	1,192	659	1,892	3,743
DEP	343	47	417	807
SEP	295	11	23	328
Total	**22,374**	**5,728**	**22,699**	**50,801**

Table 11-134: Cumulative Operational OWF Displacement Matrix for Year Round Impacts on Gannet (First Column = Displacement Rate; First Row = Mortality Rate)

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	51	102	152	203	254	508	1016	1524	2540	4064	5080
20%	102	203	305	406	508	1016	2032	3048	5080	8128	10160
30%	152	305	457	610	762	1524	3048	4572	7620	12192	15240
40%	203	406	610	813	1016	2032	4064	6096	10160	16256	20320
50%	254	508	762	1016	1270	2540	5080	7620	12700	20320	25401
60%	305	610	914	1219	1524	3048	6096	9144	15240	24384	30481
70%	356	711	1067	1422	1778	3556	7112	10668	17780	28449	35561

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
80%	406	813	1219	1626	2032	4064	8128	12192	20320	32513	40641
90%	457	914	1372	1829	2286	4572	9144	13716	22860	36577	45721
100%	508	1016	1524	2032	2540	5080	10160	15240	25401	40641	50801

609. At displacement rates of 0.600 to 0.800 and a 1% mortality rate (**Section 11.6.2.1.1**) between 305 and 406 gannets are predicted to die from cumulative operational OWF displacement annually.

610. To assess the magnitude of the year round impact of cumulative operational OWF displacement on gannet, two background populations are considered. Firstly, the largest relevant BDMPS population (autumn migration UK North Sea and Channel BDMPS, consisting of 456,298 individuals (Furness, 2015)). Based on the published baseline mortality of 19.1% across all age classes (**Table 11-17**), 87,153 individual gannets from this population would be expected to die annually. Secondly, the biogeographic population with connectivity to UK waters of 1,180,000 (Furness, 2015). 225,380 individuals would be expected to die annually from this population using the same all age class mortality rate (**Table 11-17**).

611. The predicted level of additional mortality would represent a 0.3% to 0.5% increase in annual mortality within the largest BDMPS population, or a 0.1% to 0.2% increase in annual mortality within the annual biogeographic population with connectivity to UK waters. These mortality increases would not be detectable at the population level within the context of natural variation, and for reasons discussed during the literature review in **Section 11.6.2.1.1**, are considered to be precautionary predictions.

612. Based on the numbers presented in **Table 11-133**, the potential for SEP and DEP to contribute to a significant cumulative displacement effect on gannet is considered to be negligible both in isolation and combined.

613. The year round magnitude of cumulative operational displacement on gannet is therefore assessed as negligible. As gannet is of medium sensitivity to disturbance, the impact significance is **minor adverse**. This predicted impact is not significant in EIA terms, and therefore reaches the same conclusion as presented by Natural England during DCO Examination for East Anglia ONE North and TWO (Natural England, 2021e).

11.7.3.1.2 Guillemot

614. The number of birds at risk of displacement from OWFs in the UK North Sea and Channel BDMPS is included in **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**. The seasonal totals by tier, along with the contribution made by SEP and DEP, is presented in **Table 11-135**. The displacement matrix for annual cumulative guillemot mortality is presented in **Table 11-17**.

Table 11-135: Summary of Cumulative Numbers of Guillemot Potentially at Risk of Displacement for all OWFs Included in CIA

Tiers	Non-breeding	Breeding	Annual
1 to 3 (i.e. consented, under construction or operational)	170,874	170,621	341,495

Tiers	Non-breeding	Breeding	Annual
Hornsea Project Four (PEIR)	69,555	15,245	84,800
DEP	14,887	3,839	18,726
SEP	1,085	1,095	2,180
Total	**256,401**	**190,800**	**447,201**

Table 11-136: Cumulative Operational OWF Displacement Matrix for Year Round Impacts on Guillemot (First Column = Displacement Rate; First Row = Mortality Rate)

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	447	894	1342	1789	2236	4472	8944	13416	22360	35776	44720
20%	894	1789	2683	3578	4472	8944	17888	26832	44720	71552	89440
30%	1342	2683	4025	5366	6708	13416	26832	40248	67080	107328	134160
40%	1789	3578	5366	7155	8944	17888	35776	53664	89440	143104	178880
50%	2236	4472	6708	8944	11180	22360	44720	67080	111800	178880	223601
60%	2683	5366	8050	10733	13416	26832	53664	80496	134160	214656	268321
70%	3130	6261	9391	12522	15652	31304	62608	93912	156520	250433	313041
80%	3578	7155	10733	14310	17888	35776	71552	107328	178880	286209	357761
90%	4025	8050	12074	16099	20124	40248	80496	120744	201240	321985	402481
100%	4472	8944	13416	17888	22360	44720	89440	134160	223601	357761	447201

615. At displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds (**Section 11.6.2.1.2**) between 1,342 and 31,304 guillemots are predicted to die from cumulative operational OWF displacement annually.

616. To assess the magnitude of the year round impact of operational OWF displacement on guillemot, two background populations are considered. Firstly, the largest relevant BDMPS population (UK North Sea and Channel BDMPS, consisting of 1,617,306 birds (Furness, 2015)). Assuming a published all age class baseline mortality rate of 14.0% (**Table 11-17**), 226,423 guillemots from this population would be expected to die annually. Secondly, the biogeographic population with connectivity to UK waters of 4,125,000 (Furness, 2015). 577,500 individuals would be expected to die annually from this population, using the same all age class mortality rate (**Table 11-17**).

617. The predicted level of additional mortality would represent a 0.6% to 13.8% increase in annual mortality within the largest BDMPS population, or a 1.0% increase if evidence-based mortality and displacement rates of 0.500 and 1% are used. Annual mortality rate increases in the biogeographic population with connectivity to UK waters would be 0.2% to 5.4%, or 0.4% using evidence-based displacement and mortality parameters. The mortality increases predicted using the evidence-based parameters would not be detectable at the population level within the context of natural variation, and for reasons discussed during the literature review in **Section 11.6.2.1.2**, are considered to be precautionary predictions.

618. Based on the numbers presented in **Table 11-135**, the potential for SEP and DEP to contribute to a significant cumulative displacement effect on guillemot is considered to be negligible both in isolation and combined.

619. The year round magnitude of cumulative operational displacement on guillemot is therefore assessed as negligible. As guillemot is of medium sensitivity to disturbance, the impact significance is **minor adverse**. This predicted impact is not significant in EIA terms, and therefore reaches a different conclusion than Natural England during DCO Examination for East Anglia ONE North and TWO (Natural England, 2021e). The reason for the difference in conclusion is the selection of displacement and mortality rates, with Natural England's advice focusing on higher rates.

11.7.3.1.3 Razorbill

620. The number of birds at risk of displacement from all OWFs in the UK North Sea and Channel BDMPS is included by development in **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**. The seasonal totals by tier, along with the contribution made by SEP and DEP, is presented in **Table 11-141**. Whilst 2km was the preferred buffer where it was available, the buffer zones included in this assessment varied between 0-4km depending on the data available. The displacement matrix for annual cumulative razorbill mortality is presented in **Table 11-138**.

Table 11-137: Summary of Cumulative Numbers of Razorbill Potentially at Risk of Displacement for All OWFs Included in CIA

Tiers	Autumn migration	Winter	Spring migration	Breeding	Annual
1 to 3 (i.e. consented, under construction or operational)	35,100	24,095	32,531	32,124	123,850
Hornsea Project Four (PEIR)	5,960	685	1,361	580	8,586
DEP	923	845	320	3,741	5,829
SEP	316	686	144	759	1,905
Total	**42,299**	**26,311**	**34,356**	**37,204**	**140,170**

Table 11-138: Cumulative Operational OWF Displacement Matrix for Year Round Impacts on Razorbill (First Column = Displacement Rate; First Row = Mortality Rate)

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	140	280	421	561	701	1402	2803	4205	7009	11214	14017
20%	280	561	841	1121	1402	2803	5607	8410	14017	22427	28034
30%	421	841	1262	1682	2103	4205	8410	12615	21026	33641	42051
40%	561	1121	1682	2243	2803	5607	11214	16820	28034	44854	56068
50%	701	1402	2103	2803	3504	7009	14017	21026	35043	56068	70085
60%	841	1682	2523	3364	4205	8410	16820	25231	42051	67282	84102
70%	981	1962	2944	3925	4906	9812	19624	29436	49060	78495	98119
80%	1121	2243	3364	4485	5607	11214	22427	33641	56068	89709	112136
90%	1262	2523	3785	5046	6308	12615	25231	37846	63077	100922	126153
100%	1402	2803	4205	5607	7009	14017	28034	42051	70085	112136	140170

621. At displacement rates of 0.300 to 0.700 and mortality rates of 1% to 10% of displaced birds (**Section 11.6.2.1.2**) between 421 and 9,812 razorbills are predicted to die from cumulative operational OWF displacement annually.

622. To assess the magnitude of the year round impact of operational OWF displacement on razorbill, two background populations are considered. Firstly, the largest relevant BDMPS population (UK North Sea and Channel BDMPS during autumn and spring migration seasons, consisting of 591,874 birds (Furness, 2015)). Assuming a published all age class baseline mortality rate of 17.4% (**Table 11-17**), 102,986 razorbills from this population would be expected to die annually. Secondly, the biogeographic population with connectivity to UK waters of 1,707,000 (Furness, 2015). 297,018 individuals would be expected to die annually from this population, using the same all age class mortality rate (**Table 11-17**).

623. The predicted level of additional mortality would represent a 0.4% to 9.5% increase in annual mortality within the largest BDMPS population, or a 0.7% increase if evidence-based mortality and displacement rates of 0.500 and 1% are used. Annual mortality rate increases in the biogeographic population with connectivity to UK waters would be 0.1% to 3.3%, or 0.2% using evidence-based displacement and mortality parameters. The mortality increases predicted using the evidence-based parameters would not be detectable at the population level within the context of natural variation, and for reasons discussed during the literature review in **Section 11.6.2.1.2**, are considered to be precautionary predictions.

624. Based on the numbers presented in **Table 11-141**, the potential for SEP and DEP to contribute to a significant cumulative displacement effect on razorbill is considered to be negligible both individually and combined.

625. The year round magnitude of cumulative operational displacement on razorbill is therefore assessed as negligible. As razorbill is of medium sensitivity to disturbance, the impact significance is **minor adverse**. This predicted impact is not significant in EIA terms, and therefore reaches a different conclusion than Natural England during DCO Examination for East Anglia ONE North and TWO (Natural England, 2021e). The reason for the difference in conclusion is the selection of displacement and mortality rates, with Natural England’s advice focusing on higher rates.

11.7.3.1.4 Red-Throated Diver

626. To assess the magnitude of the year round impact of operational OWF displacement on red-throated diver, two background populations are considered. Firstly, the largest relevant BDMPS population (UK North Sea BDMPS during autumn and spring migration seasons, consisting of 13,277 birds (Furness, 2015)). Assuming a published all age class baseline mortality rate of 22.8% (**Table 11-17**), 3,027 birds from this population would be expected to die annually. Secondly, the biogeographic population with connectivity to UK waters of 27,000 (Furness, 2015). 6,156 individuals would be expected to die annually from this population, using the same all age class mortality rate (**Table 11-17**).

11.7.3.1.4.1 OWF Baseline Data

627. The number of birds predicted to die due to operational phase displacement from all OWFs in the UK North Sea BDMPS is included by development in **Appendix**

11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment. The seasonal totals by tier, along with the contribution made by SEP and DEP, is presented in **Table 11-139**. Whilst 4km was the preferred buffer where it was available, the buffer zones included in this assessment varied between 0km and 4km depending on the data available. The displacement matrix for annual cumulative red-throated diver mortality is presented in **Table 11-140**.

Table 11-139: Summary of Cumulative Numbers of Red-Throated Divers Potentially at Risk of Displacement for All OWFs Included in CIA

Tiers	Autumn migration	Winter	Spring migration	Annual
1 to 3 (i.e. consented, under construction or operational)	190	750	1,880	2,820
Hornsea Project Four	0	0	0	0
DEP	31	5	54	90
SEP	75	5	191	271
Total	**296**	**760**	**2,125**	**3,181**

Table 11-140: Cumulative Operational OWF Displacement Matrix for Year Round Impacts on Red-Throated Divers (Data from Other OWF Assessments) (First Column = Displacement Rate; First Row = Mortality Rate) (First Column = Displacement Rate; First Row = Mortality Rate)

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	3	6	10	13	16	32	64	95	159	254	318
20%	6	13	19	25	32	64	127	191	318	509	636
30%	10	19	29	38	48	95	191	286	477	763	954
40%	13	25	38	51	64	127	254	382	636	1018	1272
50%	16	32	48	64	80	159	318	477	795	1272	1591
60%	19	38	57	76	95	191	382	573	954	1527	1909
70%	22	45	67	89	111	223	445	668	1113	1781	2227
80%	25	51	76	102	127	254	509	763	1272	2036	2545
90%	29	57	86	115	143	286	573	859	1431	2290	2863
100%	32	64	95	127	159	318	636	954	1591	2545	3181

628. Based on data from OWFs in the southern North Sea that have carried out a quantitative assessment of displacement, assuming a displacement rate of 1.000 from the OWF and a 4km buffer, and 1% to 10% mortality of displaced birds, is between 32 and 318 birds per year (**Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**). SEP and DEP contribute 11.3% of this total annually, with particularly high contribution during the autumn migration season (35.8% of the total) and spring migration season (11.5% of the total).

629. These annual mortality rates represent an increase in annual mortality of 1.1% to 10.5% within the largest UK North Sea BDMPS population, and 0.5% to 5.2% within the biogeographic population with connectivity to UK waters. Changes in annual mortality of greater than 1% could be detectable. The use of evidence-based

displacement and mortality rates of 90% and 1% (MacArthur Green, 2019b), which are still considered to be precautionary, results in mortality increases of less than 1% in both background populations under consideration. The magnitude of cumulative displacement is therefore assessed as negligible. As the species is of high sensitivity to disturbance, the cumulative impact significance is **minor adverse**.

11.7.3.1.4.2 SEAMAST Data

630. Using modelled at-sea density estimates produced during the SeaMAST project (Bradbury *et al*., 2014), the relative contribution of OWFs to potential cumulative impacts on red-throated diver due to operational disturbance and displacement was investigated. The assumed displacement rate was 1.000 of birds from all operational OWFs plus a 4km buffer, as recommended by UK SNCBs (2017). Full details of how the SeaMAST densities were used are presented in **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**. Whilst more recent evidence indicates that displacement effects of operational OWFs frequently exceed 4km, this approach was not amended primarily because incorporating larger buffers caused considerable complications with overlap of buffers at one OWF with buffers from other OWFs, as well as the OWFs themselves.

631. The number of birds at risk of displacement from these OWFs (arranged by tier), in addition to SEP and DEP is presented in **Table 11-141**. The displacement matrix for annual cumulative red-throated diver mortality is presented in **Table 11-142**.

Table 11-141: Summary of Cumulative Numbers of Red-Throated Diver Potentially at Risk of Displacement for All OWFs Included in CIA, Based on Data from Bradbury et al. (2014)

Tier	Number of red-throated divers present in OWFs plus 4km buffer	Number of red-throated divers as % of total reference population
1 to 3 (i.e. consented, under construction or operational)	3,176	15.9%
Hornsea Project Four	0	0%
DEP	0	0%
SEP	1	0.0%
Total	3,176	15.9%

Table 11-142: Cumulative Operational OWF Displacement Matrix for Year Round Impacts on Red-Throated Divers (SeaMAST Data) (First Column = Displacement Rate; First Row = Mortality Rate)

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	3	6	10	13	16	32	64	95	159	254	318
20%	6	13	19	25	32	64	127	191	318	508	635
30%	10	19	29	38	48	95	191	286	476	762	953
40%	13	25	38	51	64	127	254	381	635	1016	1270
50%	16	32	48	64	79	159	318	476	794	1270	1588
60%	19	38	57	76	95	191	381	572	953	1524	1906
70%	22	44	67	89	111	222	445	667	1112	1779	2223
80%	25	51	76	102	127	254	508	762	1270	2033	2541
90%	29	57	86	114	143	286	572	858	1429	2287	2858

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
100%	32	64	95	127	159	318	635	953	1588	2541	3176

632. Based on data from Bradbury *et al*. (2014), the estimated number of red-throated divers within OWFs and their 4km buffers within the southern North Sea during the non-breeding season is 15.9% of the total population of 19,978 birds estimated to be present in the English North Sea. SEP and DEP contribute virtually none of this total; with just a single bird from SEP and zero from DEP considered to be at risk of displacement. The relative contribution of both OWFs is therefore extremely small.

633. These annual mortality rates represent an increase in annual mortality of 1.1% to 10.5% within the largest UK North Sea BDMPS population, and 0.5% to 5.2% within the biogeographic population with connectivity to UK waters. Changes in annual mortality of greater than 1% could be detectable. The use of evidence-based displacement and mortality rates of 90% and 1% (MacArthur Green, 2019b), which are still considered to be precautionary, results in mortality increases of less than 1% in both background populations under consideration. The magnitude of cumulative displacement is therefore assessed as negligible. As the species is of high sensitivity to disturbance, the cumulative impact significance is **minor adverse**.

11.7.3.1.5 Sandwich tern

634. No OWF in UK waters to date has previously considered operational displacement impacts of Sandwich tern quantitatively. A review of OWF assessments revealed that very few had recorded Sandwich terns during baseline surveys, with small numbers sometimes recorded during the migration seasons. Displacement and barrier effect impacts are thought to be relatively insignificant to birds on migration (Masden *et al*., 2010, 2009). This is due to the brief duration that birds typically spend in a given area during these seasons, and the relatively modest increases in energy requirements to avoid OWFs, should it be required.

635. As a result, the cumulative displacement assessment for Sandwich tern focuses on OWFs in the wider Wash area only. These OWFs are within foraging range of breeding Sandwich terns from the North Norfolk Coast SPA, and were also included in the DECC (2012) Appropriate Assessment for this species. Since this area may be important to this species during pre and post-breeding periods, year round impacts have been considered.

636. Since this impact has not previously been considered by other OWFs, it was necessary to produce displacement matrices for other OWFs to be included within the assessment. Mean peak density data for Sandwich tern at SOW (SCIRA Offshore Energy Ltd, 2006a, 2006b), DOW (MacArthur Green, 2014), Race Bank OWF (Centrica Energy, 2009a, 2009b) and Triton Knoll OWF (RWE NPower Renewables, 2011) was collated and an operational displacement assessment carried out according to the methodology and assumptions used for the assessment of SEP and DEP in **Section 11.6.2.1.3.5**. Only flying bird densities from other OWFs (i.e. within the OWF only) were available. Published literature suggests that Sandwich terns spend the overwhelming majority of their time at sea in flight (Garthe and Hüppop, 2004; Perrow *et al*., 2017). This is supported by the fact that of the 1,710 Sandwich tern observations made during the SEP and DEP baseline surveys,

1,676 (98%) were of birds in flight. As a result, the lack of "all birds" data for other OWFs is not considered to materially affect the assessment. The displacement matrices for these OWFs are presented in **Appendix 11.1 Offshore Ornithology Technical Report**.

637. The number of birds at risk of displacement from these OWFs year round, in addition to SEP and DEP, is presented in **Table 11-143**. The data presented are based on mean peak abundances, and use the displacement and mortality rates discussed in **Section 11.6.2.1.3.5**. The displacement matrices for annual cumulative Sandwich tern mortality is presented in **Table 11-144** when mean design-based density estimates were used to calculate the impacts at SEP and DEP, and in **Table 11-145** when mean model-based density estimates were used to calculate the impacts at SEP and DEP.

Table 11-143: Summary of Cumulative Numbers of Sandwich Tern Potentially at Risk of Displacement for All OWFs Included in CIA

OWF	Birds at risk of displacement	Birds displaced (0% to 50% of birds at risk)	Predicted mortality (1% of displaced birds)
DOW	58	0 - 29	0 - 0.29
SOW	13	0 - 7	0 - 0.07
Race Bank	132	0 - 66	0 - 0.66
Triton Knoll	23	0 - 11	0 - 0.11
DEP (design-based density estimates)	216	0 - 108	0 - 1.08
DEP (model-based density estimates)	236	0 - 118	0 - 1.18
SEP (design-based density estimates)	74	0 - 37	0 - 0.37
SEP (model-based density estimates)	109	0 - 55	0 - 0.55
Total	**516 (design-based)** **571 (model-based)**	**0 - 258** **0 - 286**	**0 - 2.58** **0 - 2.86**

Table 11-144: Cumulative Operational OWF Displacement Matrix for Year Round Impacts on Sandwich Tern, when Design-Based Density Estimates were used to Calculate Impacts at SEP and DEP (First Column = Displacement Rate; First Row = Mortality Rate)

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	1	1	2	2	3	5	10	15	26	41	52
20%	1	2	3	4	5	10	21	31	52	83	103
30%	2	3	5	6	8	15	31	46	77	124	155
40%	2	4	6	8	10	21	41	62	103	165	206
50%	3	5	8	10	13	26	52	77	129	206	258
60%	3	6	9	12	15	31	62	93	155	248	310
70%	4	7	11	14	18	36	72	108	181	289	361
80%	4	8	12	17	21	41	83	124	206	330	413
90%	5	9	14	19	23	46	93	139	232	372	464
100%	5	10	15	21	26	52	103	155	258	413	516

Table 11-145: Cumulative Operational OWF Displacement Matrix for Year Round Impacts on Sandwich Tern, when Model-Based Density Estimates were used to Calculate Impacts at SEP and DEP (First Column = Displacement Rate; First Row = Mortality Rate)

	1%	2%	3%	4%	5%	10%	20%	30%	50%	80%	100%
10%	1	1	2	2	3	6	11	17	29	46	57
20%	1	2	3	5	6	11	23	34	57	91	114
30%	1	3	4	6	7	14	29	43	71	114	143
40%	2	5	7	9	11	23	46	69	114	183	228
50%	3	6	9	11	14	29	57	86	143	228	286
60%	3	7	10	14	17	34	69	103	171	274	343
70%	4	8	12	16	20	40	80	120	200	320	400
80%	5	9	14	18	23	46	91	137	228	365	457
90%	5	10	15	21	26	51	103	154	257	411	514
100%	6	11	17	23	29	57	114	171	286	457	571

638. Sandwich tern mortality during the breeding season due to operational phase displacement from the OWFs listed in **Table 11-143** is estimated to be between 0 to 2.58 or 2.86 individuals based on displacement rates of 0.000 to 0.500 and a mortality rate of 1%.

639. At the published annual mortality for this species for adults only (given the assumption that all birds at the OWFs listed in **Table 11-143** during this season are adults) (10.2%; **Table 11-17**), the number of Sandwich terns expected to die during the breeding season that are members of the relevant background population (the North Norfolk Coast SPA breeding adult population) (**Appendix 11.1 Offshore Ornithology Technical Report**) is 963 (i.e. 9,443 x 0.102).

640. This means that the predicted mortality due to cumulative operational phase displacement increases the annual mortality of the North Norfolk Coast SPA population by 0% to 0.27% or 0.30%, assuming all birds impacted are from this population. Since birds during the pre- and post-breeding seasons will likely originate from a range of colonies, these percentages are considered to be overestimated. As the predicted annual mortality increase is below 1%, it is expected that these mortality increases would not be detectable at the population level within the context of natural variation. The magnitude of cumulative displacement for Sandwich tern is therefore considered to be negligible and the impact significance of cumulative displacement on a receptor of medium sensitivity is **minor adverse**.

11.7.3.2 Cumulative Impact 2: Collision Risk

641. Cumulative collision risk was assessed for gannet, great black-backed gull, kittiwake, lesser black-backed gull and Sandwich tern. A detailed explanation of how the cumulative collision totals were derived is included in **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.

642. It is considered that all OWFs identified for inclusion in the CIA in **Table 11-132** and **Appendix 11.2 Information to Inform the Offshore Ornithology Cumulative**

Impact Assessment have the potential to contribute a cumulative effect for all species except Sandwich tern. For this species, no OWF assessment has quantitatively assessed potential cumulative collision effects since DECC (2012). Given the internationally important conservation status of the North Norfolk Coast SPA breeding Sandwich tern population (**Section 11.6.2.1.3.5**), additional work to update this assessment has been undertaken.

643. The primary source of information for predicted impacts at other OWFs was the post-Examination update of cumulative and in-combination collision risk and displacement produced for the East Anglia ONE North and TWO OWFs (MacArthur Green and Royal HaskoningDHV, 2021b). The Hornsea Project Four ES Chapter has been published since the publication of the above document. However, relevant representations of Natural England (Natural England, 2021d) make it clear that apportioning of gannet and kittiwake (and therefore the apportioning of impacts) has not occurred according to their preferred methodology. For this reason, the estimated mortality for displacement due to Hornsea Four is taken from that project's PEIR. This assessment will be updated to reflect the final outcome of the Hornsea Four examination.

644. The mean peak value for SEP and DEP, in addition to lower and upper 95% CIs are used in the assessment to increase confidence in its predictions. It should be noted that the probability of a 95% CI value occurring is 2.5%.

11.7.3.2.1 Gannet

645. Seasonal annual cumulative collision predictions for gannet at OWFs by tier, along with the contribution made by the mean collision mortalities for SEP and DEP, is presented in **Table 11-146**.

Table 11-146: Summary of Cumulative Collision Predictions for Gannet for All OWFs Included in CIA

Tiers	Autumn migration	Spring migration	Breeding	Annual
1 to 3 (i.e. consented, under construction or operational)	823	325	1,792	2,940
Hornsea Project Four (PEIR)	10	8	43	61
DEP	3	0	2	5
SEP	1	0	0	1
Total	**836**	**333**	**1,837**	**3,007**

646. The annual cumulative total of predicted collisions is 3,007, of which SEP and DEP contribute six birds (0.2%).

647. To assess the magnitude of the year round impact of cumulative OWF collision on gannet, two background populations are considered. Firstly, the largest relevant BDMPS population (autumn migration UK North Sea and Channel BDMPS, consisting of 456,298 individuals (Furness, 2015)). Based on the published baseline mortality of 19.1% across all age classes (**Table 11-17**), 87,153 individual gannets from this population would be expected to die annually. Secondly, the biogeographic population with connectivity to UK waters of 1,180,000 (Furness, 2015). 225,380

individuals would be expected to die annually from this population using the same all age class mortality rate (**Table 11-17**).

648. The predicted level of additional mortality would represent a 3.5% increase in annual mortality within the largest BDMPS population, or a 1.3% increase in annual mortality within the annual biogeographic population with connectivity to UK waters. These mortality increases could be detectable at the population level within the context of natural variation.

649. Based on the numbers presented in **Table 11-133**, the potential for SEP and DEP to contribute to a significant cumulative collision effect on gannet is considered to be negligible both individually and combined, but the year round magnitude of cumulative collision on gannet is assessed as medium. However, there are substantial levels of precaution built into these mortality predictions, notably in three areas. Firstly, the use of consented rather than as-built OWF parameters may lead to the overestimation of collision rates by up to 40% (MacArthur Green, 2017; The Crown Estate and Womble Bond Dickinson, 2021). Secondly, the omission of evidence-based nocturnal activity factors (8%) (Furness *et al*., 2018) from these collision estimates is also likely to lead to quite large overestimation of collision risk. The values presented in **Table 11-133** assume a nocturnal activity of 25%. It is estimated that the use of the evidence-based nocturnal activity factor would reduce predicted collision rates by approximately 10% to 20%, though this varies by OWF location and season/day length. Finally, the use of an avoidance rate of 0.989 is lower than the evidence-based avoidance rate of 0.995 recommended by Bowgen and Cook (2018). If this higher avoidance rate is applied, collision risk would be reduced by approximately 60%.

650. A density independent population model for the British gannet population (WWT Consulting *et al*., 2012) concluded that population growth, on average, would remain positive until additional mortality exceeded 10,000 individuals per year while the lower 95% CI on population growth remained positive until additional mortality exceeded 3,500 individuals. Both values are substantially greater than the current cumulative collision total, which itself is considered to be highly precautionary. The risk of a 5% population decline was less than 5% for additional annual mortalities below 5,000, indicating a high probability that currently predicted cumulative collision mortalities, even when high precaution is applied, will not result in population declines.

651. Finally, it should be noted that despite the predicted impacts, the UK population of gannet is increasing (JNCC, 2020), and all breeding gannet SPA qualifying features in the UK are in favourable condition.

652. In conclusion, the cumulative impact on the gannet population due to OWF collision both year round and within individual seasons presented in **Table 11-146** is considered to be overestimated. The actual collision rate is predicted to be of low magnitude. Gannets are considered to be of medium sensitivity to collision mortality and the impact significance is therefore **minor adverse**. This predicted impact is not significant in EIA terms, and therefore reaches a different conclusion than Natural England during DCO Examination for East Anglia ONE North and TWO (Natural England, 2021e).

653. Recently, it has been suggested by Natural England that the application of correction factors to CRM outputs of 0.600 to 0.800 to account for macro-avoidance may be appropriate for this species. This would further reduce collision risk. This is not explored quantitatively here since the conclusions would not be affected, but is considered in the **RIAA** (document reference 5.4) for impacts on the gannet population of the Flamborough and Filey Coast SPA.

11.7.3.2.2 Great Black-Backed Gull

654. Seasonal cumulative collision predictions for great black-backed gull by tier, along with the contribution made by the mean collision mortalities for SEP and DEP, is presented in **Table 11-147**.

655. Not all projects included in the CIA provided a seasonal breakdown of collision impacts for this species. Natural England has previously advised that an 80:20 split between the non-breeding and breeding seasons is appropriate for lesser black-backed gull in terms of apportioning collision estimates to biologically relevant seasons where this is not split by the original assessment. This is also considered to be appropriate for great black-backed gull.

Table 11-147: Summary of Cumulative Collision Predictions for Great Black-Backed Gull for All OWFs Included in CIA

Tiers	Non-breeding	Breeding	Annual
1 to 3 (i.e. consented, under construction or operational)	795	184	979
Hornsea Project Four (PEIR)	14	3	17
DEP	1	0	1
SEP	0	4	4
Total	**809**	**192**	**1,001**

656. The annual cumulative total of predicted collisions is 1,001, of which SEP and DEP contribute five birds (0.5%).

657. To assess the magnitude of the year round impact of cumulative OWF collision on great black-backed gull, two background populations are considered. Firstly, the largest relevant BDMPS population (non-breeding season UK North Sea BDMPS, consisting of 91,399 individuals (Furness, 2015)). Based on the published baseline mortality of 18.5% across all age classes (**Table 11-17**), 16,909 individuals from this population would be expected to die annually. Secondly, the biogeographic population with connectivity to UK waters of 235,000 (Furness, 2015). 43,475 individuals would be expected to die annually from this population using the same all age class mortality rate (**Table 11-17**).

658. The predicted level of additional mortality would represent a 5.9% increase in annual mortality within the largest BDMPS population, or a 2.3% increase in annual mortality within the annual biogeographic population with connectivity to UK waters. These mortality increases could be detectable at the population level within the context of natural variation.

659. There are substantial levels of precaution built into these mortality predictions, notably in two areas. Firstly, the use of consented rather than as-built OWF

parameters may lead to the overestimation of collision rates by up to 40% (MacArthur Green, 2017; The Crown Estate and Womble Bond Dickinson, 2021). Secondly, the assumed nocturnal activity of 50% may be an overestimate. Whilst no species-specific information for great black-backed gull is available, available information for lesser black-backed gull suggests that nocturnal activity values of 25% or thereabouts may be more realistic (MacArthur Green, 2015). It is estimated that the use of the evidence-based nocturnal activity factor would reduce predicted collision rates by approximately 20%, though this varies by OWF location and season/day length.

660. A density dependent population model for great black-backed gull, at the scale of the UK North Sea BDMPS (Furness, 2015), was developed during the East Anglia THREE assessment (Royal HaskoningDHV, 2016). An additional annual mortality of 900 birds resulted in impacted populations after 25 years which were 6.1% to 7.7% smaller than predicted populations in the absence of OWF collision risk impacts. JNCC population trend data for great black-backed gull indicate that the annual UK population estimate has varied by much greater amounts over the last five decades (JNCC, 2020). The modelled effect of cumulative collisions lies within the range of variation seen within the UK population, and could potentially be at a scale which is undetectable. However, great black-backed gull has been subject to relatively little research and estimates of demographic rates have been categorised as low quality (Horswill and Robinson, 2015).

661. Accounting for the precaution included in the assessments, based on the numbers presented in **Table 11-147**, the potential for SEP and DEP to contribute to a significant cumulative collision effect on great black-backed gull is considered to be negligible both individually and combined. However, the year round magnitude of cumulative operational collision on great black-backed gull is assessed as medium. This conclusion is considered appropriate due to the fact that potential mortality increases of 1% are predicted due to cumulative OWF collision mortality, and because of the potentially low reliability of demographic parameters for this species to use in PVAs. Great black-backed gull is considered to be of high sensitivity to collision mortality and. The appropriate impact significance is considered to be **moderate adverse** rather than major adverse, based on the definitions in **Table 11-13**. This predicted impact is potentially significant in EIA terms, and therefore reaches the same conclusion as Natural England during DCO Examination for East Anglia ONE North and TWO (Natural England, 2021e).

11.7.3.2.3 Kittiwake

662. Seasonal annual cumulative collision predictions for kittiwake at OWFs by tier, along with the contribution made by the mean collision mortalities for SEP and DEP, are presented in **Table 11-148**.

Table 11-148: Summary of Cumulative Collision Predictions for Kittiwake for All OWFs Included in CIA

Tiers	Autumn migration	Spring migration	Breeding	Annual
1 to 3 (i.e. consented, under construction or operational)	1,546	1,193	1,275	4,015

Tiers	Autumn migration	Spring migration	Breeding	Annual
Hornsea Project Four (PEIR)	35	10	153	198
DEP	5	1	9	15
SEP	1	0	1	2
Total	**1,587**	**1,204**	**1,439**	**4,230**

663. To assess the magnitude of the year round impact of cumulative OWF collision on kittiwake, two background populations are considered. Firstly, the largest relevant BDMPS population (autumn migration season UK North Sea BDMPS, consisting of 829,937 individuals (Furness, 2015)). Based on the published baseline mortality of 15.6% across all age classes (**Table 11-17**), 129,470 individuals from this population would be expected to die annually. Secondly, the biogeographic population with connectivity to UK waters of 5,100,000 (Furness, 2015). 795,600 individuals would be expected to die annually from this population using the same all age class mortality rate (**Table 11-17**).

664. The addition of 4,230 annual collisions would represent a 3.3% increase in the annual mortality of the largest BDMPS population, and a 0.5% increase in the annual mortality of the annual biogeographic population with connectivity to UK waters. The annual cumulative total of predicted collisions is 4,230, of which SEP and DEP contribute 17 birds (0.4%).

665. Based on the numbers presented in **Table 11-148**, the potential for SEP and DEP to contribute to a significant cumulative collision effect on kittiwake is considered to be negligible both individually and combined, but the year round magnitude of cumulative collision on kittiwake is assessed as medium. However, there are substantial levels of precaution built into these mortality predictions, notably in three areas. Firstly, the use of consented rather than as-built OWF parameters may lead to the overestimation of collision rates by up to 40% (MacArthur Green, 2017; The Crown Estate and Womble Bond Dickinson, 2021). Secondly, the assumed nocturnal activity of 50% may be an overestimate. Whilst no published species-specific literature for kittiwake is available, available information for other gull species suggests that nocturnal activity values of 25% or thereabouts may be more realistic (MacArthur Green, 2015). It is estimated that the use of the evidence-based nocturnal activity factor would reduce predicted collision rates by approximately 20%, though this varies by OWF location and season/day length. Finally, the use of an avoidance rate of 0.989 is lower than the evidence-based avoidance rate of 0.990 recommended by Bowgen and Cook (2018). If this higher avoidance rate is applied, collision risk would be reduced by approximately 10%.

666. Density dependent population models assessing the potential effects of cumulative OWF collision mortality on the kittiwake BDMPS populations indicate that an annual mortality of 4,000 birds would result in a population 3.6% to 4.4% smaller after 25 years than that predicted in the absence of the additional mortality (MacArthur Green, 2015). To place this predicted magnitude of change in context, over three approximately 15 year periods between censuses, the British kittiwake population changed by +24% (1969 to 1985), -25% (1985 to 1998) and -44% (2000 to 2015) (JNCC, 2020). When considered within this context, it seems likely that declines of up to 4.4% across a longer (25 year) period against a background of changes an

order of magnitude larger will be undetectable. It is possible that the longer term decline observed in the UK kittiwake population will continue, and that recovery over this period is unlikely on the basis that climate change seems to be a key driver in kittiwake declines (Descamps *et al*., 2017). However, precautionary estimates of additional mortality due to cumulative OWF collision are not predicted to significantly increase the rate of decline or to prevent the population from recovering should environmental conditions become more favourable.

667. In conclusion, the cumulative impact on the kittiwake population due to OWF collision both year round and within individual seasons presented in **Table 11-148** is considered to be overestimated. The actual collision rate is predicted to be of a low impact magnitude, which is lower than would be the case if these numbers were correct. Kittiwakes are considered to be of medium sensitivity to collision mortality and the impact significance is therefore **minor adverse**. This predicted impact is not significant in EIA terms, and therefore reaches a different conclusion than Natural England during DCO Examination for East Anglia ONE North and TWO (Natural England, 2021e).

11.7.3.2.4 Lesser Black-Backed Gull

668. Seasonal cumulative collision predictions for lesser black-backed gull by tier, along with the contribution made by the mean collision mortalities for SEP and DEP, is presented in **Table 11-149**.

669. Not all projects included in the CIA provided a seasonal breakdown of collision impacts for this species. Natural England has previously advised that an 80:20 split between the non-breeding and breeding seasons is appropriate for lesser black-backed gull in terms of apportioning collision estimates to biologically relevant seasons where this is not split by the original assessment. This is also considered to be appropriate for lesser black-backed gull.

Table 11-149: Summary of Cumulative Collision Predictions for Lesser Black-Backed Gull for All OWFs Included in CIA

Tiers	Non-breeding	Breeding	Annual
1 to 3 (i.e. consented, under construction or operational)	372	158	530
Hornsea Project Four (PEIR)	0	2	2
DEP	0	1	1
SEP	0	1	1
Total	**372**	**162**	**533**

670. The annual cumulative total of predicted collisions is 533, of which SEP and DEP contribute two birds (0.3%).

671. To assess the magnitude of the year round impact of cumulative OWF collision on lesser black-backed gull, two background populations are considered. Firstly, the largest relevant BDMPS population (autumn migration season UK North Sea BDMPS, consisting of 209,007 individuals (Furness, 2015)). Based on the published baseline mortality of 12.6% across all age classes (**Table 11-17**), 26,335 individuals from this population would be expected to die annually. Secondly, the biogeographic population with connectivity to UK waters of 1,707,000 (Furness, 2015). 215,082

individuals would be expected to die annually from this population using the same all age class mortality rate (**Table 11-17**).

672. The predicted level of additional mortality would represent a 2.0% increase in annual mortality within the largest BDMPS population, or a 0.2% increase in annual mortality within the annual biogeographic population with connectivity to UK waters. These mortality increases could be detectable at the population level within the context of natural variation.

673. There are substantial levels of precaution built into these mortality predictions, notably in two areas. Firstly, the use of consented rather than as-built OWF parameters may lead to the overestimation of collision rates by up to 40% (MacArthur Green, 2017; The Crown Estate and Womble Bond Dickinson, 2021). Secondly, the assumed nocturnal activity of 50% may be an overestimate. Whilst no species-specific information for lesser black-backed gull is available, available information for lesser black-backed gull suggests that nocturnal activity values of 25% or thereabouts may be more realistic (MacArthur Green, 2015). It is estimated that the use of the evidence-based nocturnal activity factor would reduce predicted collision rates by approximately 20%, though this varies by OWF location and season/day length.

674. In conclusion, the cumulative impact on the lesser black-backed gull population due to OWF collision both year round and within individual seasons presented in **Table 11-149** is considered to be overestimated. The actual collision rate is predicted to be of a low impact magnitude, which is lower than would be the case if these numbers were correct. Lesser black-backed gulls are considered to be of medium sensitivity to collision mortality and the impact significance is therefore **minor adverse**. This predicted impact is not significant in EIA terms, and therefore reaches a different conclusion than Natural England during DCO Examination for East Anglia ONE North and TWO (Natural England, 2021e).

11.7.3.2.5 Sandwich tern

675. Sandwich tern collision rates have been recalculated for OWFs in the Greater Wash area. There are two main reasons for this. Firstly, the previous assessments for most of these OWFs used methods which are no longer recommended by Natural England for the estimation of collision risk. Secondly, recalculation of collision risk has enabled the examination of different OWF scenarios, as explained below. The approach to Sandwich tern CIA is above and beyond what is normally undertaken for OWF assessment.

676. Flying density data for Sandwich tern at SOW (SCIRA Offshore Energy Ltd, 2006a, 2006b), DOW (MacArthur Green, 2014), Race Bank OWF (Centrica Energy, 2009a, 2009b) and Triton Knoll OWF (RWE NPower Renewables, 2011) was collated and CRM carried out according to the methodology and assumptions used for the "realistic worst-case scenario" CRMs of SEP and DEP (**Section 11.6.2.2.2**). These OWFs were included since they were considered by the DECC (2012) Appropriate Assessment for Sandwich tern. In addition to the avoidance rate of 0.980 being used, which is the avoidance rate used for this species throughout the assessment, two additional rates were incorporated for comparative purposes. The first, 0.9883,

allows comparison with the outputs from DECC (2012). The second, 0.993, is a behavioural avoidance rate calculated during the SOW OMP.

677. The number of birds at risk of collision from these OWFs based on consented designs (Scenario A) is presented in **Table 11-150**, along with the mean collision risk estimates at SEP and DEP calculated for the worst-case scenario (**Table 11-2**). Equivalent values for as-built designs (Scenario B) are presented in **Table 11-151**.

678. As built designs are considered to provide a more realistic assessment of cumulative impact because they consider what has actually been built (and what is therefore having an effect) rather than what could theoretically be built (but in practice is extremely unlikely to ever be built). There is a theoretical, albeit extremely unlikely possibility of additional turbines being added to the design of existing OWFs. As a result, three further sets of CRM outputs for hypothetical OWF designs have been produced. The first (**Table 11-152**) assumes that any unbuilt capacity at the consented OWFs is built out using turbines of the same specification as the consented design (Scenario C). The second (**Table 11-153**) assumes that any unbuilt capacity at the consented OWFs is built out using turbines of the same specification as those actually used at the OWF (Scenario D). The final set of CRM outputs (Scenario E) is the same as Scenario D but with the assumption that the as-built layout of DOW is legally secured (**Table 11-154**). Further details describing the mechanism for securing the as-built layout of DOW are provided in **Chapter 4 Project Description**.

Table 11-150: Summary of Cumulative Operational Collision Predictions for Sandwich Tern for All OWFs Included in CIA, Based on Consented Turbine Parameters (Scenario A)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))			0.9883	0.993
		0% MA	25% MA	50% MA		
DOW	85 turbines, 22m air gap	40.1	30.1	20.0	23.5	14.0
Race Bank	206 turbines, 22m air gap	91.5	68.6	45.7	53.5	32.0
SOW	88 turbines, 22m air gap	17.3	13.0	8.7	10.1	6.1
Triton Knoll	288 turbines, 22m air gap	17.8	13.4	8.9	23.5	6.2
Total		**166.7**	**125.0**	**83.4**	**97.5**	**58.4**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	5.7	3.8	4.4	2.7
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.4	0.9	1.1	0.7
Total (including SEP and DEP, design-based density estimates)		**176.2**	**132.1**	**88.1**	**103.1**	**61.7**
DEP	30 turbines, 30m air gap (model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)	8.9 (11.5)	6.7 (8.6)	4.5 (5.8)	5.2 (6.7)	3.1 (4.0)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))			0.9883	0.993
		0% MA	25% MA	50% MA		
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.1	1.4	1.6	1.0
Total (including SEP and DEP, model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)		**178.5 (181.1)**	**133.9 (135.8)**	**89.2 (90.5)**	**104.4 (105.9)**	**62.5 (63.4)**

Table 11-151: Summary of Cumulative Operational Collision Predictions for Sandwich Tern for All OWFs Included in CIA, Based on As-Built Turbine Parameters (Scenario B)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))			0.9883	0.993
		0% MA	25% MA	50% MA		
DOW	67 turbines, 22m air gap	33.3	25.0	16.6	19.5	11.7
Race Bank	91 turbines, 26m air gap	30.9	23.2	15.5	18.1	10.8
SOW	88 turbines, 22m air gap	17.3	13.0	8.7	10.1	6.1
Triton Knoll	90 turbines, 23m air gap	6.1	4.5	3.0	3.5	2.1
Total		**87.6**	**65.7**	**43.8**	**51.3**	**30.7**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	5.7	3.8	4.4	2.7
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.4	0.9	1.1	0.7
Total (including SEP and DEP, design-based density estimates)		**97.1**	**72.8**	**48.5**	**56.8**	**34.0**
DEP	30 turbines, 30m air gap (model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)	8.9 (11.5)	6.7 (8.6)	4.5 (5.8)	5.2 (6.7)	3.1 (4.0)
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.1	1.4	1.6	1.0
Total (including SEP and DEP, model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)		**99.4 (102.0)**	**74.5 (76.5)**	**49.7 (51.0)**	**58.1 (59.6)**	**34.8 (35.7)**

Table 11-152: Summary of Cumulative Operational Collision Predictions for Sandwich Tern for All OWFs Included in CIA, Based on As-Built Turbine Parameters, with Unbuilt Consented Capacity Built using Consented Turbine Designs (Scenario C)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))			0.9883	0.993
		0% MA	25% MA	50% MA		
DOW	67 turbines, 22m air gap, plus 158MW of consented specification turbines	44.5	33.4	22.3	26.0	15.6
Race Bank	91 turbines, 26m air gap, plus 7MW of consented specification turbines	31.9	23.9	15.9	18.6	11.2
SOW	88 turbines, 22m air gap, plus 0MW of consented specification turbines	17.3	13.0	8.7	10.1	6.1
Triton Knoll	90 turbines, 23m air gap, plus 343MW of consented specification turbines	11.2	8.4	5.6	6.6	3.9
Total		**104.9**	**78.7**	**52.5**	**61.4**	**36.7**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	5.7	3.8	4.4	2.7
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.4	0.9	1.1	0.7
Total (including SEP and DEP, design-based density estimates)		**114.4**	**85.8**	**57.2**	**66.9**	**40.0**
DEP	30 turbines, 30m air gap (model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)	8.9 (11.5)	6.7 (8.6)	4.5 (5.8)	5.2 (6.7)	3.1 (4.0)
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.1	1.4	1.6	1.0
Total (including SEP and DEP, model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)		**116.7 (119.3)**	**87.5 (89.5)**	**58.3 (59.6)**	**68.3 (69.8)**	**40.8 (41.7)**

Table 11-153: Summary of Cumulative Operational Collision Predictions for Sandwich Tern for All OWFs Included in CIA, Based on As-Built Turbine Parameters, with Unbuilt Consented Capacity Built using As-Built Turbine Designs (Scenario D)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))			0.9883	0.993
		0% MA	25% MA	50% MA		
DOW	67 turbines, 22m air gap, plus 158MW of as-built specification turbines	42.6	32.0	21.3	24.9	14.9

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))			0.9883	0.993
		0% MA	25% MA	50% MA		
Race Bank	91 turbines, 26m air gap, plus 7MW of as-built specification turbines	31.3	23.4	15.6	18.3	10.9
SOW	88 turbines, 22m air gap, plus 0MW of as-built specification turbines	17.3	13.0	8.7	10.1	6.1
Triton Knoll	90 turbines, 23m air gap, plus 343MW of as-built specification turbines	7.8	5.9	3.9	4.6	2.7
Total		**99.0**	**74.3**	**49.5**	**57.9**	**34.7**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	5.7	3.8	4.4	2.7
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.4	0.9	1.1	0.7
Total (including SEP and DEP, design-based density estimates)		**108.5**	**81.4**	**54.2**	**63.5**	**38.0**
DEP	30 turbines, 30m air gap (model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)	8.9 (11.5)	6.7 (8.6)	4.5 (5.8)	5.2 (6.7)	3.1 (4.0)
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.1	1.4	1.6	1.0
Total (including SEP and DEP, model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)		**110.8 (113.4)**	**83.1 (85.0)**	**55.4 (56.7)**	**64.8 (66.3)**	**38.8 (39.7)**

Table 11-154: Summary of Cumulative Operational Collision Predictions for Sandwich Tern for All OWFs Included in CIA, Based on As-Built Turbine Parameters, with Unbuilt Consented Capacity Built using As-Built Turbine Designs, Except for DOW, for Which the As-Built Design is Assumed to be Legally Secured (Scenario E)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))			0.9883	0.993
		0% MA	25% MA	50% MA		
DOW	67 turbines, 22m air gap, plus 158MW of as-built specification turbines	33.3	25.0	16.6	19.5	11.7
Race Bank	91 turbines, 26m air gap, plus 7MW of as-built specification turbines	31.3	23.4	15.6	18.3	10.9
SOW	88 turbines, 22m air gap, plus 0MW of as-built specification turbines	17.3	13.0	8.7	10.1	6.1

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))			0.9883	0.993
		0% MA	25% MA	50% MA		
Triton Knoll	90 turbines, 23m air gap, plus 343MW of as-built specification turbines	7.8	5.9	3.9	4.6	2.7
Total		**89.7**	**67.3**	**44.8**	**52.5**	**31.4**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	5.7	3.8	4.4	2.7
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.4	0.9	1.1	0.7
Total (including SEP and DEP, design-based density estimates)		**99.2**	**74.4**	**49.6**	**58.0**	**34.7**
DEP	30 turbines, 30m air gap (model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)	8.9 (11.5)	6.7 (8.6)	4.5 (5.8)	5.2 (6.7)	3.1 (4.0)
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.1	1.4	1.6	1.0
Total (including SEP and DEP, model-based density estimates; values in parentheses assumes all turbines installed in DEP-N)		**101.4 (104.0)**	**76.1 (78.0)**	**50.7 (52.0)**	**59.3 (60.9)**	**35.5 (36.4)**

679. Using the CRMs based on consented OWF designs (Scenario A) and CRMs based on model-based density estimates for SEP and DEP, along with the recommended avoidance rate (0.980), either 178.5 (0.000 macro-avoidance), 133.9 (0.250 macro-avoidance) or 89.2 (0.500 macro-avoidance) Sandwich terns per year are predicted to collide with operational OWFs in the wider Wash area (**Table 11-150**). SEP and DEP contribute 1.6% and 5.0% of this total respectively (6.5% combined). If it is assumed that all collisions are breeding adult birds from the North Norfolk Coast SPA (which is highly precautionary due to the distance between the breeding colonies and the OWFs, and the fact that birds from other colonies will be present during passage periods), the annual mortality rate of this population would increase by 18.2%, 13.7% or 9.1% depending on the macro-avoidance correction factor used. If it is assumed that all of the turbines at DEP will be installed at DEP-N, the annual mortality rates increase slightly to 181.1 (0.000 macro-avoidance), 135.8 (0.250 macro-avoidance) or 90.5 (0.500 macro-avoidance), which in turn result in increases in the existing mortality rate of North Norfolk Coast SPA breeding adult Sandwich terns by 18.8%, 14.1% and 9.4% respectively.

680. These mortality rates are considered to be unrealistically high, since the OWF designs used as CRM input parameters do not exist, despite being legally possible (though in practice virtually impossible). For this situation to actually occur, the as-built DOW, Race Bank, SOW and Triton Knoll OWFs would need to be decommissioned and replaced by the consented designs. These designs included

turbines that have been superseded by more modern designs. Whilst it is acknowledged that such a scenario is not "legally secured", it is not clear how or why this situation would ever arise in reality, and it is not considered by the Applicant to be a plausible scenario, though it is recognised that this is the current "legally secured" scenario. It should be noted that a legal mechanism has been included in Article 45 of the **Draft DCO** (document reference 3.1) to secure the release of the headroom from DOW (see the **Explanatory Memorandum** (document reference 3.2) and the **Draft DCO** (document reference 3.1) for further details.

681. Using the CRMs based on as-built OWF designs (Scenario B) and CRMs based on model-based density estimates for SEP and DEP, along with the recommended avoidance rate (0.980), either 99.4 (0.000 macro-avoidance), 74.5 (0.250 macro-avoidance) or 49.7 (0.500 macro-avoidance) breeding adult North Norfolk Coast SPA Sandwich terns per year are predicted to collide with operational OWFs in the wider Wash area (**Table 11-151**). SEP and DEP contribute 2.8% and 9.0% of this total respectively (11.8% combined). If it is assumed that all collisions are breeding adult birds from the North Norfolk Coast SPA (which is highly precautionary due to the distance between the breeding colonies and the OWFs, and the fact that birds from other colonies will be present during passage periods), the annual mortality rate of this population would increase by 10.1%, 7.6% or 5.1% depending on the macro-avoidance correction factor used. If it is assumed that all of the turbines at DEP will be installed at DEP-N, the annual mortality rates increase slightly to 102.0 (0.000 macro-avoidance), 76.5 (0.250 macro-avoidance) or 51.0 (0.500 macro-avoidance), which in turn result in increases in the existing mortality rate of North Norfolk Coast SPA breeding adult Sandwich terns by 10.6%, 7.9% and 5.3% respectively.

682. Whilst this situation is the most realistic in terms of OWF design, it does not account for the fact that the as-built designs are not legally secured. Noting as above that that a legal mechanism has been included in Article 45 of the **Draft DCO** (document reference 3.1) to secure the release of the headroom from DOW.

683. Using the CRMs based on as-built OWF designs with additional unbuilt capacity built out using consented design turbines (Scenario C) and CRMs based on model-based density estimates for SEP and DEP, along with the recommended avoidance rate (0.980), either 116.7 (0.000 macro-avoidance), 87.5 (0.250 macro-avoidance) or 58.3 (0.500 macro-avoidance) breeding adult North Norfolk Coast SPA Sandwich terns per year are predicted to collide with operational OWFs in the wider Wash area (**Table 11-152**). SEP and DEP contribute 2.4% and 7.6% of this total respectively (10.0% combined). If it is assumed that all collisions are breeding adult birds from the North Norfolk Coast SPA (which is highly precautionary due to the distance between the breeding colonies and the OWFs, and the fact that birds from other colonies will be present during passage periods), the annual mortality rate of this population would increase by 11.9%, 8.9% or 6.0% depending on the macro-avoidance correction factor used. If it is assumed that all of the turbines at DEP will be installed at DEP-N, the annual mortality rates increase slightly to 119.3 (0.000 macro-avoidance), 89.5 (0.250 macro-avoidance) or 59.6 (0.500 macro-avoidance), which in turn result in increases in the existing mortality rate of North Norfolk Coast SPA breeding adult Sandwich terns by 12.4%, 9.3% and 6.2% respectively.

684. This situation represents a worst-case scenario for the building out of as yet unbuilt capacity at the existing OWFs. However, this is not a highly likely scenario, because it requires any further build-out of existing OWFs to use turbine designs that have been superseded by more modern alternatives. Whilst possible, this does not seem like a realistic scenario.

685. Using the CRMs based on as-built OWF designs with additional unbuilt capacity built out using as-built design turbines (Scenario D) and CRMs based on model-based density estimates for SEP and DEP, along with the recommended avoidance rate (0.980), either 110.8 (0.000 macro-avoidance), 83.1 (0.250 macro-avoidance) or 55.4 (0.500 macro-avoidance) breeding adult North Norfolk Coast SPA Sandwich terns per year are predicted to collide with operational OWFs in the wider Wash area (**Table 11-153**). SEP and DEP contribute 2.5% and 8.1% of this total respectively (10.6%). If it is assumed that all collisions are breeding adult birds from the North Norfolk Coast SPA (which is highly precautionary due to the distance between the breeding colonies and the OWFs, and the fact that birds from other colonies will be present during passage periods), the annual mortality rate of this population would increase by 11.3%, 8.5% or 5.7% depending on the macro-avoidance correction factor used. If it is assumed that all of the turbines at DEP will be installed at DEP-N, the annual mortality rates increase slightly to 113.4 (0.000 macro-avoidance), 85.0 (0.250 macro-avoidance) or 56.7 (0.500 macro-avoidance), which in turn result in increases in the existing mortality rate of North Norfolk Coast SPA breeding adult Sandwich terns by 11.8%, 8.8% and 5.9% respectively.

686. This situation represents the most realistic scenario for the building out of as yet unbuilt capacity at the existing OWFs of the two presented. Despite that, such a situation has never yet occurred at another OWF in UK waters, and to add the additional capacity would require new consents underpinned by new assessments.

687. Using the CRMs based on as-built OWF designs with additional unbuilt capacity built out using as-built design turbines, but assuming the as-built design for DOW is legally secured (Scenario E) and CRMs based on model-based density estimates for SEP and DEP, along with the recommended avoidance rate (0.980), either 101.4 (0.000 macro-avoidance), 76.1 (0.250 macro-avoidance) or 50.7 (0.500 macro-avoidance) breeding adult North Norfolk Coast SPA Sandwich terns per year are predicted to collide with operational OWFs in the wider Wash area (**Table 11-154**). SEP and DEP contribute 2.8% and 8.8% of this total respectively (11.6%). If it is assumed that all collisions are breeding adult birds from the North Norfolk Coast SPA (which is highly precautionary due to the distance between the breeding colonies and the OWFs, and the fact that birds from other colonies will be present during passage periods), the annual mortality rate of this population would increase by 10.5%, 7.9% or 5.3% depending on the macro-avoidance correction factor used. If it is assumed that all of the turbines at DEP will be installed at DEP-N, the annual mortality rates increase slightly to 104.0 (0.000 macro-avoidance), 78.0 (0.250 macro-avoidance) or 52.0 (0.500 macro-avoidance), which in turn result in increases in the existing mortality rate of North Norfolk Coast SPA breeding adult Sandwich terns by 10.8%, 8.1% and 5.4% respectively.

688. As per Scenario D, this situation represents the most realistic scenario for the building out of as yet unbuilt capacity at the existing OWFs of the two presented, but with the assumption that the as-built design of DOW is legally secured.

689. Based on the increases in annual mortality of the breeding adult Sandwich tern population of the North Norfolk Coast SPA, there is potential for significant effects to occur at the population level due to this impact pathway. PVAs for a selection of possible scenarios are presented in **Table 11-155** when the SEP and DEP CRMs were prepared using design-based density estimates, **Table 11-156** when the SEP and DEP CRMs were prepared using model-based density estimates, and **Table 11-157** when the SEP and DEP CRMs were prepared using model-based density estimates, but it is assumed that at DEP, all turbines will be installed in DEP-N rather than across DEP as a whole. For each Scenario (A to E), the population level effects of predicted annual collision mortality at three macro-avoidance rates has been examined.

Table 11-155: PVA Outputs for Breeding Adult North Norfolk Coast SPA Sandwich Terns Incorporating Collision Impacts of SEP and DEP (Based on CRMs using Design-Based Density Estimates) In-Combination with Other Projects

Scenario	Avoidance rate	Macro-avoidance rate	Annual mortality	Increase in existing mortality rate[1,2]	Median CGR[3]	Median CPS[3]
A	0.980	0%	176.2	0.0210538894	0.976	0.375
	0.980	25%	132.1	0.0157844426	0.982	0.481
	0.980	50%	88.1	0.0105269447	0.988	0.615
B	0.980	0%	97.1	0.0116023420	0.987	0.584
	0.980	25%	72.8	0.0086987693	0.990	0.669
	0.980	50%	48.5	0.0057951966	0.994	0.766
C	0.980	0%	114.4	0.0136694946	0.985	0.531
	0.980	25%	85.8	0.0102521209	0.988	0.622
	0.980	50%	57.2	0.0068347473	0.992	0.729
D	0.980	0%	108.5	0.0129645119	0.985	0.548
	0.980	25%	81.4	0.0097263711	0.989	0.638
	0.980	0%	54.2	0.0064762815	0.993	0.742
E	0.980	25%	99.2	0.0118532680	0.987	0.578
	0.980	50%	74.4	0.0088899510	0.990	0.663
	0.980	0%	49.6	0.0059266340	0.993	0.761

Notes

1. This is a key input into PVA, and is provided to ten decimal places to enable the model to be reproduced
2. Background population is North Norfolk Coast SPA breeding adults (8,369 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015), assumes 100% of impacts year round are apportioned to this population, which is a precautionary overestimate
3. After 40 years of operation

Table 11-156: PVA Outputs for Breeding Adult North Norfolk Coast SPA Sandwich Terns Incorporating Collision Impacts of SEP and DEP (Based on CRMs using Model-Based Density Estimates) In-Combination with Other Projects

Scenario	Avoidance rate	Macro-avoidance rate	Annual mortality	Increase in existing mortality rate[1,2]	Median CGR[3]	Median CPS[3]
A	0.980	0%	178.5	0.0213287131	0.976	0.371
	0.980	25%	133.9	0.0159995220	0.982	0.476
	0.980	50%	89.2	0.0106583821	0.988	0.611
B	0.980	0%	99.4	0.0118771657	0.987	0.577
	0.980	25%	74.5	0.0089018999	0.990	0.662
	0.980	50%	49.7	0.0059385829	0.993	0.760
C	0.980	0%	116.7	0.0139443183	0.984	0.524
	0.980	25%	87.5	0.0104552515	0.988	0.616
	0.980	50%	58.3	0.0069661847	0.992	0.725
D	0.980	0%	110.8	0.0132393356	0.985	0.541
	0.980	25%	83.1	0.0099295017	0.989	0.632
	0.980	0%	55.4	0.0066196678	0.993	0.737
E	0.980	0%	101.4	0.0121161429	0.986	0.571
	0.980	25%	76.1	0.0090930816	0.990	0.657
	0.980	50%	50.7	0.0060580715	0.993	0.756

Notes

1. This is a key input into PVA, and is provided to ten decimal places to enable the model to be reproduced
2. Background population is North Norfolk Coast SPA breeding adults (8,369 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015), assumes 100% of impacts year round are apportioned to this population, which is a precautionary overestimate
3. After 40 years of operation

Table 11-157: PVA Outputs for Breeding Adult North Norfolk Coast SPA Sandwich Terns Incorporating Collision Impacts of SEP and DEP (Based on CRMs using Model-Based Density Estimates, but Assuming All Turbines at DEP are Installed at DEP-N) In-Combination with Other Projects

Scenario	Avoidance rate	Macro-avoidance rate	Annual mortality	Increase in existing mortality rate[1],[2]	Median CGR[3]	Median CPS[3]
A	0.980	0%	181.1	0.0216393834	0.976	0.365
	0.980	25%	135.8	0.0162265504	0.982	0.471
	0.980	50%	90.5	0.0108137173	0.988	0.607
B	0.980	0%	102.0	0.0121878361	0.986	0.569
	0.980	25%	76.5	0.0091408770	0.990	0.655
	0.980	50%	51.0	0.0060939180	0.993	0.755
C	0.980	0%	119.3	0.0142549886	0.984	0.516
	0.980	25%	89.5	0.0106942287	0.988	0.610
	0.980	50%	59.6	0.0071215199	0.992	0.720
D	0.980	0%	113.4	0.0135500060	0.985	0.534
	0.980	25%	85.0	0.0101565301	0.989	0.625
	0.980	0%	56.7	0.0067750030	0.992	0.732
E	0.980	0%	104.0	0.0124268132	0.986	0.563
	0.980	25%	78.0	0.0093201099	0.990	0.650
	0.980	50%	52.0	0.0062134066	0.993	0.751

Notes

1. This is a key input into PVA, and is provided to ten decimal places to enable the model to be reproduced
2. Background population is North Norfolk Coast SPA breeding adults (8,369 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015), assumes 100% of impacts year round are apportioned to this population, which is a precautionary overestimate
3. After 40 years of operation

690. The PVAs investigating the population-level effects of potential collision and displacement impacts for SEP and DEP in-combination with other projects produced median CGRs ranging from 0.976 to 0.993, and median CPSs ranging from 0.365 to 0.760. The CGRs and CPSs for PVAs produced using SEP and DEP CRMs that used either model-based or design-based density estimates were extremely similar, with slightly higher population impacts predicted for scenarios where CRM at SEP and DEP was calculated using model-based density estimates than design-based density estimates, and slightly higher again if it was assumed that all of the turbines at DEP would be installed in DEP-N. However, differences between the impacts predicted by the three sets of models would likely be indistinguishable at the population level.

691. For reference, the annual rate of change in the North Norfolk Coast SPA breeding Sandwich tern population is -2.3%, 0.8%, -0.5% and 2.9% when measured over the last 40, 30, 20 and 10 years respectively. Compared to the 2019 count, the population increase at the North Norfolk Coast SPA has been 21.6%, 27.7%, 7.5% and 22.4% over the last 40, 30, 20 and 10 years respectively. The predicted impacts of all OWFs in-combination are similar to or larger than changes which have occurred in the last 40 years.

692. The median CGR values for all scenarios are within the variation recorded in the growth rate at the colony over the last 40 years. However, such a consistent reduction in growth rate over a 40 year period would result in substantial reductions in population size at the end of the 40 year modelled period when compared to the unimpacted baseline scenario. This is reflected in the median CPS values for all scenarios.

693. If it is assumed that no macro-avoidance will occur at the OWFs included in the assessment, the annual growth rate of the breeding adult Sandwich tern population of the North Norfolk Coast SPA will reduce by 1.3% to 2.4% compared with the unimpacted baseline scenario, with a corresponding reduction in population size after 40 years of operation of between 41.6% to 63.5% depending on the scenario in question. However, the assumption of no macro-avoidance occurring seems unlikely, based on the evidence examined by the assessment regarding the response of Sandwich terns to operational OWFs.

694. Assuming that a level of macro-avoidance (either 25% or 50%) will occur during the operation of all OWFs, it is anticipated that the annual growth rate of the breeding adult Sandwich tern population of the North Norfolk Coast SPA will reduce by 0.6% to 1.8% when compared with the unimpacted baseline scenario, with a corresponding reduction in population size after 40 years of operation of between 23.4% to 52.9%.

695. Scenario A was predicted to have the greatest impact at the population level by a large extent compared to the other scenarios. This is because the consented OWF parameters often consist of many more, smaller turbines than as-built designs. The predicted decreases in annual growth rate for Scenarios B, C, D and E when compared with the unimpacted baseline scenario are considerably smaller than the corresponding decrease under Scenario A (**Plate 11.1**). It is clear that both the OWF design of existing OWFs selected for modelling, and macro-avoidance level have a considerable impact on the predicted population level impacts predicted as a result of cumulative collision risk. The scenario with the next largest impact was Scenario

C, followed by D, E, and B, although the differences in these scenarios were not as large as the differences between Scenario A and all other scenarios. The reduction in population size compared to the unimpacted baseline scenario is presented in **Plate 11.2**, and presents a similar set of trends. These plates present differences from the PVAs produced from CRMs that used the model-based density estimate-based CRMs for SEP and DEP, but the differences between scenarios is the same for other PVAs. Scenario B, whilst not legally secured, is clearly the most realistic scenario presented, and has the lowest impacts.

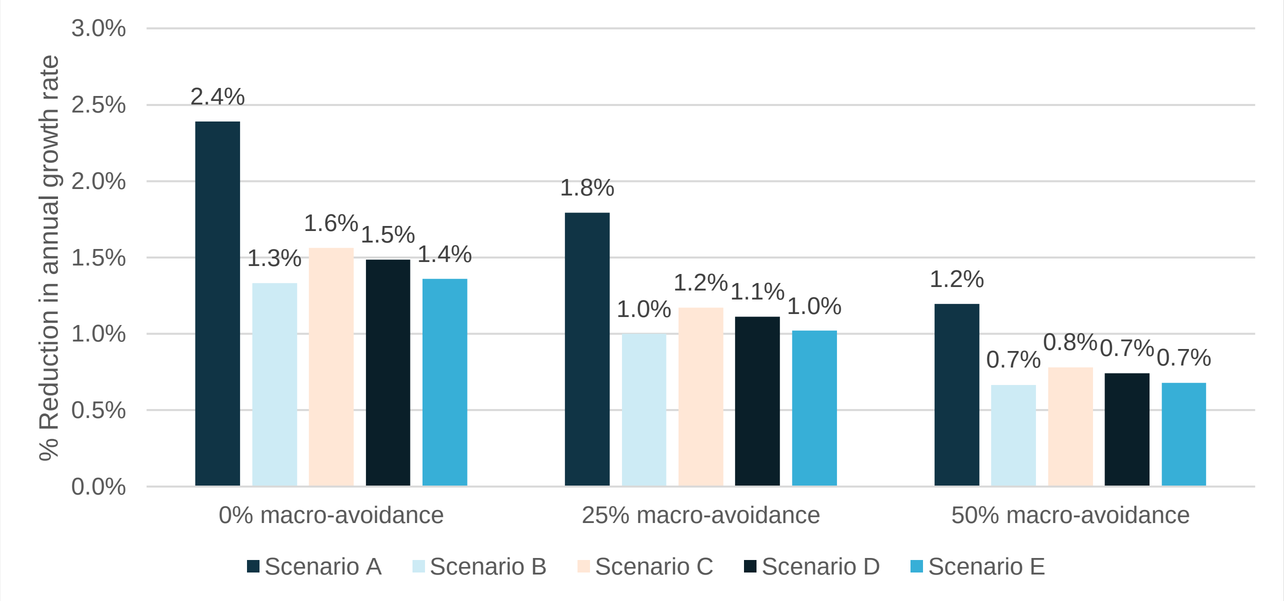

Plate 11.1: Graphical Representation of North Norfolk Coast SPA Growth Rate Reduction Compared to Unimpacted Baseline of Scenarios A to E at Different Levels of Macro-Avoidance. Counterfactuals used to Produce the Graph were Taken from PVAs Where SEP and DEP CRMs were Undertaken using Model-Based Density Estimates

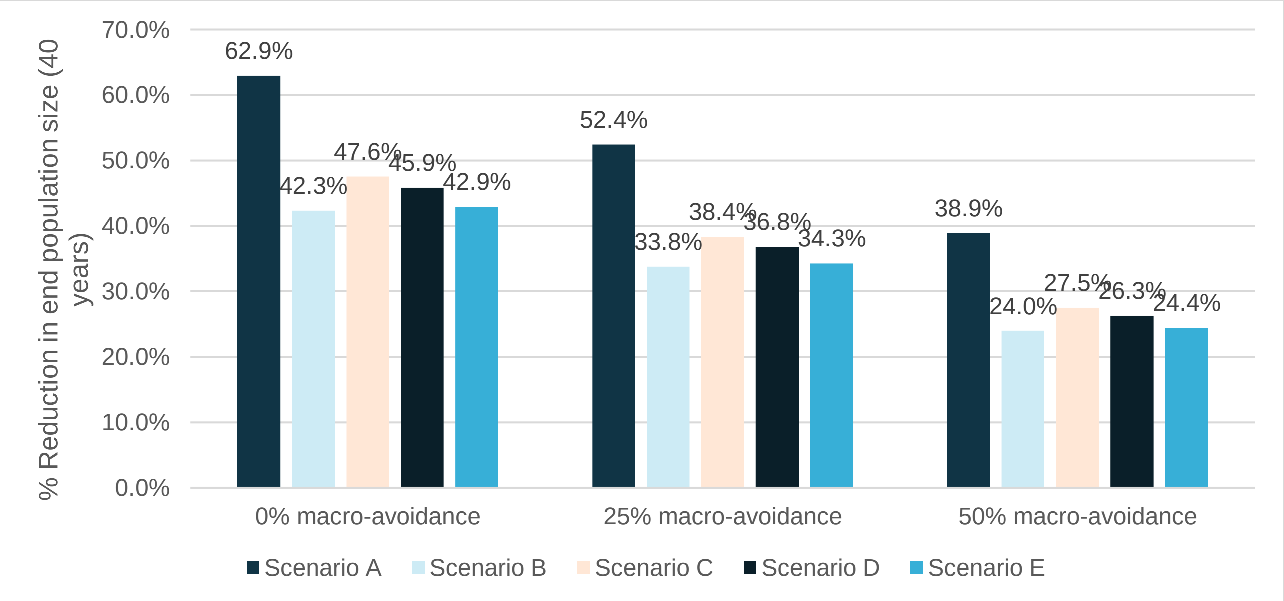

Plate 11.2: Graphical Representation of North Norfolk Coast SPA Population Size Reduction after 40 Years of Operation Compared to Unimpacted Baseline of Scenarios A to E at Different Levels of Macro-Avoidance. Counterfactuals used to Produce the Graph were Taken from PVAs where SEP and DEP CRMs were Undertaken using Model-Based Density Estimates

696. The counterfactuals calculated from the model outputs should be interpreted in light of the precautionary assumptions made both within the PVAs themselves, and the processes that were undertaken to produce the inputs into the PVAs. These include:

- The assumption that all birds recorded, particularly at DEP, are breeding adults from this population, given the OWF is situated towards the edge of the typical foraging range for this species.
- The avoidance rate applied in the CRM (0.980) might substantially underestimate the behavioural avoidance of this species to OWFs, based on evidence collected at SOW.
- The PVA does not incorporate density dependence, which means the outputs of the model are likely to be precautionary.
- The North Norfolk Coast SPA Sandwich tern population is modelled as a closed population, with no emigration or immigration occurring.

697. The contribution of SEP and DEP to the overall impact is relatively small in the context of the overall cumulative impact. Depending on the OWF designs considered, the contribution of DEP amounts to between 5% and 10% of all predicted North Norfolk Coast SPA Sandwich tern mortality due to OWF impacts, and SEP between 2% to 3%.

698. On balance, the input parameters used in both the PVAs themselves, and the inputs into other processes that feed into PVA (e.g. density estimation, CRM and apportioning), are generally considered to be appropriately precautionary given the importance of the breeding Sandwich tern population under consideration and the uncertainty around a number of aspects of the assessment. The incorporation of avoidance rates that have a greater evidential basis, reduce population level impacts, but a degree of uncertainty exists as to the extent of macro-avoidance that will occur.

699. In conclusion, it seems reasonable to assume that the annual mortalities considered in the PVAs summarised in **Table 11-155**, **Table 11-156** and **Table 11-157** could cause substantial population level impacts on the breeding adult Sandwich tern population of the North Norfolk Coast SPA.

700. The magnitude of effect of cumulative collision risk for this species is assessed as medium, though it may be lower if higher avoidance rates are applicable. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **moderate adverse**.

11.7.3.3 Cumulative Impact of Combined Operational Displacement and Collision Risk

701. Gannet and Sandwich tern have been scoped into the assessments for combined operational disturbance, displacement and barrier effects, and collision risk. This is because they are the only species included within the CIA that are considered to be susceptible to both of these impacts. It is possible that these potential impacts could combine to adversely affect populations of these species. The impacts would not act on the same individuals, as birds which do not enter an OWF cannot be subject to mortality from collision.

11.7.3.3.1 Gannet

702. At displacement rates of 0.600 to 0.800 and a 1% mortality rate (**Section 11.6.2.1.1**) between 305 and 406 gannets are predicted to die from cumulative operational

OWF displacement annually. SEP and DEP contribute between seven and nine birds to this total, or 2.2%. The annual cumulative total of predicted OWF collisions for gannet is 3,007, of which SEP and DEP contribute six birds (0.2%). In total, 3,312 to 3,413 gannets could die annually due to these combined cumulative impacts. The impacts attributable to SEP and DEP represent 0.4% of this total.

703. To assess the magnitude of the year round impact of cumulative OWF collision on gannet, two background populations are considered. Firstly, the largest relevant BDMPS population (autumn migration UK North Sea and Channel BDMPS, consisting of 456,298 individuals (Furness, 2015)). Based on the published baseline mortality of 19.1% across all age classes (**Table 11-17**), 87,153 individual gannets from this population would be expected to die annually. Secondly, the biogeographic population with connectivity to UK waters of 1,180,000 (Furness, 2015). 225,380 individuals would be expected to die annually from this population using the same all age class mortality rate (**Table 11-17**).

704. The predicted level of additional mortality would represent up to a 3.9% increase in annual mortality within the largest BDMPS population, or up to a 1.5% increase in annual mortality within the annual biogeographic population with connectivity to UK waters. These mortality increases could be detectable at the population level within the context of natural variation.

705. For reasons discussed in **Section 11.7.3.2.1**, it is thought that the assessment of cumulative collision risk produces precautionary and overestimated collision rates. The actual collision rate is predicted to be of low magnitude. Gannets are considered to be of medium sensitivity to both operational phase displacement collision mortality and the impact significance is therefore **minor adverse**. This predicted impact is not significant in EIA terms.

11.7.3.3.2 Sandwich Tern

706. The project alone impact assessment for Sandwich tern (**Section 11.6.2.3.2**) demonstrated that for this species, the highest predicted mortality rates are obtained when macro-avoidance is 0% (i.e. displacement is not predicted to occur). This means that the worst-case scenario for combined cumulative displacement and collision is actually the same as for cumulative collision risk only (**Section 11.7.3.2.5**). This is confirmed by the predicted cumulative Sandwich tern mortalities due to combined operational phase displacement and collision at three different macro-avoidance levels for Scenario A (**Table 11-158**), B (**Table 11-159**), C (**Table 11-160**), D (**Table 11-161**) and E (**Table 11-162**). The information below assumes that turbines will be installed across DEP as a whole, not just DEP-N.

707. Whilst the worst-case scenario for combined collision and displacement is as presented in for cumulative collision risk (**Table 11-155**, **Table 11-156**, **Table 11-157** and **Appendix 11.1 Offshore Ornithology Technical Report**), PVAs for combined displacement and collision scenarios are presented in **Table 11-163** and **Table 11-164**.

Table 11-158: Summary of Cumulative Operational Displacement and Collision Mortality Predictions for Sandwich Tern for All OWFs Included in CIA, Based on Consented Turbine Parameters (Scenario A)

OWF	Summary of design	Annual mortality (0.980 avoidance rate, variable macro-avoidance (MA))		
		0% MA	25% MA	50% MA
DOW	85 turbines, 22m air gap	40.1	30.2	20.3
Race Bank	206 turbines, 22m air gap	91.5	68.9	46.4
SOW	88 turbines, 22m air gap	17.3	13.0	8.7
Triton Knoll	288 turbines, 22m air gap	17.8	13.4	8.9
Total		**166.7**	**125.6**	**84.5**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	6.2	4.9
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.6	1.3
Total (including SEP and DEP, design-based density estimates)		**176.2**	**133.4**	**90.7**
DEP	30 turbines, 30m air gap (model-based density estimates)	8.9	7.3	5.6
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.3	1.8
Total (including SEP and DEP, model-based density estimates)		**178.5**	**135.2**	**91.9**

Table 11-159: Summary of Cumulative Operational Displacement and Collision Mortality Predictions for Sandwich Tern for All OWFs Included in CIA, Based on As-Built Turbine Parameters (Scenario B)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))		
		0% MA	25% MA	50% MA
DOW	67 turbines, 22m air gap	33.3	25.1	16.9
Race Bank	91 turbines, 26m air gap	30.9	23.5	16.1
SOW	88 turbines, 22m air gap	17.3	13.0	8.7
Triton Knoll	90 turbines, 23m air gap	6.1	4.6	3.1
Total		**87.6**	**66.3**	**44.9**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	6.2	4.9
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.6	1.3
Total (including SEP and DEP, design-based density estimates)		**97.1**	**74.1**	**51.1**
DEP	30 turbines, 30m air gap (model-based density estimates)	8.9	7.3	5.6

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))		
		0% MA	25% MA	50% MA
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.3	1.8
Total (including SEP and DEP, model-based density estimates)		**99.4**	**75.8**	**52.3**

Table 11-160: Summary of Cumulative Operational Displacement and Collision Mortality Predictions for Sandwich Tern for All OWFs Included in CIA, Based on As-Built Turbine Parameters, with Unbuilt Consented Capacity Built Using Consented Turbine Designs (Scenario C)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))		
		0% MA	25% MA	50% MA
DOW	67 turbines, 22m air gap, plus 158MW of consented specification turbines	44.5	33.5	22.5
Race Bank	91 turbines, 26m air gap, plus 7MW of consented specification turbines	31.9	24.2	16.6
SOW	88 turbines, 22m air gap, plus 0MW of consented specification turbines	17.3	13.0	8.7
Triton Knoll	90 turbines, 23m air gap, plus 343MW of consented specification turbines	11.2	8.5	5.7
Total		**104.9**	**79.3**	**53.6**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	6.2	4.9
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.6	1.3
Total (including SEP and DEP, design-based density estimates)		**114.4**	**87.1**	**59.8**
DEP	30 turbines, 30m air gap (model-based density estimates)	8.9	7.3	5.6
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.3	1.8
Total (including SEP and DEP, model-based density estimates)		**116.7**	**88.8**	**61.0**

Table 11-161: Summary of Cumulative Operational Displacement and Collision Mortality Predictions for Sandwich Tern for All OWFs Included in CIA, Based on As-Built Turbine Parameters, with Unbuilt Consented Capacity Built using As-Built Turbine Designs (Scenario D)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))		
		0% MA	25% MA	50% MA
DOW	67 turbines, 22m air gap, plus 158MW of as-built specification turbines	42.6	32.1	21.6
Race Bank	91 turbines, 26m air gap, plus 7MW of as-built specification turbines	31.3	23.8	16.3
SOW	88 turbines, 22m air gap, plus 0MW of as-built specification turbines	17.3	13.0	8.7

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))		
		0% MA	25% MA	50% MA
Triton Knoll	90 turbines, 23m air gap, plus 343MW of as-built specification turbines	7.8	5.9	3.9
Total		**99.0**	**74.8**	**50.6**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	6.2	4.9
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.6	1.3
Total (including SEP and DEP, design-based density estimates)		**108.5**	**82.7**	**56.8**
DEP	30 turbines, 30m air gap (model-based density estimates)	8.9	7.3	5.6
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.3	1.8
Total (including SEP and DEP, model-based density estimates)		**110.8**	**84.4**	**58.0**

Table 11-162: Summary of Cumulative Operational Displacement and Collision Mortality Predictions for Sandwich Tern for All OWFs Included in CIA, Based on As-Built Turbine Parameters, with Unbuilt Consented Capacity Built using As-Built Turbine Designs, Except for DOW, for which the As-Built Design is Assumed to be Legally Secured (Scenario E)

OWF	Summary of design	Annual collisions (0.980 avoidance rate, variable macro-avoidance (MA))		
		0% MA	25% MA	50% MA
DOW	67 turbines, 22m air gap, plus 158MW of as-built specification turbines	33.3	25.1	16.9
Race Bank	91 turbines, 26m air gap, plus 7MW of as-built specification turbines	31.3	23.8	16.3
SOW	88 turbines, 22m air gap, plus 0MW of as-built specification turbines	17.3	13.0	8.7
Triton Knoll	90 turbines, 23m air gap, plus 343MW of as-built specification turbines	7.8	5.9	4.0
Total		**89.7**	**67.8**	**46.0**
DEP	30 turbines, 30m air gap (design-based density estimates)	7.6	6.2	4.9
SEP	23 turbines, 30m air gap (design-based density estimates)	1.9	1.6	1.3
Total (including SEP and DEP, design-based density estimates)		**99.2**	**75.7**	**52.2**
DEP	30 turbines, 30m air gap (model-based density estimates)	8.9	7.3	5.6
SEP	23 turbines, 30m air gap (model-based density estimates)	2.8	2.3	1.8
Total (including SEP and DEP, model-based density estimates)		**101.4**	**77.4**	**53.3**

Table 11-163: PVA Outputs for Breeding Adult North Norfolk Coast SPA Sandwich Terns Incorporating Combined Displacement and Collision Impacts of SEP and DEP (Based on CRMs using Design-Based Density Estimates) In-Combination with Other Projects

Scenario	Avoidance rate	Macro-avoidance rate	Annual mortality	Increase in existing mortality rate[1,2]	Median CGR[3]	Median CPS[3]
A	0.980	0%	176.2	0.0210538894	0.976	0.375
	0.980	25%	133.4	0.0159397778	0.982	0.477
	0.980	50%	90.7	0.0108376150	0.988	0.605
B	0.980	0%	97.1	0.0116023420	0.987	0.585
	0.980	25%	74.1	0.0088541044	0.990	0.664
	0.980	50%	51.1	0.0061058669	0.993	0.755
C	0.980	0%	114.4	0.0136694946	0.985	0.531
	0.980	25%	87.1	0.0104074561	0.988	0.618
	0.980	50%	59.8	0.0071454176	0.992	0.719
D	0.980	0%	108.5	0.0129645119	0.985	0.548
	0.980	25%	82.7	0.0098817063	0.989	0.633
	0.980	0%	56.8	0.0067869518	0.992	0.731
E	0.980	25%	99.2	0.0118532680	0.987	0.578
	0.980	50%	75.7	0.0090452862	0.990	0.658
	0.980	0%	52.2	0.0062373043	0.993	0.750

Notes

1. This is a key input into PVA, and is provided to ten decimal places to enable the model to be reproduced
2. Background population is North Norfolk Coast SPA breeding adults (8,369 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015), assumes 100% of impacts year round are apportioned to this population, which is a precautionary overestimate
3. After 40 years of operation

Table 11-164: PVA Outputs for Breeding Adult North Norfolk Coast SPA Sandwich Terns Incorporating Collision Impacts of SEP and DEP (Based on CRMs using Model-Based Density Estimates) In-Combination with Other Projects

Scenario	Avoidance rate	Macro-avoidance rate	Annual mortality	Increase in existing mortality rate[1,2]	Median CGR[3]	Median CPS[3]
A	0.980	0%	178.5	0.0213287131	0.976	0.371
	0.980	25%	135.2	0.0161548572	0.982	0.473
	0.980	50%	91.9	0.0109810013	0.988	0.601
B	0.980	0%	99.4	0.0118771657	0.987	0.577
	0.980	25%	75.8	0.0090572350	0.990	0.658
	0.980	50%	52.3	0.0062492532	0.993	0.750
C	0.980	0%	116.7	0.0139443183	0.984	0.524
	0.980	25%	88.8	0.0106105867	0.988	0.612
	0.980	50%	61.0	0.0072888039	0.992	0.714

Scenario	Avoidance rate	Macro-avoidance rate	Annual mortality	Increase in existing mortality rate[1,2]	Median CGR[3]	Median CPS[3]
D	0.980	0%	110.8	0.0132393356	0.985	0.541
	0.980	25%	84.4	0.0100848369	0.989	0.627
	0.980	0%	58.0	0.0069303382	0.992	0.726
E	0.980	0%	101.4	0.0121161429	0.986	0.571
	0.980	25%	77.4	0.0092484168	0.990	0.652
	0.980	50%	53.3	0.0063687418	0.993	0.746

Notes
1. This is a key input into PVA, and is provided to ten decimal places to enable the model to be reproduced
2. Background population is North Norfolk Coast SPA breeding adults (8,369 individuals), adult age class annual mortality rate of 10.2% (Horswill and Robinson, 2015), assumes 100% of impacts year round are apportioned to this population, which is a precautionary overestimate
3. After 40 years of operation

708. The discussion regarding the impact magnitudes and interpretation of the PVA counterfactuals presented for collision impacts only (**Section 11.7.3.2.5**) remains relevant for the combined impact of displacement and collision.

709. The magnitude of effect of cumulative collision risk for this species is assessed as medium, though it may be lower if higher avoidance rates are applicable. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **moderate adverse**.

11.8 Transboundary Impacts

710. Collisions and displacement of offshore ornithology receptors will also occur at OWFs located outside UK territorial waters. This means that potential transboundary impacts are greater than that quantitatively assessed in the CIA presented in **Section 11.7**.

711. It is considered that the spatial scale and hence seabird reference populations sizes for a transboundary assessment would be very large; considerably larger than those presented in this assessment. However, information on the sizes of these populations is not available. In addition, the methods used to assess potential OWF impacts varies by country, and more often than not, the outputs of impact assessments are not directly comparable. This makes quantitative transboundary impact assessment impossible. A limited attempt at quantifying this has recently been made as part of the Strategic Environmental Assessment North Seas Energy (SEANSE) project (DHI, 2020a, 2020b). It provides a useful indicator of the level of potential impacts on offshore ornithology receptors beyond UK waters, and suggests that in the majority of cases, impacts on offshore ornithology receptors are largest in UK waters. However, there are a range of limitations that make the approach unsuitable for quantitative impact assessment purposes in its current form.

712. Because of the increased reference populations that would result from the expansion of the area of search, it is anticipated that the inclusion of non-UK OWFs

is highly likely to reduce the cumulative impact assessed for each species presented in **Section 11.7**.

11.9 Inter-relationships

713. The construction, operation and decommissioning of SEP and DEP would cause a range of effects on offshore ornithology receptors. These may be inter-related with other receptor groups. With respect to the impacts assessed for offshore ornithology receptors at SEP and DEP (**Section 11.6**), this is considered to be the case for indirect impacts through effects on habitats and prey species only.

714. Inter-relationships are summarised in **Table 11-165**, which indicates where assessments carried out in other ES chapters have been used to inform the offshore ornithology assessment.

Table 11-165: Offshore Ornithology Inter-Relationships

Impact	Related chapter	Where addressed in this chapter	Rationale
Construction			
Impact 2: Indirect effects	**Chapter 9 Fish and Shellfish Ecology** **Chapter 8 Benthic Ecology**	**Section 11.6.1.2**	Potential impacts on fish, shellfish and benthic ecology during construction could affect prey resource for offshore ornithology receptors
Operation			
Impact 5: Indirect effects	**Chapter 9 Fish and Shellfish Ecology** **Chapter 8 Benthic Ecology**	**Section 11.6.2.4**	Potential impacts on fish, shellfish and benthic ecology during operation could affect prey resource for offshore ornithology receptors
Decommissioning			
Impact 7: Indirect effects	**Chapter 9 Fish and Shellfish Ecology** **Chapter 8 Benthic Ecology**	**Section 11.6.3.2**	Potential impacts on fish, shellfish and benthic ecology during decommissioning could affect prey resource for offshore ornithology receptors

11.10 Interactions

715. The potential impacts on offshore ornithology receptors that have been identified and assessed in this chapter have the potential to interact with each other. A screening for offshore ornithology impacts is provided in **Table 11-166**. No potential interactions between the impacts assessed were identified.

Table 11-166: Screening for Interaction Between Impacts

Construction			
	Impact 1: Disturbance, displacement and barrier effects	Impact 2: Indirect effects	
Impact 1: Disturbance, displacement and barrier effects	-	No. Birds that are subject to displacement effects will not be impacted by prey availability effects, which are highly localized.	
Impact 2: Indirect effects	No. Birds that are subject to prey availability effects, which are highly localized, have not been displaced by construction activities.	-	
Operation			
	Impact 3: Disturbance, displacement and barrier effects	Impact 4: Collision risk	Impact 5: Indirect effects
Impact 3: Disturbance, displacement and barrier effects	-	No. Birds that are displaced by the operational OWF would not be at risk of collision.	No. Birds that are displaced by the operational OWF would not be subject to prey availability effects as spatial magnitude of the latter is predicted to be small
Impact 4: Collision risk	No. Birds involved in collisions would not be susceptible to displacement.	-	No. Birds involved in collisions would not be susceptible to indirect effects.
Impact 5: Indirect effects	No. Birds that are subject to prey availability effects, which are highly localized, have not been displaced by the operational OWF.	No. Birds susceptible to indirect effects have not been involved in collisions.	-
Decommissioning			
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.			

11.11 Potential Monitoring Requirements

716. Monitoring requirements are described in the **In-Principle Monitoring Plan (IPMP)** (document reference 9.5) submitted alongside the DCO application and will be further developed and agreed with stakeholders prior to construction based on the **IPMP** and taking account of the final detailed design of the Projects.

717. Post-consent, the final detailed design of SEP and DEP will refine the worst-case parameters assessed in **Section 11.6**. The Applicant is supportive, in principle, of joint industry projects or alternative site-based monitoring of existing seabird activity inside the area(s) within the Order Limits in which it is proposed to carry out construction works with its potential wider benefits and would welcome collaboration opportunities from SNCBs, NGOs or other developers in strategic monitoring programmes.

718. The Project Environmental Management Plan (PEMP) (to be submitted post-consent in accordance with the **Outline PEMP** (document reference 9.10)), is also relevant to offshore ornithology and will set out the Applicant's intentions for managing potential impacts on red-throated divers. The requirement for and final design and scope of monitoring will be agreed with the regulator and relevant stakeholders and included within the Ornithological Monitoring Plan (as secured through the **Draft DCO** (document reference 3.1), submitted for approval, prior to construction works commencing

11.12 Assessment Summary

719. This chapter provides an assessment of the potential impacts on offshore ornithology receptors that may arise from the construction, operation and decommissioning of the offshore components of SEP and DEP. It describes the extensive consultation that has occurred with stakeholders (principally Natural England and RSPB) through the ornithology ETG. This has included detailed discussions regarding the overall approach to the impact assessment on offshore ornithology receptors, through to highly technical discussions on a range of key aspects of the assessment. The chapter sets the scope and methodology of the assessment, and the baseline state of the aerial survey study area and cable corridor (the latter for red-throated diver only).

720. The aerial survey study area was surveyed using high resolution digital aerial surveys over a period of 24 months (a total of 29 surveys). Data from these surveys have been used to estimate the abundance and assemblage of birds using the study area. Reporting regions within the aerial survey study area have been used to provide abundances for SEP, DEP and appropriate buffer zones.

721. The impacts that could potentially occur on offshore ornithology receptors during the construction, operation and decommissioning of SEP and DEP were discussed with Natural England and RSPB during the ETG meetings. It was agreed that the potential impacts that required detailed assessment were:

- In the construction phase:

- Impact 1: Disturbance and displacement covering work activity, vessel movements and lighting, as well as barrier effects due to presence of turbines and infrastructure (from erection of first turbines).
- Impact 2: Indirect impacts through effects on habitats and prey species during the construction phase.

- In the operational phase:
  - Impact 3: Displacement and barrier effects due to presence of turbines and infrastructure, as well as disturbance and displacement covering work activity, vessel movements and lighting.
  - Impact 4: Collision risk.
  - Impact 5: Indirect impacts through effects on habitats and prey species during the operational phase.
- In the decommissioning phase:
  - Impact 6: Disturbance and displacement covering work activity, vessel movements, lighting, as well as barrier effects due to presence of turbines and infrastructure (until final turbine is removed).
  - Impact 7: Indirect impacts through effects on habitats and prey species during the decommissioning phase.

722. The potential impacts on offshore ornithology receptors have been minimised by two embedded mitigation measures; site selection and provision of an air gap of 30m HAT.

723. During the construction and decommissioning phases of SEP and DEP, no project alone impacts have been assessed to be greater than minor adverse significance for any offshore ornithology receptor in any biologically relevant season. This includes the more sensitive receptors screened into detailed assessment for disturbance, displacement and barrier effects during these phases i.e. guillemot, razorbill and red-throated diver.

724. During the operational phase of SEP and DEP, project alone impacts due to disturbance, displacement and barrier effects on the more sensitive receptors screened into detailed assessment (gannet, guillemot, razorbill, red-throated diver and Sandwich tern) would not result in impacts of more than minor adverse significance during any biological season.

725. The risk posed to offshore ornithology receptors due to collisions with turbines at SEP and DEP is assessed as no greater than minor adverse significance for all species recorded in flight at the wind farm sites for all biologically relevant seasons. This includes the species screened into detailed assessment (common tern, gannet, great black-backed gull, herring gull, kittiwake, lesser black-backed gull, little gull and Sandwich tern).

726. The identified impacts for the project alone assessment are summarised in **Table 11-167**.

727. Two potential effects were screened in for cumulative assessment for SEP and DEP; operational displacement and collision risk, as well as the combined effects of both impacts. Other potential effects would be temporary, small scale and localised.

A screening process determined that within the offshore environment only other UK OWFs that were operational, under construction, consented but not constructed, subject to current applications or subject to consultation were screened in. The risk to ornithological receptors from cumulative displacement and collisions is assessed as no greater than minor adverse significance for all species with the exception of great black-backed gull (collision risk) and Sandwich tern (collision risk, and collision risk and displacement combined).

728. The identified impacts for the cumulative impact assessment are summarised in **Table 11-168**.

729. The potential for collisions and displacement from OWFs outside UK territorial waters (transboundary) to contribute to cumulative impacts was considered. The spatial scale and hence seabird population sizes for a transboundary assessment would be much larger and the available information is not sufficiently detailed, or of equivalence to data available for OWFs and seabird populations within the UK and its waters to allow meaningful assessment. The inclusion of non-UK OWFs is considered unlikely to alter the conclusions of the existing cumulative assessment, and may reduce the cumulative impact assessed on the larger population present over a larger spatial scale.

Table 11-167: Summary of Potential Impacts of SEP and DEP Combined on Offshore Ornithology Receptors

Potential impact	Receptor	Sensitivity	Magnitude	Impact significance	Mitigation measures	Residual impact	Confidence
Construction							
Disturbance, displacement and barrier effects (OWFs)	Guillemot	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Razorbill	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Red-throated diver	High	Negligible	Minor adverse	None	**Minor adverse**	High
Disturbance, displacement and barrier effects (export and interlink cable corridors)	Red-throated diver	High	Negligible	Minor adverse	None	**Minor adverse**	Medium
Indirect effects	All offshore ornithology receptors	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
Operation							
Disturbance, displacement and barrier effects	Gannet	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Guillemot	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Razorbill	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Red-throated diver	High	Negligible	Minor adverse	None	**Minor adverse**	High
	Sandwich tern	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
Collision risk	Black-headed gull	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Common gull	Medium	Negligible	Minor adverse	None	**Minor adverse**	High

Potential impact	Receptor	Sensitivity	Magnitude	Impact significance	Mitigation measures	Residual impact	Confidence
	Common tern	Low	Negligible	Minor adverse	None	**Minor adverse**	High
	Gannet	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Great black-backed gull	High	Negligible	Minor adverse	None	**Minor adverse**	High
	Herring gull	High	Negligible	Minor adverse	None	**Minor adverse**	High
	Kittiwake	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Lesser black-backed gull	High	Negligible	Minor adverse	None	**Minor adverse**	High
	Little gull	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Sandwich tern	Medium	Low	Minor adverse	None	**Minor adverse**	High
	Non-breeding waterbirds	Medium	Negligible	Minor adverse	None	**Minor adverse**	Medium
Disturbance, displacement and barrier effects combined with collision risk	Gannet	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Sandwich tern	Medium	Low	Minor adverse	None	**Minor adverse**	High
Indirect effects	All offshore ornithology receptors	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
Decommissioning							
	Guillemot	Medium	Negligible	Minor adverse	None	**Minor adverse**	High

Potential impact	Receptor	Sensitivity	Magnitude	Impact significance	Mitigation measures	Residual impact	Confidence
Disturbance, displacement and barrier effects (OWFs)	Razorbill	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Red-throated diver	High	Negligible	Minor adverse	None	**Minor adverse**	High
Disturbance, displacement and barrier effects (export and interlink cable corridors)	Red-throated diver	High	Negligible	Minor adverse	None	**Minor adverse**	Medium
Indirect effects	All offshore ornithology receptors	Medium	Negligible	Minor adverse	None	**Minor adverse**	High

Table 11-168: Summary of Potential Cumulative Impacts on Offshore Ornithology Receptors

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact	Confidence
Operation							
Disturbance, displacement and barrier effects	Gannet	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Guillemot	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
	Razorbill	High	Negligible	Minor adverse	None	**Minor adverse**	High
	Red-throated diver	High	Negligible	Minor adverse	None	**Minor adverse**	Medium
	Sandwich tern	Medium	Negligible	Minor adverse	None	**Minor adverse**	High
Collision risk	Gannet	Medium	Low	Minor adverse	None	**Minor adverse**	High
	Great black-backed gull	High	Medium	Moderate adverse	None	**Moderate adverse**	High
	Kittiwake	Medium	Low	Minor adverse	None	**Minor adverse**	High
	Lesser black-backed gull	Medium	Low	Minor adverse	None	**Minor adverse**	High
	Sandwich tern	Medium	Moderate	Moderate adverse	None	**Moderate adverse**	High
	Gannet	Medium	Low	Minor adverse	None	**Minor adverse**	High

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact	Confidence
Disturbance, displacement and barrier effects combined with collision risk	Sandwich tern	Medium	Moderate	Moderate adverse	None	**Moderate adverse**	High

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