Dudgeon and Sheringham Shoal Offshore Wind Farm Extensions

Preliminary Environmental Information Report

Volume 1

Chapter 13 - Offshore Ornithology

April 2021

Title:	
Dudgeon and Sheringham Shoal Offshore Wind Farm Extensions Preliminary Environmental Information Report Chapter 13 Offshore Ornithology	
Document no.: PB8164-RHD-ZZ-XX-RP-Z-0010	
Date:	Classification
29th April 2021	**Final**
Prepared by:	
Royal HaskoningDHV	
Approved by:	Date:
Magnus Eriksen, Equinor	29th April 2021

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Glossary of Acronyms

BACI	Before After Control Impact
BAG	Before After Gradient
BDMPS	Biologically Defined Minimum Population Size
BoCC	Birds of Conservation Concern
CIA	Cumulative Impact Assessment
CRM	Collision Risk Modelling
DAS	Discretionary Advice Service
DCO	Development Consent Order
DECC	Department for Energy and Climate Change
DEP	Dudgeon Extension Offshore Wind Farm Project
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
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
MERP	Marine Ecosystems Research Programme
MMO	Marine Management Organisation
NPS	National Policy Statement
OMP	Operational Monitoring Programme
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
SEANSE	Strategic Environmental Assessment North Seas Energy
SEP	Sheringham Shoal Extension Offshore Wind Farm 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

Glossary of Terms

The Applicant	Equinor New Energy Limited
Dudgeon Offshore Wind Farm Extension site	The Dudgeon Offshore Wind Farm Extension lease area.
The Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.
Grid option	Mechanism by which DEP and SEP 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 DEP and SEP to transmit electricity entirely separately.
Infield cables	Cables which link the wind turbine generators to the offshore substation platforms.
Interlink cables	Cables linking two separate project areas. This can be cables linking: 1. DEP South and DEP North 2. DEP South and SEP 3. DEP North and SEP 1 is relevant if DEP is constructed in isolation or first with a separated grid option. 2 and 3 are relevant with an integrated grid option.
Landfall	The point on the coastline at which the offshore export cables are brought onshore and connected to the onshore export cables.
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 export cables	The cables which would bring electricity from the offshore substation platform(s) to the landfall. 220 – 230kV
PEIR boundary	The area subject to survey and preliminary impact assessment to inform the PEIR, including all permanent and temporary works for DEP and SEP. 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.

13 OFFSHORE ORNITHOLOGY

13.1 Introduction

1. This chapter of the Preliminary Environmental Information Report (PEIR) considers the potential impacts of the proposed Dudgeon Extension Offshore Wind Farm Project (DEP) and Sheringham Shoal Extension Offshore Wind Farm Project (SEP) on offshore ornithology. The chapter provides an overview of the existing environment for the proposed offshore development area and its surrounding habitats, followed by an assessment of the potential impacts and associated mitigation for the construction, operation, and decommissioning phases of DEP and SEP.
2. This chapter has been written by Royal HaskoningDHV, with the assessment undertaken with specific reference to the relevant legislation and guidance, of which the primary source 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 **Section 13.4**.
3. An assessment of the ornithological receptors present at the export cable landfall and onshore development area is included in **Chapter 22 Onshore Ecology and Ornithology**.
4. The assessment should be read in conjunction with the linked chapters **Chapter 10 Benthic and Intertidal Ecology** and **Chapter 11 Fish and Shellfish Ecology**.
5. Additional information to support the offshore ornithology assessment is presented in **Appendix 13.1 Offshore Ornithology Technical Report** and **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.

13.2 Consultation

6. This chapter will be updated following the consultation on the PEIR in order to produce the final assessment that will be submitted with the Development Consent Order (DCO) application. Full details of the consultation process will also be presented in the Consultation Report alongside the DCO application.
7. **Table 13-1** lists the consultation responses received to date, and provides a summary of how they have influenced the approach that has been taken.

Table 13-1 Consultation responses

Consultee	Date/ Document	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 13.1 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 13.6.2.2.2**) relies on previously published flight height distributions ("Corrigendum," 2014; Johnston et al., 2014) that have been used in other offshore wind farm (OWF) assessments.
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	An investigation found that doubling the camera coverage for the surveys will reduce the

Consultee	Date/ Document	Comment	Project response
		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).	variability about mean 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 13.6.2.2.2**).
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.	The assessment makes the precautionary assumption that the birds recorded on site during the breeding season are breeding adults.
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 DEP and SEP. 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	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 makes use of CRM outputs based on consented parameters, but also makes reference to corrections to mortality totals based on as-built OWF parameters (**Section 13.7 and Appendix 13.2**

Consultee	Date/ Document	Comment	Project response
		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.	**Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.).
Natural England	Meeting 29/04/19	Natural England noted that in-combination impacts on other species, namely kittiwake collisions is likely to be such that any additional impact due to the development of DEP and SEP may result in a conclusion of adverse effect.	This is noted, and is dealt with by the Appropriate Assessment for DEP and SEP.
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 DEP and SEP assessment.	An updated PVA has been prepared using a tool commissioned by Natural England (Searle et al., 2019). Detail is available in **Appendix 13.1 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 DEP and SEP 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 13.6.2.2.3**.

Consultee	Date/ Document	Comment	Project response
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 DEP and SEP to interact with birds from much more distant SPAs during the migration and non-breeding seasons as a proportion of the birds using the DEP and SEP 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.	Apportioning of seabirds outside the breeding season has been carried out according to the information presented in Furness (2015).
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.	This advice is noted. For the species included within the cumulative impact assessment, 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. In addition, no transboundary sites have been screened into the appropriate assessment.

Consultee	Date/ Document	Comment	Project response
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 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 13.6**).

Consultee	Date/ Document	Comment	Project response
Natural England	Scoping Opinion (06/11/19)	Natural England notes that the area of the “offshore scoping area” as depicted in Figure 1.1.1 of the Scoping Report does not correspond with the area covered by the survey design for the digital aerial surveys as depicted in Figure 2 of the Method Statement for ornithological, and marine megafauna survey May 2018 – which is the latest information Natural England has regarding the area being surveyed. Clarity is needed on this issue.	This issue was addressed during the Second Expert Topic Group (ETG) Meeting, and Natural England have indicated that they are content with the explanation provided.
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 DEP and SEP 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	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. With specific reference to red-throated diver, data from the Seabird Mapping and Sensitivity Tool (SEAMAST) project (Bradbury et al., 2014) have been used to assess potential impacts due to operational displacement at distances beyond 4km from DEP and SEP, out to distances of 12km, along with data used to designate the

Consultee	Date/ Document	Comment	Project response
		project requirement to start Ornithological surveys ahead of the evidence plan process.	Greater Wash SPA (Lawson et al., 2016) (**Section 13.6.2.1.4**).
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 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.	This position has been noted. The approach taken for collecting baseline data was similar to that employed at other OWFs. The 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.	This position was noted. Any modification of the offshore development area as the project 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	This position was noted.

Consultee	Date/ Document	Comment	Project response
		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.	
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	Natural England's comments on this document have been obtained from the Crown Estate and are noted.

Consultee	Date/ Document	Comment	Project response
		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	Scoping Opinion (06/11/19)	Natural England advises that, as far as it is aware, the errors associated with site-specific flight height data that may be gathered as part of the digital aerial survey programme will be greater than required for the purpose of CRM. If, in the case of CRM for Sandwich tern, the intention is to explore the use of flight height data gathered during the Sheringham Shoal post-construction monitoring, these data must be satisfactorily validated in order for any confidence to be placed in conclusions based on their use.	The collision risk assessment (**Section 13.6.2.2.2**) relies on previously published flight height distributions ("Corrigendum," 2014; Johnston et al., 2014) that have been used in other OWF assessments. Flight height data from other sources are referred to where it is considered useful to do so, but it is not been subject to external validation.
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 in the relevant parts of the assessment.
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	Outputs from the MERP report (Waggitt et al., 2019) have been used when considering the relative importance of DEP and SEP for offshore ornithology

Consultee	Date/ Document	Comment	Project response
		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.	receptors (**Section 13.5**). Woodward et al. (2019) is a key source of many of the breeding season foraging ranges referred to by the assessment.
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.
Natural England and RSPB	First ETG Meeting (09/01/20)	With respect to design-based density estimation, neither Natural England nor RSPB stated a preference for bootstrapping or poisson error regression based upon the null model.	No action required.
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 13.5.2.2**.
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	After extensive further consideration (including a minuted meeting with HiDef Aerial Surveys Ltd on 25th March

Consultee	Date/ Document	Comment	Project response
		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.	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.
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.

Consultee	Date/ Document	Comment	Project response
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 data are used in the appraisal of seasonal reference populations for this species (**Section 13.5.2.2**). The 2019 data and report have not been made available at the time of writing.
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).	In the absence of “better” data, the assessment takes a precautionary view, and assumes that during the breeding season, 100% of birds 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 the batteries for x/y positioning at a small

Consultee	Date/ Document	Comment	Project response
			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, as requested by Natural England's Discretionary Advice Service (DAS) advice of 7th August 2020. This includes the rerunning of Sandwich tern CRM for other OWFs in the Greater Wash area. Individual parameters have been verified at the request of Natural England (**Section 13.6.2.2.2.2**).
Natural England and RSPB	First ETG Meeting (09/01/20)	Both Natural England and RSPB stated that any limitations of stochastic model outputs related to limitations on the parameters for which variability could be assessed would need to be made clear.	Deterministic CRM has been used throughout the assessment, as requested by Natural England's DAS advice of 7th August 2020. Individual parameters have been verified at the request of Natural England (**Section 13.6.2.2.2.2**).

Consultee	Date/ Document	Comment	Project response
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 is referred to.
Natural England and RSPB	First ETG Meeting (09/01/20)	Natural England reiterated their position in the Scoping Opinion on as-built versus consented turbine parameters for CRM, which states, “any assessment of collision risk using ‘as built’ scenarios should also be accompanied with equivalent information for the ‘as consented’ and as ‘as proposed’ scenarios since there is no apparent legal mechanism in place which secures a reduction in turbine numbers from the consented, and proposed development.”. Natural England also stated in its scoping response email that its “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	This position was noted.

Consultee	Date/ Document	Comment	Project response
		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. Natural England stated that the provision of legally binding documentary proof that as built OWFs will not change or expand is key before as built would be accepted in the CRM assessment. RSPB agreed with this position.	
Natural England and RSPB	First ETG Meeting (09/01/20)	Regarding Sandwich tern, 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 the end of this financial year (April 2020). However, this work has yet to be commissioned. RSPB advised caution when using predictors from the Folkerts model: Bear in mind 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.	This position was noted. The JNCC avoidance rates work has not been seen during the preparation of this assessment.

Consultee	Date/ Document	Comment	Project response
		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.	
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, advice which the assessment has followed.
Natural England and RSPB	First ETG Meeting (09/01/20)	Natural England confirmed that the 2019 Natural England PVA tool is the preferred tool to be used for this project, noting that there are some minor issues with the coding of the current version, although it is still functional. A final updated version of the tool is expected in early February 2020.	PVAs have been prepared using the Natural England PVA tool (Searle et al., 2019). Detail is available in **Appendix 13.1 Offshore Ornithology Technical Report**.

Consultee	Date/ Document	Comment	Project response
Natural England and RSPB	First ETG Meeting (09/01/20)	The ETG broadly agreed that the 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.
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 DEP and SEP. 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.	This position has been noted, and a discussion of how the potential for a switching of breeding location has been incorporated into the assessment is provided in **Appendix 13.1 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.
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 DEP and SEP).	This position was noted.

Consultee	Date/ Document	Comment	Project response
		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 and scenarios including patchy distributions, limited covariate data and low numbers.	
Natural England	Second ETG Meeting (04/06/20)	Natural England requested more information on how density and abundance will be calculated in reporting regions.	Further information is provided in **Appendix 13.1 Offshore Ornithology Technical Report**.
Natural England	Second ETG Meeting (04/06/20)	Natural England stated that more information will have to be provided before Natural England can comment on the spatial coverage and acceptability of the baseline survey data. Methodology will be easier to discuss if there are examples of what is being proposed are presented to support the Method Statement.	This position was noted.

Consultee	Date/ Document	Comment	Project response
		At the time of the meeting it was stated that the report would be ready in early July; however, following further correspondence with HiDef, delivery of data is now expected by the end of August, with the report following later.	
		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.	Raw data have not been presented by the assessment; however, they can be made available to stakeholders if required.
Natural England	Second ETG Meeting (04/06/20)	Natural England would prefer reporting regions to be OWF, OWF plus 2km buffers and OWF plus 4km buffers. Natural England questioned why there are separate reporting regions for DEP (north and south).	Equinor stated that lease areas provide flexibility in terms of turbine location, for example there is one scenario where all turbines could be located in DEP-N and therefore DEP-S would not be used. The reporting areas were therefore chosen to assess all these scenarios as well as the scenario that only one project will be consented. Further discussions have taken place on this topic, and changes have been made to the reporting regions presented in the method statement due to concerns

Consultee	Date/ Document	Comment	Project response
			surrounding their size, and the number of observations made within them. Included within these changes were those requested by Natural England.
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.	This response was noted. The assessment presents findings based on density estimates calculated without data from the second pair of cameras.
Natural England and RSPB	Second ETG Meeting (04/06/20)	Royal HaskoningDHV summarised the proposed parameters to be used for the sCRM for Sandwich tern compared to those used in the 2012 assessment. It was proposed that Option 2 would be used and sCRM recalculated for existing wind farm sites, although it was noted that it may not be possible to calculate 95% confidence intervals for other wind farms due to data availability, asking whether this would be an issue. Natural England and RSPB both stated that they are happy with use of the sCRM input data proposed by Royal HaskoningDHV.	CRM for Sandwich tern has been recalculated according to these parameters. Deterministic CRM has been used throughout the assessment, as requested by Natural England's DAS advice of 7th August 2020. Individual parameters have been verified at

Consultee	Date/ Document	Comment	Project response
		Regarding other wind farms, Natural England stated that the assessment will have to be undertaken with the data available and that it would be going too far to expect calculation of these for other sites, however the assessment will have to be transparent about any limitations. RSPB suggested recalculation sCRM for other wind farms should be deterministic with zero values for variability. Natural England offered to respond in writing with preferred approach to sCRM having consulted internally.	the request of Natural England (**Section 13.6.2.2.2.2**).
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 estimates. In their DAS advice (7th August 2020), Natural England recommended that CRM utilising this latest evidence on Sandwich

Consultee	Date/ Document	Comment	Project response
			tern flight speed was not pursued, and that previously used values should be retained, advice which the assessment has followed.
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 26m for the 14MW turbines and 30m for the 26MW turbines used in the assessment has been selected. Collision risk is calculated in **Section 13.6.2.2.2**. 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.	Equinor replied that a strategic approach would be considered. The assessment uses consented parameters for existing OWFs, alongside data for as-built layouts.

Consultee	Date/ Document	Comment	Project response
		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. Natural England and RSPB could not advise the best way to undertake such an approach, other than to say a wider discussion is required.	The applicant requests that Natural England and the RSPB provide clarification on the request for a strategic approach further, in writing to avoid any confusion about what is being requested.
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 (2020a), is presented in **Appendix 13.1 Offshore Ornithology Technical Report.**
Natural England	DAS Letter, 07/08/20	Natural England accept the explanation of differences between the Offshore Scoping Area and The Study Area and therefore no further information is required.	This position was noted.

Consultee	Date/ Document	Comment	Project response
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 DEP and SEP using baseline data, and out to 12km from DEP and SEP using other data sources (Bradbury et al., 2014; Lawson et al., 2016). This is presented in **Section 13.6.2.1.4**.
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 13.1 Offshore Ornithology Technical Report**.

Consultee	Date/ Document	Comment	Project response
Natural England	DAS Letter, 07/08/20	It is important that reporting regions encompass OWF and relevant buffers, as opposed to reporting the array and buffer regions separately. Natural England expects that the abundance (and confidence intervals) should be reported for the OWF and buffer as a whole.	Densities have been presented in **Appendix 13.1 Offshore Ornithology Technical Report**.
Natural England	DAS Letter, 07/08/20	Natural England advises that there may be a benefit in processing additional data during surveys where numbers are higher, it may be appropriate to have a ‘stratified’ approach to data processing, identifying focal seasons/months during which additional data is analysed. Furthermore, the benefit of increased sample size may be different if using a model-based approach.	This response was noted. The assessment presents findings based on density estimates calculated without data from the second pair of cameras.
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.
Natural England	DAS Letter, 07/08/20	Sandwich terns at North Norfolk Coast SPA make use of two distinct colonies, Blakeney Point and Scolt Head. Every few years their colony preference changes. It is important to consider what effects this might have on the distribution of sandwich terns at sea, and to make use of existing data on density and distribution of Sandwich terns to inform 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 13.1**

Consultee	Date/ Document	Comment	Project response
			Offshore Ornithology Technical Report.
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 season is relevant. These are presented in **Table 13-14**.
Natural England	DAS Letter, 07/08/20	We advise that colony specific evidence is used to inform seasons at an HRA level.	This approach will be taken.
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.
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.	This position was noted. The assumptions used with regard to apportioning are considered by the applicant to be precautionary. These are set out in **Section 13.5.2**.

Consultee	Date/ Document	Comment	Project response
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 13.4.3**.
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 DEP and SEP, 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.
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	This position was contradictory to advice provided up to this point of the Evidence Plan Process. Deterministic CRM has been used throughout the assessment, and parameters varied according to this advice (**Section 13.6.2.2.2**).

Consultee	Date/ Document	Comment	Project response
		currently recommend running deterministic models. However, due to the 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.	The Band spreadsheets have been used, though are not included in the assessment. They can be supplied to stakeholders if required.

Consultee	Date/ Document	Comment	Project response
Natural England	DAS Letter, 07/08/20	Natural England agrees that presenting a range of avoidance rate for Sandwich tern is appropriate. 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.	Avoidance rates of 0.980, 0.9883 and 0.993 have been presented for Sandwich tern CRM, which can be found in **Section 13.6.2.2.2**.
Natural England	DAS Letter, 07/08/20	Natural England accepts that there are now additional sources of data available which includes information on flight speeds (e.g. from seabird tracking studies) for a number of species and that a review is needed of appropriate flight speeds and variability around these to use for CRM. However, at this time Natural England continues to advise that previously published figures (Alerstam et al., 2007; Pennycuick, 1997, 1987) (also used in Cook et al. (2014)) should be used until a full review of all evidence sources has been undertaken. 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.	Whilst the applicant would prefer to follow an evidence-based approach over precedent, older flight speeds have been used in the CRM as requested (**Section 13.6.2.2.2**).

Consultee	Date/ Document	Comment	Project response
Natural England	DAS Letter, 07/08/20	Generic flight height data should be used during CRM, using Band Option 2. However, 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. Flight height was measured as part of the SOW post consent monitoring. DOW have it as an objective as part of their PCM, but this will not report in time.	CRM for Sandwich tern has been recalculated according to these parameters. Alternative flight height data from relevant sources has also been presented as requested (**Section 13.6.2.2.2**).
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. With regards to the use of pre-existing population models for the other species, this will need to be advised upon on a case by case basis.	This comment was noted. The approach to PVA is explained and discussed in **Appendix 13.1 Offshore Ornithology Technical Report**.
Natural England	Third ETG Meeting (09/12/20)	Natural England queried why the Greater Wash SPA as foraging habitat had not been included in the assessments.	It was confirmed that this has been taken into account in the Appropriate Assessment.

Consultee	Date/ Document	Comment	Project response
	(draft minutes)		
Natural England	Third ETG Meeting (09/12/20) (draft minutes)	Natural England noted that the difference in Sandwich tern flight speed from the DOW OMP was interesting and asked whether the project would be interested in exploring this. Natural England would support that despite previously advising against the use of updated flight speed due to the relationship with avoidance rate. Exploring what this means could be of value to the assessment i.e. reduced speed increases the chance of a single collision but reduces overall flux.	This will be investigated with a view to inclusion in the Environmental Statement, but due to time constraints, is not included in the PEIR.
Natural England	Third ETG Meeting (09/12/20) (draft minutes)	Natural England described the ongoing work on Sandwich tern avoidance. Work is underway to try and resolve some differences in the original Zeebrugge datasets. The study has to complete by end March 2021, after which it would be useful to also consider the more recent flight speed data from the DOW OMP. The study has considered the SOW OMP data but it is still expected than the Zeebrugge data to be more applicable. Natural England's view is that it will be appropriate to consider the SOW OMP data in some capacity, but will not be appropriate for the overall review of the avoidance rate due to differences in methodology. This is because the SOW OMP dataset does not consider flux, and is more focused on behavioural aspects.	This information was noted. It is presumed that the outputs from the study will be available for consideration in the Environmental Statement, but were not available for the PEIR. Avoidance rates of 0.980, 0.9883 and 0.993 have been presented for Sandwich tern CRM, which can be found in **Section 13.6.2.2.2**.
Natural England	Third ETG Meeting (09/12/20)	Regarding survey timings and Sandwich tern activity, Natural England recommended investigation of the peak in activity circa 1400. Agreed nocturnal 10% assumption sounds sensible but recommends checking	This will be investigated with a view to inclusion in the Environmental Statement, but

Consultee	Date/ Document	Comment	Project response
	(draft minutes)	if the DOW OMP data gives any insight into whether the birds are actually foraging at these times.	due to time constraints, is not included in the PEIR.
Natural England	Third ETG Meeting (09/12/20) (draft minutes)	Natural England have held a workshop with RenewableUK, the Crown Estate and other SNCBs to try to gain consensus on how to 'legally secure' headroom (the difference between consented and as-built turbine parameters). The final report from this workshop will be available in April/early May.	This information was noted.
Natural England	Third ETG Meeting (09/12/20) (draft minutes)	Natural England requested further information to justify the design based density estimation approach being taken.	This information has since been supplied to Natural England.
Natural England	Third ETG Meeting (09/12/20) (draft minutes)	Natural England noted that for kittiwake, distribution maps for the whole survey area would be useful given the complex nature of the reporting regions.	This request was noted.
Natural England	Third ETG Meeting (09/12/20) (draft minutes)	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 western area and oil and gas activity.
Natural England	Third ETG Meeting	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 Appropriate Assessment.

Consultee	Date/ Document	Comment	Project response
	(09/12/20) (draft minutes)		
RSPB	Third ETG Meeting (09/12/20) (draft minutes)	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) (draft minutes)	Natural England noted that they are planning updated GW SPA surveys in the future.	This information was noted.
RSPB	Third ETG Meeting (09/12/20) (draft minutes)	RSPB asked whether an increased air gap would be realistic to consider at this point. Natural England noted other projects including those currently in examination have needed to assess any potential trade off in impacts as a result of such a change e.g. between reduced collision risk and increased visual impact.	An increase in air gap comes at significant additional cost for the turbine foundations. This will continue to be explored as the assessment process moves ahead.
RSPB	Third ETG Meeting (09/12/20)	RSPB requested that auks be included in the CRM.	Any species recorded in flight at DEP and SEP has been included in CRM. This includes auks.

Consultee	Date/ Document	Comment	Project response
	(draft minutes)		Details of the CRM can be found in **Section 13.6.2.2.2**..
RSPB	Third ETG Meeting (09/12/20) (draft minutes)	RSPB noted the importance of the in-combination assessment for Sandwich tern, which may be critical even where individual project numbers may be very low.	This information was noted.
Natural England	Third ETG Meeting (09/12/20) (draft minutes)	Natural England questioned the accuracy of flight height estimations from the boat-based Sandwich tern tracking surveys, and suggested transparent presentation of what is used in the assessment.	This information was noted. A review of all available Sandwich tern flight height data is provided in **Appendix 13.1 Offshore Ornithology Technical Report**.
Natural England	Third ETG Meeting (09/12/20) (draft minutes)	Regarding Sandwich tern flight height at other OWFs in the wider Wash, the pre-construction survey data for Race Bank, Dudgeon and Docking Shoal has been used to inform previous assessments, but our understanding of both species behaviours and data collection approaches is constantly evolving. Natural England expect the best available evidence to be used.	This information was noted.
Natural England	Third ETG Meeting (09/12/20) (draft minutes)	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.	This information was noted. However, the DOW OMP only covers a small part of the breeding season, so may not be useful in that regard.

13.3 Scope

13.3.1 Study Area

8. The study area for offshore ornithology consists of the aerial survey study area, which covers DEP, SEP and a 4km buffer around them (including the interlink cable corridors), and the offshore export cable corridor. 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 DEP and SEP than 4km. For this species, habitats within 8km of the aerial survey study area (i.e. within 12km of DEP and SEP) are considered. The study area for offshore ornithology is presented in **Appendix 13.1 Offshore Ornithology Technical Report**.

13.3.2 Realistic Worst Case Scenario

13.3.2.1 General Approach

9. The final design of DEP and SEP 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 (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 other options will have a lower impact. Further details are provided in **Chapter 6 EIA Methodology**.

10. The realistic worst case scenarios for the offshore ornithology assessment are summarised in **Table 13-2**. These are based on DEP and SEP parameters described in **Chapter 5 Project Description**, which provides further details regarding specific activities and their durations.

11. In addition to the design parameters set out in **Table 13-2**, consideration is also given to how the Projects will be built, operated and decommissioned as described in **Section 13.3.2.2** to **Section 13.3.2.4**. This accounts for the fact that whilst DEP and SEP are the subject of one DCO application, it is possible that either one or both of the Projects will be developed, and if both are developed, that construction may be undertaken either concurrently or sequentially.

Table 13-2 Realistic Worst Case Scenarios

Impact	Parameter	Notes and Rationale
Construction		
Impact 1: Disturbance, Displacement and Barrier Effects	Construction scenarios (N.B. durations describe both onshore and offshore construction works): • DEP and SEP may be constructed at the same time, or at different times; • If built at the same time both DEP and SEP could be constructed in four years; • If built at different times, either Project could be built first; • If built at different times the first Project would require a four-year period of construction and the second Project a three-year period of construction; • If built at different times, the duration of the gap 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; • Assuming a maximum construction period per project of four years, and taking the above into account, the maximum construction period over which the construction of both Projects could take place is seven years. The maximum number of construction sites operating simultaneously within DEP and SEP during construction would be three (i.e. six across both sites in a simultaneous construction scenario). Installation of the export cable/s would take place over 60 days for DEP in isolation, 50 days for SEP in isolation, and 110 days for DEP and SEP	The worst case scenario is based on the longest construction period and the maximum numbers of plant on site and operational at a given time.

Impact	Parameter			Notes and Rationale
	together. The speed of cable laying vessels would be limited to 300m per hour for ploughing or jetting and 80m per hour if trenching.			
Impact 2: Indirect Effects	The construction scenarios detailed for Impact 1 are also relevant to this impact.			The worst case scenario is based on the longest construction period.
	The worst case area of temporary disturbance to benthic habitats during construction: **1,932,721m²** (1.87% of the DEP wind farm site).	The worst case area of temporary disturbance to benthic habitats during construction: **528,595m²** (0.57% of SEP wind farm area).	The realistic[1] worst case area of temporary disturbance to benthic habitats during construction: **2,474,797m²** (1.26% of the DEP and SEP wind farm areas).	For reference, the DEP wind farm sites cover an area of 103.5km² and the SEP wind farm site covers an area of 92.6km². Some of the habitat loss would actually occur along the export and interlink cable, however the exact areas for these cables are not currently known. Therefore, total temporary disturbance to benthic habitats of the entire DEP or SEP offshore areas would be less. **Realistic worst case scenario** The realistic worst case scenario for temporary seabed disturbance is DEP and SEP developed with an integrated

[1] The individual worst case scenario for DEP and SEP together, in some cases, does not represent a developable scenario if taken as a total, therefore a 'realistic' worst case scenario is presented.

Impact	Parameter			Notes and Rationale
				grid option and both DEP North and DEP South are developed. Further information is provided in **Chapter 10 Benthic and Intertidal Ecology**.
	Worst case increase in suspended sediment concentrations during construction activities: **1,165,529.16m^3**	Worst case scenario increase in SSC during construction activities: **520,521.87m^3**	Realistic worst case increase in SSC during construction activities: **1,744,451.03m^3**	The worst case scenario for displacement of sediment during the construction period assumes sea bed preparation for the maximum number of GBS foundations, drilling for OSPs, jetting for export cable installation, and mechanical cutting for infield and interlink cable installation. The realistic worst case scenario for increased SSC is DEP and SEP are developed with an integrated grid option and both DEP North and DEP South are developed. Further information is provided in **Chapter 8 Marine Geology, Oceanography and Physical Processes**, **Chapter 9 Marine**

Impact	Parameter			Notes and Rationale
				Water and Sediment Quality, **Chapter 10 Benthic and Intertidal Ecology** and **Chapter 11 Fish and Shellfish Ecology.**
Operation				
Impact 3: Disturbance, Displacement and Barrier Effects	DEP occupies an area of 103.50km^2 plus 4km buffer. A maximum of 32 wind turbines will be installed, with a minimum spacing of 990m between turbines (both inter-row and in-row). SEP occupies an area of 92.60km^2 plus 4km buffer. A maximum of 24 wind turbines will be installed, with a minimum spacing of 990m between turbines (both inter-row and in-row). Approximately 690 vessel round trips per annum (DEP or SEP) or 694 (DEP and SEP) will occur to support OWF operations (although the majority (624) will be small O&M vessel (CTV)).			The maximum density of turbines and structures across each OWF is considered by the assessment, which maximises the potential for avoidance and displacement. It is also assumed that turbines will cover the entirety of the area within each OWF boundary.
Impact 4: Collision Risk	In the 14MW scenario, a maximum of 32 and 24 wind turbines will be installed at DEP and SEP respectively. The turbines have a rotor diameter of 220m, giving a total swept area of 1,216,425m^2 at DEP, and 912,319m^2 at SEP. The air gap between the sea surface and lowest point of the swept area is 26m at Highest Astronomical Tide (HAT). In the 26MW scenario, a maximum of 17 and 13 wind turbines will be installed at DEP and SEP respectively. The turbines have a rotor diameter of 300m, giving a total swept area of 1,201,659m^2 at DEP, and 918,916m^2 at SEP. The air gap between the sea surface and lowest point of the swept area is 30m at HAT.			CRM has been carried out for two wind turbine scenarios for DEP and SEP. The scenario which produces the highest collision risk has been used in the assessment.

Impact	Parameter	Notes and Rationale
	In both cases, an operational life of 35 years is assumed for both OWFs.	
Impact 5: Indirect Effects	Further information is provided in **Chapter 8 Marine Geology, Oceanography and Physical Processes**, **Chapter 9 Marine Water and Sediment Quality**, **Chapter 10 Benthic and Intertidal Ecology** and **Chapter 11 Fish and Shellfish Ecology.**	
Decommissioning		
Impact 6: Disturbance, Displacement and Barrier Effects	Impacts are assumed to be similar to construction and therefore a worst case would be as for Impact 1.	N/A
Impact 7: Indirect Effects	Impacts are assumed to be similar to construction and therefore a worst case would be as for Impact 2.	N/A

13.3.2.2 Construction Scenarios

12. In order to determine which construction scenario presents the realistic worst case for each receptor and impact, the assessment considers both maximum duration effects and maximum peak effects, in addition to each Project being developed in isolation, drawing out any differences between DEP and SEP.

13. The three construction scenarios considered by the offshore ornithology assessment are to build DEP or build SEP in isolation, build DEP and SEP concurrently (reflecting the maximum peak effects) and build one project followed by the other (sequential) (reflecting the maximum duration of effects). For a sequential build there may be a gap of approximately one year between the end of offshore construction on the first project and the start of offshore construction on the second.

14. Any differences between DEP and SEP, 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 13.6**). 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 13.6**.

13.3.2.3 Operation Scenarios

15. The assessment considers the following three scenarios; only DEP in operation, only SEP in operation, and both projects operating at the same time. The operational phase duration of each project is expected to be 35 years.

13.3.2.4 Decommissioning Scenarios

16. Decommissioning scenarios are described in detail in **Chapter 5 Project Description**. Decommissioning arrangements will be agreed through the submission of a Decommissioning Plan prior to construction, however for the purpose of this assessment it is assumed that decommissioning of DEP and SEP could be conducted separately, or at the same time.

13.3.3 Summary of Mitigation Embedded in the Design

17. This section outlines the embedded mitigation relevant to the offshore ornithology assessment, which has been incorporated into the design of the Project (**Table 13-3**). Embedded mitigation will continue to be considered as the EIA process evolves and the details presented in the final ES chapter as necessary. Where other mitigation measures are proposed, these are detailed in the impact assessment (**Section 13.6**).

Table 13-3: Embedded Mitigation Measures

Parameter	Mitigation Measures Embedded into the Design of DEP and SEP
Site Selection	Wind farm boundary site selection process: the shallow area to the northwest of the existing Dudgeon OWF was excluded from the DEP North 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

Parameter	Mitigation Measures Embedded into the Design of DEP and SEP
	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 North.

13.4 Impact Assessment Methodology

13.4.1 Policy, Legislation and Guidance

13.4.1.1 National Policy Statements

18. The assessment of potential impacts on 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), produced by the Department of Energy and Climate Change (DECC). Those relevant to the Project are:

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

19. The specific assessment requirements for offshore ornithology, as detailed in the NPS, are summarised in **Table 13-4** together with an indication of the section of the PEIR chapter where each is addressed.

Table 13-4 NPS Assessment Requirements

NPS Requirement	NPS Reference	Section Reference
En-1 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 13.6**
Show how the proposed project has taken advantage of opportunities to conserve and enhance biodiversity conservation interests.	EN-1 – 5.3.4	**Section 13.6**
Include appropriate mitigation measures as an integral part of the proposed development	EN-1 – 5.3.18	**Section 13.6**
Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the	EN-3 – 2.6.64	**Section 13.6**

NPS Requirement	NPS Reference	Section Reference
proposed OWF and in accordance with the appropriate policy for OWF EIAs		
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 negative effects on marine ecology and biodiversity	EN-3 – 2.6.67	This is discussed throughout the assessment
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 13.6.2.2**

13.4.1.2 Other

20. The most relevant EIA guidance for offshore ornithology receptors is CIEEM (2018). The EIA methodology described in **Section 13.4.3** and applied in this chapter is based on this guidance.

21. A wide range of additional guidance has been referred to throughout the assessment as required.

22. Further detail of policy, legislation and guidance referred to more widely by the overall assessment is provided in **Chapter 3 Policy and Legislative Context**.

13.4.2 Data and Information Sources

23. In order to provide site specific and up to date information to inform the impact assessment, a baseline program of digital aerial bird surveys 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. A polygon encompassing both DEP and SEP areas and a 4km buffer was surveyed. Further information on the survey programme is provided in **Appendix 13.1 Offshore Ornithology Technical Report**.

24. Other sources that have been used to inform the assessment are referred to in this chapter, and are listed in the references section at the end of the chapter.

13.4.3 Impact Assessment Methodology

25. **Chapter 6 EIA Methodology** summarises the general impact assessment methodology applied to DEP and SEP. The following sections provide further details on the methodology used to assess the potential impacts on offshore ornithology receptors.

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

27. 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 DEP and SEP. This process provides an easy to follow assessment route between impact sources and potentially sensitive receptors, ensuring a transparent impact assessment. The parameters of this model are defined as follows:

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

28. 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.

13.4.3.1 Receptor Sensitivity

29. 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 13-5**, whilst capacity for recovery definitions are presented in **Table 13-6**. A matrix showing how the definitions for tolerance and recovery can be combined to estimate receptor sensitivity is provided in **Table 13-7**. 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 13-8** using the example of disturbance due to construction activity.

30. 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 DEP, SEP, and the habitats surrounding them (e.g. migratory birds).

Table 13-5: Definition of tolerance for an offshore ornithology receptor

Tolerance	Definition
High	No or minor negative 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.
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 13-6: 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 13-7: 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 13-8: 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.

31. The sensitivity of each ornithological receptor to each impact pathway will be estimated by information identified by a literature review. The overall confidence in the information used to define the sensitivity of each seabird receptor will also be 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.

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

13.4.3.2 Conservation Value

33. 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.

34. 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 DEP, SEP, 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.

35. Example definitions of the value levels for ornithology receptors are given in **Table 13-9**. 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 13-9: 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.
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.

13.4.3.3 Impact Magnitude

36. The definitions of the impact magnitude levels for offshore ornithology receptors are set out in **Table 13-10**. 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 13-10: Definitions of levels of impact magnitude for an offshore ornithology receptor

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.

13.4.3.4 Impact Significance

37. 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 6 EIA Methodology** for further details). The determination of significance is guided by the use of an impact significance matrix, as shown in **Table 13-11**. Definitions of each level of significance are provided in **Table 13-12**. The matrix, along with the definitions of sensitivity and magnitude are a framework to aid understanding of how a judgement has been reached from the narrative of each impact assessment. Primarily, the assessment of likelihood and ecological significance of a predicted impact will be drawn from evidence where such evidence exists. Expert judgement will also be applied as required.

38. Potential impacts identified within the assessment as major or moderate are regarded as ecologically significant in terms of the EIA regulations. 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 13-11: Impact significance matrix

		Negative Magnitude				Beneficial Magnitude			
		High	Medium	Low	Negligible	Negligible	Low	Medium	High
Sensitivity	High	*Major*	*Major*	*Moderate*	*Minor*	*Minor*	*Moderate*	*Major*	*Major*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*Minor*	*Minor*	*Moderate*	*Major*
	Low	*Moderate*	*Minor*	*Minor*	*Negligible*	*Negligible*	*Minor*	*Minor*	*Moderate*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Negligible*	*Minor*

Table 13-12: Definition of impact significance

Significance	Definition
Major	Very large or large change in receptor condition, both negative or beneficial, which are likely to be important considerations for the national population or the population of an internationally designated site, because they contribute to achieving national, or site-specific 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 regional or district level, or in relation to the population of a nationally designated site.
Minor	Small change in receptor condition, which may be raised as a local issue 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.

13.4.4 Cumulative Impact Assessment Methodology

39. The cumulative impact assessment (CIA) considers other plans, projects and activities that may impact cumulatively with DEP and SEP. As part of this process, the assessment considers which of the impacts (or residual impacts where mitigation is applied) assessed for DEP and/or SEP 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 6 EIA Methodology** provides further details of the general framework and approach to the CIA.

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

13.4.5 Transboundary Impact Assessment Methodology

41. The transboundary assessment considers the potential for transboundary effects to occur on offshore ornithology receptors as a result of DEP and SEP; 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. **Chapter 6 EIA Methodology** provides further details of the general framework and approach to the assessment of transboundary effects.

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

13.4.6 Assumptions and Limitations

43. 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.

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

13.5 Existing Environment

45. The characterisation of the existing or baseline environment has been undertaken based on site-specific baseline surveys (**Section 13.4.2** and **Appendix 13.1 Offshore Ornithology Technical Report**), along with a desk study which considers all known and available relevant literature.

13.5.1 Relative Importance of the Aerial Survey Study Area

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

47. 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 DEP and SEP are situated is relatively unimportant in the context of the large area considered by Waggitt et al. (2019). None of the 12 seabird species included in Waggitt et al. (2019) are expected to occur in large numbers in the area occupied by DEP and SEP 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 DEP and SEP. There are several locations where two large gull species included in Waggitt et al. (2019) (lesser black-backed gull and herring gull) breed in relatively modest numbers along the Norfolk coast. These breeding locations lie within the mean maximum foraging range of DEP and SEP for these species (Woodward et al., 2019).

48. Sandwich tern, a species not included in Waggitt et al. (2019), breed at the North Norfolk Coast SPA. DEP and SEP are within the mean maximum foraging range of Sandwich tern breeding within the SPA, and are also within the maximum recorded foraging range of Sandwich tern from this particular site (Woodward et al., 2019). Data from Sandwich tern tracking work carried out as part of the DOW OMP clearly demonstrates functional linkage between DEP and SEP, and Sandwich terns breeding at this SPA (Green et al., 2019). This species is therefore a key focus of the assessment.

49. The Flamborough and Filey Coast SPA is another seabird colony which is within published foraging ranges of DEP and SEP 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 DEP and SEP do not fall within the core foraging ranges (i.e. the area of habitat in which 50% of a colonies activity is expected to occur) for birds breeding at this SPA (Cleasby et al., 2018; Langston et al., 2013; Wakefield et al., 2017, 2013; Wischnewski et al., 2017). 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 gannet and kittiwake, as well as other qualifying features of the SPA, do not overlap with DEP and SEP. Breeding birds from this SPA are expected to be present at DEP and SEP during passage periods (Furness, 2015; Waggitt et al., 2019), and are considered by the assessment.

50. 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 DEP and SEP year round. For three species of gull (lesser black-backed gull, herring gull and kittiwake), and guillemot and razorbill, data presented in Waggitt et al. (2019) suggest that DEP and SEP may be more important during the non-breeding season than the breeding season, particularly with respect to the latter two species.

51. It is expected that a wide range of migratory birds (including seabirds and non-breeding waterbirds) may pass through DEP and SEP 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 not adequately recorded in baseline surveys (Wright et al., 2012). These are considered by the assessment.

52. Overall, whilst there are a number of offshore ornithology receptors that require further consideration in this assessment, existing information indicates that generally, the area in which DEP and SEP 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.

13.5.2 Offshore Ornithology Receptors Recorded During Baseline Surveys

13.5.2.1 Overview

53. Species recorded by the site-specific baseline surveys (digital video aerial bird surveys of the aerial survey study area, as described in **Appendix 13.1 Offshore Ornithology Technical Report**) are listed in **Table 13-13** along with details of their conservation status (Birds of Conservation Concern (BoCC) status (Eaton et al., 2015), and whether listed on Annex I of the Birds Directive).

Table 13-13: Species recorded in the DEP and SEP 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
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

Common Name	Scientific Name	Conservation Status
Lapwing	*Vanellus vanellus*	BoCC Red
Lesser black-backed gull	*Larus fuscus*	BoCC Amber
Little gull	*Hydrocoloeus minutus*	BoCC Green
Long-tailed duck	*Clangula hyemalis*	BoCC Red
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
Sandwich tern	*Thalasseus sandvicensis*	Annex I, BoCC Amber
Shag	*Phalacrocorax aristotelis*	BoCC Red
Tufted duck	*Aythya fuligula*	BoCC Green
Woodpigeon	*Columba palumbus*	BoCC Green

54. For the offshore cable corridor located beyond the aerial survey study area, no site-specific baseline ornithology surveys were carried out. The assessment for this component of DEP and SEP 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).

55. Detail on the seabird species recorded during the baseline surveys (**Table 13-13**) is presented in **Appendix 13.1 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 13.6**, which places predicted seasonal mortality into context by comparing it to relevant background populations, and the predicted increase in background mortality which could result.

13.5.2.2 Biologically Relevant Seasons

56. 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 13-14**. 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.

13.5.2.3 Calculation of Species Densities and Abundance

57. The methods used to calculate species density and abundance are presented in A**ppendix 13.1 Offshore Ornithology Technical Report**. Abundances within species-specific seasons (**Table 13-14**) recorded within the aerial survey study area are provided in **Table 13-15**.

13.5.2.4 Demographic Data

58. Demographic data for species scoped in for assessment for one or more potential impacts are provided in **Table 13-16**. 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 DEP and SEP in terms of changes to population mortality rates.

Table 13-14: Biologically relevant seasons for offshore ornithology receptors at DEP and SEP. Prefixes indicate early in month ("e."), mid-month ("m.") and late in month ("l.").

Species	Breeding	Migration-free Breeding	Autumn Migration (UK Waters)	Winter	Spring Migration (UK Waters)	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)

Species	Breeding	Migration-free Breeding	Autumn Migration (UK Waters)	Winter	Spring Migration (UK Waters)	Non-breeding	Source
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)
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	-	Furness (2015)
Sandwich tern	Apr - Aug	Jun	Jul - Sept	-	Mar - May	Sept - Mar	Furness (2015)

Species	Breeding	Migration-free Breeding	Autumn Migration (UK Waters)	Winter	Spring Migration (UK Waters)	Non-breeding	Source
Shag	Feb - Aug	Mar - Jul	Aug - Oct	Nov	Dec - Feb	Sept - Jan	Furness (2015)

Table 13-15: 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.

Species	Autumn Migration	Winter	Spring Migration	Non-breeding	Breeding
Arctic skua	6 (0 - 11)	0	0	-	0
Arctic tern	0	0	17 (0 - 50)	-	7 (0 - 20)
Black-headed gull	-	-	-	83 (0 - 129)	37 (0 - 111)
Common gull	-	-	-	81 (40 - 162)	13 (0 - 40)
Common scoter	-	-	-	37 (0 - 91)	0
Common tern	17 (0 - 40)	0	60 (0 - 181)	-	48 (0 - 145)
Cormorant	0	0	0	-	27 (0 - 61)
Fulmar	53 (21 - 85)	0	14 (0 - 21)	-	44 (21 - 81)
Gannet	1,655 (1,115 - 2,194)	0	81 (51 - 111)	-	590 (222 - 838)
Great black-backed gull	491 (399 - 582)	123 (0 - 288)	44 (0 - 90)	-	24 (20 - 30)

Species	Autumn Migration	Winter	Spring Migration	Non-breeding	Breeding
Great skua	6 (0 - 11)	7 (0 - 11)	0	-	0
Guillemot	-	-	-	16,089 (887 - 25,550)	6,462 (2,378 - 12,940)
Herring gull	-	-	-	34 (21 - 51)	51 (11 - 110)
Kittiwake	4,037 (3,491 – 4,538)	0	116 (0 - 199)	-	2,985 (1,308 - 5,430)
Lesser black-backed gull	27 (22 - 31)	7 (0 - 11)	0	-	176 (10 - 349)
Little gull	-	-	-	1,066 (0 - 1,741)	7 (0 - 20)
Manx shearwater	134 (0 - 268)	0	0	-	3 (0 - 10)
Pomarine skua	0	4 (0 - 11)	0	-	0
Puffin	-	-	-	71 (51 – 110)	14 (0 - 21)
Razorbill	8480 (7506 – 9,453)	1,925 (0 - 3,583)	531 (0 - 853)	-	1,964 (31 – 5,512)
Red-throated diver	181 (161 - 200)	21 (0 - 41)	33 (0 - 60)	-	220 (21 - 547)
Sandwich tern	111 (110 - 111)	0	0	-	1,133 (0 - 2,557)
Shag	0	0	0	-	3 (0 - 10)

Table 13-16: 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

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	0.13	0.08	0.08	0.08	-	0.63		
Arctic skua	Survival	0.346	0.346	0.346	0.346	-	0.910	0.487	0.519
	Proportion	0.15	0.09	0.09	0.09	-	0.58		
Common tern	Survival	0.441		0.850		-	0.883	0.764	0.215
	Proportion	0.13	0.08	0.08	0.08		0.63		
Gannet	Survival	0.424	0.829	0.891	0.895	-	0.912	0.7	0.191
	Proportion	0.191	0.081	0.067	0.06	-	0.600		
Great skua	Survival	0.730	-	-	-	-	0.882	0.651	0.157
	Proportion	0.14	-	-	-	-	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	0.56	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	0.79	0.854	0.854	0.854	-	0.854	0.69	0.156
	Proportion	0.155	0.123	0.105	0.089	-	0.527		
Lesser black-backed gull	Survival	0.82	0.885	0.885	0.885	-	0.885	0.53	0.126
	Proportion	0.134	0.109	0.085	0.084	-	0.577		

Species	Parameter	Age Class						Productivity	Average Mortality
		0-1	1-2	2-3	3-4	4-5	Adult		
Little gull	Survival	-	-	-	-	-	0.800	-	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	0.63	0.63	0.895	0.895	-	0.895	0.57	0.174
	Proportion	0.159	0.102	0.065	0.059	-	0.613		
Red-throated diver	Survival	0.6	0.62	-	-	-	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		

13.5.3 Existing Pressures on Wider Environment

59. 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).

60. 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). In the UK, and particularly in the northern North Sea, seabird populations are generally undergoing substantial declines, which have so far been occurring for at least two decades (Grandgeorge et al., 2008; JNCC, 2020b; Mitchell et al., 2020). Whilst there are exceptions (for instance gannet), the wider trend is reflected in the fact that according to the UK Marine Strategy, UK breeding seabirds have not achieved good environmental status (DEFRA, 2019).

61. Climate change has the potential to impact seabird populations in two 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). This means that it is reasonable to assume that future trends will see effects on seabirds increase in both frequency and magnitude.

62. In general, as 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).

63. 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.

64. 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).

65. 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).

66. 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.

13.6 Potential Impacts

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

68. 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.

69. 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.

70. 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.

71. 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 13.4.3**, on the basis of the worst case scenarios set out in **Section 13.3.2** and accounting for the embedded mitigation described in **Section 13.3.3**.

13.6.1 Potential Impacts during Construction

13.6.1.1 Impact 1: Disturbance, Displacement and Barrier Effects

72. During the construction phase, DEP and SEP 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.

73. 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 DEP and SEP. The approximate duration of offshore construction for DEP and SEP would be four years. Construction could occur simultaneously, or sequentially, with a maximum gap between construction at DEP and SEP of two years, giving a maximum construction period duration of 10 years (**Section 13.3.2**).

74. Details of activities to be undertaken during the construction phase are provided in **Chapter 5 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, meteorological masts, export cables and other infrastructure.

75. Construction will not occur across the whole of DEP and SEP simultaneously or every day. 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 DEP and SEP sites. For this reason, the assessment assumes that construction activities will occur at a maximum of three discrete locations simultaneously. The exact level of disturbance at each work location would differ dependent 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 13.6.2.1**).

76. Offshore ornithology receptors differ considerably in their sensitivity to anthropogenic disturbance in the marine environment (Fliessbach et al., 2019; Furness et al., 2013; Furness and Wade, 2012; Garthe and Hüppop, 2004; MMO, 2018), though uncertainty also exists surrounding displacement effects (Wade et al., 2016), and disentangling the relative contribution of different disturbance pathways is challenging.

77. 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 relevant pathway that could contribute to the effect.

78. 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, though such anatomical adaptations have been shown to include protection against the large pressure changes that may occur while diving, which may protect the ear from damage due to acoustic overexposure (Dooling and Therrien, 2012). Accurate measurements of the underwater hearing capabilities of seabirds are limited. A paper studying this in a

cormorant suggested that hearing thresholds for the species were high compared to marine-adapted mammals, but acknowledged the sources of error present in the methodologies employed (Johansen et al., 2016). The principal source of noise during construction of DEP and SEP would be subsea noise from piling works associated with the installation of foundations for wind turbines and associated offshore substations. It is presumed that a high proportion of birds will be displaced prior to underwater noise being created by activities such as piling. The potential for underwater noise impacts on fisheries and marine mammals has been considered in detail in **Chapter 11 Fish Ecology** and **Chapter 12 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. It is presumed that these measures will have similar effects on any seabirds that are sensitive to these effects. Therefore, underwater noise impacts are not considered further by the assessment.

79. Lighting of construction sites, vessels and other structures at night may potentially be a source of attraction (phototaxis), as opposed to displacement, for birds; however, the areas affected would be very small, and restricted to offshore construction areas which are active at a given time. Phototaxis can be a serious hazard for fledglings of some seabird species (Deppe et al., 2017; Raine et al., 2007; Rodríguez et al., 2015), but 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 DEP and SEP 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 DEP and SEP.

80. In this assessment, 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, as opposed to birds on passage during migratory seasons. Birds that are resident in an area during the breeding season may regularly encounter and be displaced by an OWF that is under construction, during daily commuting trips to foraging areas from nest sites. No disturbance at breeding sites due to construction activities at DEP and SEP is anticipated; no breeding site for any offshore ornithology receptor falls within the impact zone for this impact.

81. 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 DEP and SEP (including seabirds, waders and waterbirds on passage) are considered negligible and these have been scoped out of the assessment.

82. In order to focus the assessment, a screening exercise was 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 DEP and SEP (**Table 13-17**). Any species recorded only in very small numbers and/or infrequently within the estimated ZoI (considered to extend to 4km from DEP and SEP), 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.

83. 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 is also presented, and was considered to be high if evidence of behaviour around anthropogenic disturbance sources in the marine environment was identified (mainly with reference to Fliessbach et al. (2019), the extensive, systematic literature review of the Marine Management Organisation (MMO) (2018), and observations local to DEP and SEP from the ornithological monitoring carried out at SOW, LID and Lincs OWFs (Harwood et al., 2018; Hi Def Aerial Surveying, 2017)), and if this concorded with expert opinion (i.e. Furness and Wade (2012) and Garthe and Hüppop (2004).

84. 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.

Table 13-17: Construction disturbance and displacement screening for DEP and SEP

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

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
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)	High	Out
Long-tailed duck	Unknown	N/A	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

13.6.1.1.1 Auks (Guillemot and Razorbill)

85. Much of the general information on the potential sensitivity of guillemot and razorbill to displacement during the construction of OWFs referred to in **Section 13.6.1.1** indicates that both species are moderately sensitive to such effects. Locally, 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 Sheringham Shoal ES for both species was an appropriate prediction. In contrast, no construction displacement effects were reported for either species at the LID and Lincs OWFs (Hi Def Aerial Surveying, 2017).

86. A recent review of available evidence for auk displacement at operational OWFs (Vattenfall, 2019) made conclusions that are also relevant to the same effect during OWF construction; namely the increase in density of auks outside an displacement zone will be negligible because the rest of 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 6% or 10% total annual mortality for guillemot and razorbill respectively (Horswill and Robinson, 2015), which is a result of natural factors and existing anthropogenic activities. Precautionary rates of displacement and mortality of auks from operational OWFs of 50% and 1% respectively were suggested.

87. Based on all of the available information, guillemot and razorbill are considered to possess a medium sensitivity to disturbance and displacement from DEP and SEP 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.

88. It has been assumed that 100% displacement of guillemot and razorbill will occur within 2km of construction activities, and a mortality rate of 1% to 10% of displaced birds is predicted. This represents a highly precautionary assessment that the evidence reviewed suggests is biologically unrealistic.

89. Escape distances of auks was much lower than 2km when reported by Fliessbach et al. (2019). The mean escape distance for guillemot and razorbill was 127m (standard deviation 110m) and 395m (standard deviation 216m), with 37% of guillemots and 78% of razorbills responding 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.

90. The upper limit of the mortality range is nearly double the background annual adult mortality for guillemot, and approximately equivalent to the annual mortality for razorbill (Horswill and Robinson, 2015), which results from a very wide range of environmental and anthropogenic pressures. These include prey availability driven by climate change and fisheries activities, bycatch, predation, displacement by other 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.. The use of 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.

13.6.1.1.1.1 Guillemot

91. 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 (0.140; **Table 13-16**), the number of guillemots expected to die annually from this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 226,423 (i.e. 1,617,306 x 0.140).

92. 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 guillemots (0.140; **Table 13-16**), the number of guillemots expected to die annually that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 97,362 (i.e. 695,441 x 0.140).

13.6.1.1.1.1.1 DEP

93. 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 13-18**.

Table 13-18: 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.

Parameter	Non-breeding	Breeding
Mean peak density (birds/km^2)	27.97	10.40
Number of birds at risk of displacement[1]	1,054.44	392.07
Estimated mortality due to impact[2]	10.54 - 105.44	3.92 - 39.21
Wider population size[3]	1,617,306	695,441
Estimated existing annual mortality[4]	0.140	0.140
Expected annual background mortality in wider population	226,423	97,362
Mortality increase due to impact	0.00% - 0.05%	0.00% - 0.04%
Notes		

Parameter	Non-breeding	Breeding
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) 4. For the breeding and non-breeding season, the average mortality for all age classes, from Horswill and Robinson (2015)		

94. The mean peak density of flying and sitting guillemots during the non-breeding season within DEP and its 2km buffer was 28 birds/km^2. This means that within 2km of a single construction location (i.e. 12.57km^2), 351 birds are at risk of displacement, or 1,054 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 11 to 105 birds. Adding the predicted mortality due to construction-related disturbance and displacement at DEP during the non-breeding season to the existing mortality levels within the BDMPS will increase the existing mortality level within this population by 0.00% to 0.05%.

95. During the breeding season, the mean peak density of flying and sitting guillemots within DEP and its 2km buffer was 10 birds/km^2. This means that within 2km of a single construction location, 131 birds are at risk of displacement, or 392 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 4 to 39 birds. Adding the predicted mortality due to construction-related disturbance and displacement at DEP during the breeding season to the existing mortality levels within the non-breeding component of UK North Sea and Channel BDMPS population will increase the existing mortality level within this population by 0.00% to 0.04%.

96. Summing the seasonal totals in **Table 13-18**, the estimated number of guillemots subject to construction disturbance and displacement throughout the year at DEP is 1,446 individuals, of which between 14 and 145 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 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 0.06%.

97. The predicted magnitude of increase in mortality 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 negative**.

13.6.1.1.1.1.2 SEP

98. 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 13-19**.

Table 13-19: 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

Parameter	Non-breeding	Breeding
Mean peak density (birds/km^2)	2.92	2.88
Number of birds at risk of displacement[1]	110.08	108.57
Estimated mortality due to impact[2]	1.10 - 10.01	1.09 - 10.86
Wider population size[3]	1,617,306	695,441
Estimated existing annual mortality[4]	0.140	0.140
Expected annual background mortality in wider population	226,423	97,362
Mortality increase due to impact	0.00% - <0.01%	0.00% - 0.01%

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)
4. For the breeding and non-breeding seasons, the average mortality for all age classes, from Horswill and Robinson (2015)

99. The mean peak density of flying and sitting guillemot during the non-breeding season within SEP and its 2km buffer was 3 birds/km^2. This means that within 2km of a single construction location (i.e. 12.57km^2), 37 birds are at risk of displacement, or 110 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 1 to 11 birds. Adding the predicted mortality due to construction-related disturbance and displacement at SEP during the non-breeding season to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to <0.01%.

100. During the breeding season, the mean peak density of flying and sitting guillemots within SEP and its 2km buffer was 3 birds/km^2. This means that within 2km of a single construction location, 36 birds are at risk of displacement, or 109 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 1 to 11 birds. Adding the predicted mortality due to construction-related disturbance and displacement at DEP during the breeding season to the existing mortality levels within the non-breeding component of UK North Sea and Channel BDMPS population will increase the existing mortality level within this population by 0.00% to 0.01%.

101. Summing the seasonal totals in **Table 13-19**, the estimated number of guillemots subject to construction disturbance and displacement throughout the year at SEP is 219 individuals, of which between 2 and 22 could be at risk of mortality. Adding the predicted annual mortality due to construction-related disturbance and displacement at SEP to the existing mortality levels within the largest BDMPS 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 0.01%.

102. The predicted magnitude of increase in mortality 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 negative**.

13.6.1.1.1.1.3 DEP and SEP Combined

103. Summing the relevant seasonal totals in **Table 13-18** and **Table 13-19**, the estimated number of guillemots subject to construction disturbance and displacement at DEP and SEP combined during the non-breeding season is 1,165 individuals, of which between 12 and 116 could be at risk of mortality. Adding this predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.01% to 0.05%.

104. Summing the relevant seasonal totals in **Table 13-18** and **Table 13-19, t**he estimated number of guillemots subject to construction disturbance and displacement at DEP and SEP combined during the breeding season is 501 individuals, of which between 5 and 50 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the non-breeding component of UK North Sea and Channel BDMPS population will increase the existing mortality level by 0.01% to 0.05%.

105. Summing the seasonal totals in **Table 13-18** and **Table 13-19**, the estimated number of guillemots subject to construction disturbance and displacement throughout the year at DEP and SEP combined is 1,665 individuals (summing the seasonal totals in **Table 13-18** and **Table 13-19**), of which between 17 and 167 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within the wider population by 0.02% to 0.07%.

106. The predicted magnitude of increase in mortality in the wider population is very small in all cases due to this impact, and would be undetectable in the context of natural variation. Therefore, during the non-breeding season, breeding season, and year round the magnitude of effect of construction-related disturbance and displacement at DEP and SEP combined is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.1.1.1.2 Razorbill

107. The UK North Sea and Channel BDMPS is considered to be the relevant background population for razorbill during the spring and autumn migration seasons, and the winter season (Furness, 2015). Using the published baseline annual mortality averaged across all classes (0.174; **Table 13-16**), the number of razorbills expected to die annually from this population (spring and autumn migration seasons) (**Appendix 13.1 Offshore Ornithology Technical Report**) is 102,986 (i.e. 591,874 x 0.174). During the winter season, existing mortality from the wider population is estimated to be 38,040 (i.e. 218,622 x 0.174).

108. The non-breeding component of the winter UK North Sea and Channel BDMPS is considered to be the relevant razorbill background population for the breeding season. At the published baseline annual mortality for all razorbills (0.174; **Table 13-16**), the number of razorbills expected to die in the breeding season that are members of the non-breeding component of the winter UK North Sea and Channel BDMPS (**Appendix 13.1 Offshore Ornithology Technical Report**) is 38,040 (i.e. 218,622 x 0.174).

13.6.1.1.1.2.1 DEP

109. The predicted effects on razorbill within 2km of three construction sites due to construction disturbance and displacement during the construction of DEP are summarised in **Table 13-20**.

Table 13-20: 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

Parameter	Autumn migration	Winter	Spring migration	Breeding
Mean peak density (birds/km^2)	12.66	2.50	0.94	2.86
Number of birds at risk of displacement[1]	477.27	94.25	35.44	107.82
Estimated mortality due to impact[2]	4.77 - 47.73	0.94 - 9.42	0.35 - 3.54	1.08 - 10.78
Wider population size[3]	591,874	218,622	591,874	218,622
Estimated existing annual mortality[4]	0.174	0.174	0.174	0.174
Expected annual background mortality in wider population	102,986	38,040	102,986	38,040
Mortality increase due to impact	0.00% - 0.05%	0.00% - 0.02%	0.00% - <0.01%	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

Parameter	Autumn migration	Winter	Spring migration	Breeding
3. Autumn, winter and spring populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of winter UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015) 4. For all seasons, the average mortality for all age classes from Horswill and Robinson (2015)				

110. The mean peak density of flying and sitting razorbills during the autumn migration season within DEP and its 2km buffer was 13 birds/km^2. This means that within 2km of a single construction location (i.e. 12.57km^2), 159 birds are at risk of displacement, or 477 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 5 to 48 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to 0.05%.

111. During the winter season, the mean peak density of flying and sitting razorbills within DEP and its 2km buffer was 3 birds/km^2. This means that within 2km of a single construction location, 31 birds are at risk of displacement, or 94 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 1 to 9 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to 0.02%.

112. During the spring migration season, the mean peak density of flying and sitting razorbills within DEP and its 2km buffer was 1 birds/km^2. This means that within 2km of a single construction location, 12 birds are at risk of displacement, or 35 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 0 to 4 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to <0.01%.

113. During the breeding season, the mean peak density of flying and sitting razorbills within DEP and its 2km buffer was 3 birds/km^2. This means that within 2km of a single construction location, 36 birds are at risk of displacement, or 107.82 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 1 to 11 birds. Adding the predicted mortality due to construction-related disturbance and displacement at DEP during the breeding season to the existing mortality levels within the breeding adult population of the non-breeding component of the winter UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to 0.03%.

114. Summing the seasonal totals in **Table 13-20**, the estimated number of razorbills subject to construction disturbance and displacement throughout the year at DEP is 715 individuals, of which between 7 and 71 could be at risk of mortality. Adding the predicted annual mortality to the existing mortality levels within the largest BDMPS (autumn and spring migration seasons of the UK North Sea and Channel BDMPS; 102,986 individuals) will increase the existing mortality level within this population by 0.01% to 0.07%.

115. The predicted magnitude of increase in mortality 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. Therefore, during the autumn migration, winter, spring migration, 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 negative**.

13.6.1.1.1.2.2 SEP

116. The predicted effects on razorbill within 2km of three construction sites due to construction disturbance and displacement during the construction of DEP are summarised in **Table 13-21**.

Table 13-21: 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.

Parameter	Autumn migration	Winter	Spring migration	Breeding
Mean peak density (birds/km^2)	3.10	2.83	0.71	1.15
Number of birds at risk of displacement[1]	116.87	106.69	26.77	43.35
Estimated mortality due to impact[2]	1.17 - 11.69	1.07 - 10.67	0.27 - 2.68	0.43 - 4.34
Wider population size[3]	591,874	218,622	591,874	218,622
Estimated existing annual mortality[4]	0.174	0.174	0.174	0.174
Expected annual background mortality in wider population	102,986	38,040	102,986	38,040
Mortality increase due to impact	0.00% - 0.01%	0.00% - 0.03%	0.00% - <0.01%	0.01% - 0.01%

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, winter and spring populations from UK North Sea and Channel BDMPS (all birds) (Furness, 2015), breeding season population from non-breeding component of winter UK North Sea and Channel BDMPS (0.43 of total population) (Furness, 2015)
4. For all seasons, the average mortality for all age classes, , from Horswill and Robinson (2015)

117. The mean peak density of flying and sitting razorbills during the autumn migration season within DEP and its 2km buffer was 3 birds/km^2. This means that within 2km of a single construction location (i.e. 12.57km^2), 39 birds are at risk of displacement, or 117 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 1 to 12 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to 0.01%.

118. During the winter season, the mean peak density of flying and sitting razorbills within DEP and its 2km buffer was 3 birds/km^2. This means that within 2km of a single construction location, 36 birds are at risk of displacement, or 107 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 1 to 11 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to 0.03%.

119. During the spring migration season, the mean peak density of flying and sitting razorbills within DEP and its 2km buffer was 1 bird/km^2. This means that within 2km of a single construction location, 9 birds are at risk of displacement, or 27 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 0 to 3 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to <0.01%.

120. During the breeding season, the mean peak density of flying and sitting razorbills within DEP and its 2km buffer was 1 bird/km^2. This means that within 2km of a single construction location, 14 birds are at risk of displacement, or 43 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 0 to 4 birds. Adding the predicted mortality to the existing mortality levels within the non-breeding component of the winter UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to 0.01%.

121. Summing the seasonal totals in **Table 13-21**, the estimated number of razorbills subject to construction disturbance and displacement throughout the year at DEP is 294 individuals, of which between 3 and 29 could be at risk of mortality. Adding the predicted annual mortality to the existing mortality levels within the largest BDMPS (autumn and spring migration seasons of the UK North Sea and Channel BDMPS; 102,986 individuals) will increase the existing mortality level within this population by 0.00% to 0.03%.

122. The predicted magnitude of increase in mortality is very small across all seasons, and would be undetectable in the context of natural variation. Therefore, during the autumn migration, winter, spring migration, 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 negative**.

13.6.1.1.1.2.3 DEP and SEP Combined

123. Summing the relevant seasonal totals in **Table 13-20** and **Table 13-21**, the estimated number of razorbills subject to construction disturbance and displacement at DEP and SEP combined during the autumn migration season is 832 individuals, of which between 8 and 83 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.01% to 0.08%.

124. Summing the relevant seasonal totals in **Table 13-20** and **Table 13-21**, the estimated number of razorbills subject to construction disturbance and displacement at DEP and SEP combined during the winter season is 201 individuals, of which between 2 and 20 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.01% to 0.05%.

125. Summing the relevant seasonal totals in **Table 13-20** and **Table 13-21**, the estimated number of razorbills subject to construction disturbance and displacement at DEP and SEP combined during the spring migration season is 62 individuals, of which between 0 and 6 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to <0.01%.

126. Summing the relevant seasonal totals in **Table 13-20** and **Table 13-21**, the estimated number of razorbills subject to construction disturbance and displacement at DEP and SEP combined during the breeding season is 151 individuals, of which between 2 to 15 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the non-breeding component of the winter North Sea and Channel BDMPS will increase the existing mortality level by 0.01% to 0.04%.

127. Summing the seasonal totals in **Table 13-20** and **Table 13-21**, the estimated number of razorbills subject to construction disturbance and displacement throughout the year at DEP and SEP combined is 1,246 individuals, of which between 12 and 125 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the largest BDMPS (autumn and spring migration seasons of the UK North Sea and Channel BDMPS) will increase the existing mortality level within this population by 0.01% to 0.12%.

128. The predicted magnitude of increase in mortality is very small in all cases, and would be undetectable in the context of natural variation. Therefore, during the autumn migration season, winter season, spring migration season, breeding season, and year round the magnitude of effect of construction-related disturbance and displacement at DEP and SEP combined is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.1.1.2 Red-throated diver

129. General information on the potential sensitivity of red-throated diver to displacement during the construction of OWFs referred to in **Section 13.6.1.1** indicates the species 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).

130. Birds commonly avoid disturbed areas associated with shipping (Bellebaum et al., 2006; Jarrett et al., 2018; Schwemmer et al., 2011), and flushing effects have been recorded in excess of 1km of vessels (Fliessbach et al., 2019). Birds avoid operational OWFs (**Section 13.6.2.1.4**) 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 construction of OWFs on red-throated diver distribution. The majority of birds present before OWFs are constructed are displaced by the construction (and operation; **Section 13.6.2.1.4**) of OWFs. It is expected (based on expert opinion), that this is due to a combination of anthropogenic activities (mainly vessel-based), as well as the presence of OWF infrastructure as construction progresses.

131. For this assessment, it has been assumed that 100% displacement will occur within 2km of construction activities. This is considered appropriately precautionary based on the suggestion 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 379m).

132. Definitive mortality rates associated with displacement of red-throated diver are not known and precautionary estimates have to be used. There is no empirical evidence that displaced birds suffer any consequent mortality; any mortality due to displacement would be most likely a result of increased density in areas outside the affected area, resulting in increased competition for food where density was elevated. Such impacts are most likely to be negligible (Dierschke et al., 2017), and below levels that could be quantified. Impacts of displacement are also likely to be context-dependent. In years when food supply has been severely depleted, displacement of sandeel-dependent seabirds from optimal habitat may increase mortality. In years when food supply is good, displacement is unlikely to have any negative effect on seabird populations. Red-throated divers take a wide diversity of small fish prey (Kleinschmidt et al., 2019), so would be buffered to an extent from fluctuations in abundance of individual fish species.

133. The annual mortality rate of red-throated divers is 0.160 for adults (three years and older) and 0.380 to 0.400 for juveniles (Horswill and Robinson, 2015). These rates include mortality in the breeding and non-breeding season due to environmental factors such as weather or predation, as well as mortality (if any) from anthropogenic impacts such as disturbance and displacement by ships. As ships are mobile and red-throated divers will often fly away from approaching vessels (Fliessbach et al., 2019; Jarrett et al., 2018; Schwemmer et al., 2011), the energy costs of displacement from moving vessels may be considerably greater than those of avoiding static structures; and the impact (if any) of disturbance by ships must already be incorporated in the existing estimates of survival.

134. Natural England have advised recent OWF assessments that a highly precautionary 10% maximum mortality rate should be used for birds displaced by cable laying vessels. This magnitude of impact is not supported by the literature. Given that this would equate to more than half the natural annual adult mortality rate (16%) as a result of what is effectively a single occasion of disturbance, it is highly improbable that such a large magnitude of effect would occur. Macarthur Green (2019) concluded that 1% mortality is an appropriately precautionary estimate for displacement for red-throated diver, and that in reality the additional mortality rate may be closer to zero.

135. Despite the evidence presented by the literature reviewed, a mortality rate of 1% to 10% of displaced birds is predicted, as per previous advice provided by Natural England.

136. Such is their sensitivity to disturbance, displacement effects could also occur on red-throated divers within the offshore export cable corridor by cable laying vessels, including where it passes between DEP and SEP, and between SEP and Weybourne, where it passes through the Greater Wash SPA for approximately 9km.

137. Where it overlaps with the Greater Wash SPA, the offshore export cable corridor is between 1km and 2km wide, resulting in an overlap between the export cable corridor and the SPA of approximately 12km^2, or 0.34% of the area within the SPA. This represents the area of search; the actual export cable route (once defined) will have a smaller overlap.

138. 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 emitting operation, particularly when compared to activities such as piling. However, 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%. It is considered reasonable to assume that birds will reoccupy areas following the passage of the vessels.

139. The UK North Sea and Channel 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 (0.228; **Table 13-16**), the number of red-throated divers expected to die annually that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 3,027 (i.e. 13,277 x 0.228).

140. 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 (0.228; **Table 13-16**), the number of red-throated divers expected to die that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 2,320 (i.e. 10,177 x 0.228).

13.6.1.1.2.1 DEP

141. The predicted effects on red-throated diver within 2km of three construction sites due to disturbance and displacement during the construction of DEP are summarised in **Table 13-22**.

Table 13-22: 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.

Parameter	Autumn migration	Winter	Spring migration
Mean peak density (birds/km^2)	0.17	0.04	0.11
Number of birds at risk of displacement[1]	6.41	1.32	4.15
Estimated mortality due to impact[2]	0.06 - 0.64	0.01 - 0.13	0.04 - 0.41
Wider population size[3]	13,277	10,177	13,277
Estimated existing annual mortality[4]	0.228	0.228	0.228
Expected annual background mortality in wider population	3,027	2,320	3,027
Mortality increase due to impact	0.00% - 0.02%	0.00% - 0.01%	0.00% - 0.01%

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, winter and spring populations (all birds) from Furness (2015)
4. The average mortality for all age classes from Horswill and Robinson (2015)

142. The mean peak density of flying and sitting red-throated divers during the autumn migration season within DEP and its 2km buffer was 0.17 birds/km^2. This means that within 2km of a single construction location, 2.14 birds are at risk of displacement, or 6.41 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 0.06 to 0.64 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to 0.02%.

143. During the winter season, the mean peak density of flying and sitting red-throated divers within DEP and its 2km buffer was 0.04 birds/km^2. This means that within 2km of a single construction location, 0.44 birds are at risk of displacement, or 1.32 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 0.01 to 0.13 birds. Adding the predicted mortality to the existing mortality levels within the SW North Sea BDMPS will increase the existing mortality level within this population by 0.00% to 0.01%.

144. 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. This means that within 2km of a single construction location, 1.38 birds are at risk of displacement, or 4.15 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 0.04 to 0.41 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to 0.01%.

145. Summing the seasonal totals in **Table 13-22**, the estimated number of red-throated divers subject to construction disturbance and displacement throughout the year at DEP is 11.88 individuals, of which between 0.12 and 1.19 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the largest BDMPS (UK North Sea and Channel BDMPS for autumn and spring migration seasons; 3,027 individuals) will increase the existing mortality level within this population by 0.01% to 0.04%.

146. The predicted magnitude of increase in mortality 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. Therefore, during the autumn migration, winter, spring migration and year round, 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 negative**.

13.6.1.1.2.2 SEP

147. The predicted effects on red-throated diver within 2km of three construction sites due to disturbance and displacement during the construction of SEP are summarised in **Table 13-23**.

Table 13-23: 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.

Parameter	Autumn migration	Winter	Spring migration
Mean peak density (birds/km^2)	0.15	0.00	0.58
Number of birds at risk of displacement[1]	5.65	0.00	21.87
Estimated mortality due to impact[2]	0.06 - 0.57	0.00	0.22 - 2.19

Parameter	Autumn migration	Winter	Spring migration
Wider population size[3]	13,277	10,177	13,277
Estimated existing annual mortality[4]	0.228	0.228	0.228
Expected annual background mortality in wider population	3,027	2,320	3,027
Mortality increase due to impact	0.00% - 0.02%	0.00%	0.00% - 0.07%

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, winter and spring populations (all birds) from Furness (2015)
4. The average mortality for all age classes from Horswill and Robinson (2015)

148. The mean peak density of flying and sitting red-throated divers during the autumn migration season within SEP and its 2km buffer was 0.15 birds/km^2. This means that within 2km of a single construction location, 1.88 birds are at risk of displacement, or 5.65 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 0.06 to 0.57 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.00% to 0.02%.

149. During the winter season, no red-throated divers were recorded within SEP and its 2km buffer. This means that no birds are at risk of displacement, and additional mortality is therefore predicted.

150. During the spring migration season, the mean peak density of flying and sitting red-throated divers within SEP and its 2km buffer was 0.58 birds/km^2. This means that within 2km of a single construction location, 7.29 birds are at risk of displacement, or 21.87 birds if three construction locations occur across the site simultaneously. The estimated annual mortality based on rates of 1% to 10% is 0.22 to 2.19 birds. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.01% to 0.07%.

151. Summing the seasonal totals in **Table 13-23**, the estimated number of red-throated divers subject to construction disturbance and displacement throughout the year at SEP is 27.52 individuals, of which between 0.28 and 2.75 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the largest BDMPS (UK North Sea and Channel BDMPS for autumn and spring migration seasons; 3,027 individuals) will increase the existing mortality level within this population by 0.01% to 0.09%.

152. The predicted magnitude of increase in mortality 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. Therefore, during the autumn migration, winter, spring migration 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 high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.1.1.2.3 DEP and SEP Combined

153. Summing the relevant seasonal totals in **Table 13-22** and **Table 13-23**, the estimated number of red-throated divers subject to construction disturbance and displacement at DEP and SEP combined during the autumn migration season is 33.39 individuals, of which between 0.34 and 3.39 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.01% to 0.11%.

154. Summing the relevant seasonal totals in **Table 13-22** and **Table 13-23**, the estimated number of red-throated divers subject to construction disturbance and displacement at DEP and SEP combined during the winter season is 1.32 individuals, of which between 0.01 and 0.13 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the SW North Sea BDMPS will increase the existing mortality level within this population by 0.00% to 0.01%.

155. Summing the relevant seasonal totals in **Table 13-22** and **Table 13-23**, the estimated number of red-throated divers subject to construction disturbance and displacement at DEP and SEP combined during the spring migration season is 26.01 individuals, of which between 0.26 and 6.22 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the UK North Sea and Channel BDMPS will increase the existing mortality level within this population by 0.01% to 0.09%.

156. Summing the seasonal totals in **Table 13-22** and **Table 13-23**, the estimated number of red-throated divers subject to construction disturbance and displacement throughout the year at DEP and SEP combined is 61.26 individuals, of which between 0.61 to 6.13 could be at risk of mortality. Adding the predicted mortality to the existing mortality levels within the largest BDMPS (UK North Sea and Channel BDMPS for autumn and spring migration seasons) will increase the existing mortality level within this population by 0.02% to 0.20%.

157. The predicted magnitude of increase in mortality is very small in all cases, and would be undetectable in the context of natural variation Therefore, during the autumn migration season, winter season, spring migration season, and year round, the magnitude of effect of construction-related disturbance and displacement at DEP and SEP combined is assessed as negligible. As this species is considered to possess a high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.1.1.2.4 Export Cable Corridor

158. The baseline surveys did not cover large parts of the export cable corridor. To perform an assessment of potential disturbance and displacement for red-throated diver due to construction activities within the 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.

159. Bradbury et al. (2014) indicates that within the 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 rate of 1% to 10% amongst displaced birds, 0.07 to 0.7 birds would be expected to be lost to the population. 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%.

160. The predicted magnitude of increase in mortality 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 export cable corridor, this is a highly precautionary assessment. During the autumn migration season, winter season, spring migration season, and year round, the magnitude of effect of construction-related disturbance and displacement within the 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 negative**. This conclusion also applies if the predicted mortality is added to that predicted at DEP and SEP.

13.6.1.2 Impact 2: Indirect Effects

161. Indirect effects on offshore ornithology receptors may occur during the construction phase of DEP and SEP if there are impacts on prey species and/or their habitats. Potential indirect effects include those resulting from the production of underwater noise (e.g. during piling) and the generation of suspended sediments (e.g. during preparation of the seabed for piling) that 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 10 Benthic Ecology** and **Chapter11 Fish and Shellfish Ecology** and the conclusions of those assessments inform this assessment of indirect effects on offshore ornithology receptors.

162. With regard to noise impacts on fish, **Chapter 11 Fish and Shellfish Ecology** considers the potential impacts upon fish relevant to ornithology as prey species of DEP and SEP. For species such as herring, sprat and sandeel, which are the main prey items of a range of seabirds including Sandwich tern, kittiwake, gannet and auks, underwater noise impacts (physical injury or behavioural changes) during construction are considered to be minor or negligible. 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 DEP and SEP during the construction phase due to this impact is **minor negative**.

163. **Chapter 8 Marine Geology and Physical Processes** and **Chapter 10 Benthic Ecology** discuss the impacts on the seabed and benthic habitats due to the construction of DEP and SEP. Such changes are considered to be temporary, small scale and highly localised. The consequent indirect impact on fish through habitat loss is considered to be minor or negligible for species such as herring, sprat and sandeel which are the main prey items of a range of seabirds including 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 DEP and SEP during the construction phase due to this impact is **minor negative**.

164. This impact significance level applies to DEP and SEP combined and in isolation.

13.6.2 Potential Impacts during Operation

13.6.2.1 Impact 3: Disturbance, Displacement and Barrier Effects

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

166. Operational phase displacement is defined as a reduced number of birds occurring within or immediately adjacent to an OWF (Furness et al., 2013), and 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 would 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 DEP and SEP, which is 35 years, with a gap of up to 3 years between each project commencing operation. The worst case scenarios outlined in **Section 13.3.2** describe the elements of DEP and SEP considered within this assessment. 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. The operational assessment provides a worst-case scenario assessment of displacement and barrier effects.

167. Offshore ornithology receptors differ considerably in their sensitivity to anthropogenic disturbance in the marine environment (Fliessbach et al., 2019; Furness et al., 2013; Furness and Wade, 2012; Garthe and Hüppop, 2004; MMO, 2018), though uncertainty also exists surrounding displacement effects (Wade et al., 2016), and disentangling the relative contribution of different disturbance pathways is challenging.

168. 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. within a radius of 2km as considered in **Section 13.6.1.1**), but in comparison to the presence of an operational turbine array these are considered to have a negligible contribution to operational OWF disturbance and displacement.

169. Offshore wind turbines and other infrastructure will be equipped with lighting for air safety and navigational safety. Other lighting for personnel working at night will also be present, though these would not be as bright as air and navigational safety lighting. Air safety lights will be placed high on the wind turbine structures, and as a minimum on wind turbines at the periphery of DEP and SEP. Navigational lights for shipping will be placed lower on wind turbine structures and other offshore structures. A review of the potential effects of operational lighting on birds considered available evidence to investigate potential impacts across eight categories of potential effect on birds (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 separately.

170. The required operational and maintenance activities of the export cable may have short-term and localised disturbance and displacement impacts on offshore ornithology receptors. 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.

171. 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, although the number of available studies is increasing. When reviewing the results of previous studies it is crucial to develop an understanding of the context of displacement effects to avoid misinterpretation, and to provide greater insight into the likelihood of an impact resulting in an effect at the population level. 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 caused by operational OWFs (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.

172. 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 by razorbill, guillemot, little gull and Sandwich tern; no evidence of any consistent response by kittiwake, common tern and Arctic tern, evidence of weak attraction 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.

173. Whilst displacement or barrier effects due to operational OWFs could potentially result in the reduction of survival rates (i.e. mortality rate increases) of impacted offshore ornithology receptors, there is no empirical evidence that this has occurred. 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). Modelling of the consequences of displacement suggests that even in the case of breeding seabirds that are displaced on a daily basis, there is likely to be little or no impact on survival unless the OWF causing the effect is 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).

174. 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, as opposed to birds on passage during migratory seasons. Birds that are resident in an area may regularly encounter and be displaced by an OWF, for example during daily commuting trips to foraging areas from nest sites. In this assessment, the effects of displacement and barrier effects on the key resident species are considered together.

175. 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 the site (including seabirds, waders and waterbirds on passage) are considered negligible and these have been scoped out of the assessment.

176. In order to focus the assessment of disturbance and displacement during the operation of DEP and SEP, a screening exercise was undertaken to identify offshore ornithology receptors most likely to be at risk of significant impacts (**Table 13-24**). Any species recorded only in very small numbers and/or infrequently within the estimated ZoI (considered to extend to 4km from DEP and SEP, though actual displacement buffers vary by species), 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. 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.

177. 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). 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.

178. 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 the proposed project. These losses are then placed in the context of the relevant population (e.g. SPA or BDMPS) to determine the magnitude of effect.

Table 13-24: Operational disturbance and displacement screening for DEP and SEP

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

Species	Estimated Sensitivity to Disturbance and Displacement from Operational OWFs	Confidence in Sensitivity Estimate	Relative Frequency in ZoI	Relative Abundance in ZoI	Screening Result
Lesser black-backed gull	Low	High	Medium	Medium	Out
Little gull	Low	Medium	Medium (migrant)	High	In
Long-tailed duck	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	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

13.6.2.1.1 Gannet

179. Although gannets show a low level of sensitivity to ship and helicopter traffic based on much of the literature referred to in **Section 13.6.2.1**, the species is more sensitive to displacement from operational OWFs (Cook et al., 2018; Elston et al., 2016; Gill et al., 2018; Krijgsveld et al., 2011; Rehfisch et al., 2014; Skov et al., 2018; Wade et al., 2016). Locally to DEP and SEP, evidence from the SOW OMP (Harwood et al., 2018) recorded avoidance of the operational OWF by gannet. Operational displacement effects were also detected at the Lincs OWF (Hi Def Aerial Surveying, 2017).

180. Gannet displacement rates from OWFs of 64% to 100% were reported from a review by Cook et al. (2018). Some of the reviewed studies however reported no displacement response of gannets, which is perhaps due to the OWFs in question being situated in areas where low densities of birds were present. 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).

181. 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.

182. 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 (**Table 13-14**) 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 60% to 80% are considered.

183. Mortality rates of displaced birds are assumed to be a maximum of 1%. This value has been selected because gannet is known to possess high habitat flexibility (Furness and Wade, 2012), which suggests that displaced birds will readily find alternative habitats including foraging areas.

184. 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.

13.6.2.1.1.1 Autumn Migration

185. 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 (0.191; **Table 13-16**), the number of gannets expected to die annually that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 87,153 (i.e. 456,298 x 0.191).

13.6.2.1.1.1.1 DEP

186. Gannet mortality during the autumn migration season due to operational phase displacement from DEP is estimated to be 0 to 3 individuals annually, based on a mean peak abundance of 343 birds at the site and 2km buffer, displacement rates of 60% to 80% and a mortality rate of 0% to 1% (**Table 13-25**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%.

Table 13-25: Displacement matrix for gannet at DEP during the autumn migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
Displacement (%)		1	2	3	4	5	10	20	30	50	80	100
	10	0	1	1	1	2	3	7	10	17	27	34
	20	1	1	2	3	3	7	14	21	34	55	69
	30	1	2	3	4	5	10	21	31	51	82	103
	40	1	3	4	5	7	14	27	41	69	110	137
	50	2	3	5	7	9	17	34	51	86	137	172
	60	**2**	4	6	8	10	21	41	62	103	165	206
	70	**2**	5	7	10	12	24	48	72	120	192	240
	80	**3**	5	8	11	14	27	55	82	137	220	274
	90	3	6	9	12	15	31	62	93	154	247	309
	100	3	7	10	14	17	34	69	103	172	274	343

187. The magnitude of 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 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 negative**.

13.6.2.1.1.1.2 SEP

188. At SEP, gannet mortality during the autumn migration season due to operational displacement is estimated to be between 0 to 2 individuals annually, based on a mean peak abundance of 295 birds at the site and 2km buffer, displacement rates of 60% to 80% and a mortality rate of 0% to 1% (**Table 13-26**). Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%.

Table 13-26: Displacement matrix for gannet at SEP during the autumn migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	0	1	1	1	1	3	6	9	15	24	29
	20	1	1	2	2	3	6	12	18	29	47	59
	30	1	2	3	4	4	9	18	27	44	71	88
	40	1	2	4	5	6	12	24	35	59	94	118
	50	1	3	4	6	7	15	29	44	74	118	147
	60	**2**	4	5	7	9	18	35	53	88	141	177
	70	**2**	4	6	8	10	21	41	62	103	165	206
	80	**2**	5	7	9	12	24	47	71	118	188	236
	90	3	5	8	11	13	27	53	80	133	212	265
	100	3	6	9	12	15	29	59	88	147	236	295

189. The magnitude of increase in mortality 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 negative**.

13.6.2.1.1.1.3 DEP and SEP Combined

190. When combined (**Table 13-25** and **Table 13-26**), operational displacement impacts at DEP and SEP during the autumn migration season could result in the mortality of between 0 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 magnitude of 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.

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

13.6.2.1.1.2 Spring Migration

192. 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 ages classes (0.191; **Table 13-16**), the number of gannets expected to die annually that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 47,527 (i.e. 248,835 x 0.191).

13.6.2.1.1.2.1 DEP, SEP, and DEP and SEP Combined

193. Gannet mortality during the spring migration season due to operational phase displacement from DEP (**Table 13-27**) is estimated to be 0 to <1 individual based on a mean peak abundance of 47 birds at the site and 2km buffer, displacement rates of 60% to 80% and a mortality rate of 0% to 1%. At SEP, predicted mortality is zero. For DEP, SEP, and DEP and SEP combined, this increases the annual mortality of the UK North Sea and Channel BDMPS population by <0.01%. This magnitude of increase in mortality is very small and would be undetectable in the context of natural variation. Therefore, during the spring migration season, the magnitude of effect of operational displacement at DEP, SEP, and DEP and SEP combined is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

Table 13-27: Displacement matrix for gannet at DEP during the spring migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	**2**	**3**	**4**	**5**	**10**	**20**	**30**	**50**	**80**	**100**
Displacement (%)	**10**	0	0	0	0	0	0	1	1	2	4	5
	20	0	0	0	0	0	1	2	3	5	7	9
	30	0	0	0	1	1	1	3	4	7	11	14
	40	0	0	1	1	1	2	4	6	9	15	19
	50	0	0	1	1	1	2	5	7	12	19	23
	60	**0**	1	1	1	1	3	6	8	14	22	28
	70	**0**	1	1	1	2	3	7	10	16	26	33
	80	**0**	1	1	1	2	4	7	11	19	30	37
	90	0	1	1	2	2	4	8	13	21	33	42
	100	0	1	1	2	2	5	9	14	23	37	47

13.6.2.1.1.3 Breeding

194. 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 DEP and SEP during this season are breeding adults) (0.088; **Table 13-16**), the number of gannets expected to die annually that are members of the population at the Flamborough and Filey Coast SPA (**Appendix 13.1 Offshore Ornithology Technical Report**) is 2,357 (i.e. 26,784 x 0.088).

13.6.2.1.1.3.1 DEP

195. Gannet mortality during the breeding season due to operational phase displacement from DEP is estimated to be between 0 to 3 individuals based on a mean peak abundance of 361 birds at the site and 2km buffer, displacement rates of 60% to 80% and a mortality rate of 0% to 1% (**Table 13-28**). This increases the annual mortality of the Flamborough and Filey Coast SPA population by 0% to 0.13%. The magnitude of 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.

196. Therefore, during the breeding season, the magnitude of effect of operational displacement at DEP is assessed as negligible. As this species has a medium sensitivity to disturbance, the impact significance is **minor negative**. It is expected that the actual impact may be lower because a proportion of birds present during the breeding season will not be breeding adults from the Flamborough and Filey Coast SPA.

Table 13-28: Displacement matrix for gannet at DEP during the breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	**2**	**3**	**4**	**5**	**10**	**20**	**30**	**50**	**80**	**100**
Displacement (%)	**10**	0	1	1	1	2	4	7	11	18	29	36
	20	1	1	2	3	4	7	14	22	36	58	72
	30	1	2	3	4	5	11	22	32	54	87	108
	40	1	3	4	6	7	14	29	43	72	116	144
	50	2	4	5	7	9	18	36	54	90	144	181
	60	**2**	4	6	9	11	22	43	65	108	173	217
	70	**3**	5	8	10	13	25	51	76	126	202	253
	80	**3**	6	9	12	14	29	58	87	144	231	289
	90	3	6	10	13	16	32	65	97	162	260	325
	100	4	7	11	14	18	36	72	108	181	289	361

13.6.2.1.1.3.2 SEP

197. At SEP, gannet mortality during the breeding season due to operational displacement is estimated to be <1 individual based on the same displacement and mortality rates, and a mean peak abundance of 40 birds at the site and 2km buffer (**Table 13-29**). Adding this impact to existing mortality levels increases the annual mortality of the Flamborough and Filey Coast SPA population by 0.01%. The magnitude of 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.

198. Therefore, during the breeding season, the magnitude of effect of operational displacement at SEP is assessed as negligible. As this species has a medium sensitivity to disturbance, the impact significance is **minor negative**. It is expected that the actual impact may be lower because a proportion of birds present during the breeding season will not be breeding adults from the Flamborough and Filey Coast SPA.

Table 13-29: Displacement matrix for gannet at SEP during the breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	0	0	0	0	0	0	1	1	2	3	4
	20	0	0	0	0	0	1	2	2	4	6	8
	30	0	0	0	0	1	1	2	4	6	10	12
	40	0	0	0	1	1	2	3	5	8	13	16
	50	0	0	1	1	1	2	4	6	10	16	20
	60	**0**	0	1	1	1	2	5	7	12	19	24
	70	**0**	1	1	1	1	3	6	8	14	22	28
	80	**0**	1	1	1	2	3	6	10	16	26	32
	90	0	1	1	1	2	4	7	11	18	29	36
	100	0	1	1	2	2	4	8	12	20	32	40

13.6.2.1.1.3.3 DEP and SEP Combined

199. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 0 to 3 individuals annually during the breeding season, based on a mean peak abundance of 401 birds at the sites and 2km buffers. This represents an increase of between 0% to 0.13% of existing gannet mortality within the Flamborough and Filey Coast SPA population. The magnitude of 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.

200. Therefore, during the breeding season, the magnitude of effect of operational displacement due to DEP and SEP is assessed as negligible. As the species has a medium sensitivity to disturbance, the impact significance is **minor negative**. It is expected that the actual impact may be lower because a proportion of birds present during the breeding season will not be breeding adults from the Flamborough and Filey Coast SPA.

13.6.2.1.1.4 Year Round

201. At the published baseline annual mortality for this species averaged across all age classes (0.191; **Table 1 18**), the number of gannets expected to die from the largest UK North Sea and Channel BDMPS population (the autumn migration season) (**Appendix 13.1 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).

13.6.2.1.1.4.1 DEP, SEP, and DEP and SEP Combined

202. The estimated number of gannets subject to displacement mortality throughout the year due to operational displacement at DEP is between 0 and 6 individuals. For SEP the mortality level is between 0 and 2 individuals, meaning that for both DEP and SEP combined, the total is 0 to 8 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS and biogeographic population mortality rate by <0.01% for DEP, SEP, and DEP and SEP combined. The magnitudes of increase in mortality are very small, would not materially alter the background mortality of the population, and would be undetectable in the context of natural variation.

203. Therefore, the year round magnitude of effect is assessed as negligible. As gannet is of medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2 Auks (Guillemot and Razorbill)

204. In addition to the literature describing the potential sensitivity of guillemot and razorbill to operational displacement by OWFs referred to in **Section 13.6.2.1**, evidence from the SOW OMP (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 Sheringham Shoal 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).

205. A recent review of available evidence for auk displacement (Vattenfall, 2019) concluded that displacement of guillemots and razorbills by OWFs is incomplete and may reduce with habituation. The review also suggested that in the longer term, OWFs may increase food availability through 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. The increase in density of auks outside the OWF will be negligible because the rest of the available habitat is vast. The mortality rate due to displacement may therefore feasibly be 0%, and is highly unlikely to be anywhere near to the 6% or 10% total annual mortality for adult guillemot and razorbill respectively that occurs due to the combination of environmental factors and anthropogenic activities (Horswill and Robinson, 2015). The review suggested that precautionary rates of displacement and mortality of auks from operational OWFs would be 50% and 1% respectively.

206. 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 considered in the two most recent studies using the SeabORD model typically found that in 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 (a total of 2.8GW of OWF deployment), plus the proposed Seagreen Phase 2 project)), adult guillemot and razorbill mortality at three SPA colonies would increase by <1% in the majority of scenarios considered. These OWFs are all situated within the maximum foraging range of guillemot and razorbill that occupy these breeding colonies. This suggests that impacts of displacement and barrier effects for guillemots and razorbills have a very small impact on adult survival, even when tested in scenarios with multiple OWFs situated close to colonies between breeding sites and foraging grounds.

207. 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.

208. 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 13-14**) have been used to produce displacement matrices.

209. Natural England has advised that a range of mortality rates of 1% to 10% and displacement rates of 30% to 70%, should be considered. This guidance is followed by the assessment, however, the available evidence (including that discussed above) suggests that these displacement and mortality rate ranges at the upper end may be excessively precautionary.

13.6.2.1.2.1 Guillemot: Non-breeding

210. 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 (0.140; **Table 13-16**), the number of guillemots expected to die annually from this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 226,423 (i.e. 1,617,306 x 0.140).

13.6.2.1.2.1.1 DEP

211. Guillemot mortality during the non-breeding season due to operational phase displacement from DEP is estimated to be between 24 to 564 individuals annually, based on a mean peak abundance of 8,061 birds at the site and 2km buffer, displacement rates of 30% to 70% and mortality rates of 1% to 10% (**Table 13-30**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.01% to 0.25%.

Table 13-30: Displacement matrix for guillemot at DEP during the non-breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	8	16	24	32	40	81	161	242	403	645	806
	20	16	32	48	64	81	161	322	484	806	1290	1612
	30	**24**	**48**	**73**	**97**	**121**	**242**	484	725	1209	1935	2418
	40	**32**	**64**	**97**	**129**	**161**	**322**	645	967	1612	2580	3224
	50	**40**	**81**	**121**	**161**	**202**	**403**	806	1209	2015	3224	4031
	60	**48**	**97**	**145**	**193**	**242**	**484**	967	1451	2418	3869	4837
	70	**56**	**113**	**169**	**226**	**282**	**564**	1129	1693	2821	4514	5643
	80	64	129	193	258	322	645	1290	1935	3224	5159	6449
	90	73	145	218	290	363	725	1451	2176	3627	5804	7255
	100	81	161	242	322	403	806	1612	2418	4031	6449	8061

212. The predicted magnitude of increase in mortality is 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. This is particularly true of predictions based on displacement and mortality rates at the lower end of the predicted range, which the existing evidence indicates would be expected to be more biologically realistic than the higher rates (Vattenfall, 2019). Therefore, during the non-breeding season, the magnitude of effect of operational phase displacement at DEP individually is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.1.2 SEP

213. At SEP, guillemot mortality during the non-breeding season due to displacement during the operational phase is estimated to be between 2 to 43 individuals annually, based on the same displacement and mortality rates used for DEP, and a mean peak abundance of 610 birds at the site and 2km buffer (**Table 13-31**). Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.00% to 0.02%.

Table 13-31: Displacement matrix for guillemot at SEP during the non-breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	**2**	**3**	**4**	**5**	**10**	**20**	**30**	**50**	**80**	**100**
Displacement (%)	**10**	1	1	2	2	3	6	12	18	31	49	61
	20	1	2	4	5	6	12	24	37	61	98	122
	30	**2**	**4**	**5**	**7**	**9**	**18**	37	55	92	146	183
	40	**2**	**5**	**7**	**10**	**12**	**24**	49	73	122	195	244
	50	**3**	**6**	**9**	**12**	**15**	**31**	61	92	153	244	305
	60	**4**	**7**	**11**	**15**	**18**	**37**	73	110	183	293	366
	70	**4**	**9**	**13**	**17**	**21**	**43**	85	128	214	342	427
	80	5	10	15	20	24	49	98	146	244	390	488
	90	5	11	16	22	27	55	110	165	275	439	549
	100	6	12	18	24	31	61	122	183	305	488	610

214. The predicted magnitude of increase in mortality 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. This is particularly true of predictions based on displacement and mortality rates at the lower end of the predicted range, which the existing evidence indicates would be expected to be more biologically realistic than the higher rates (Vattenfall, 2019). Therefore, during the non-breeding season, the magnitude of effect of operational phase displacement at SEP individually is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.1.3 DEP and SEP Combined

215. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 26 and 607 guillemots annually during the non-breeding season based on a mean peak abundance of 8,671 individuals within the sites and 2km buffers. This represents an increase of between 0.01% to 0.27% of existing annual guillemot mortality within the UK North Sea and Channel BDMPS (226,423 individuals). The predicted magnitude of increase in mortality 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, during the non-breeding season, the magnitude of effect of operational displacement due to DEP and SEP is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.2 Guillemot: Breeding

216. 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 (0.140; **Table 13-16**), the number of guillemots expected to die annually that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 97,362 (i.e. 695,441 x 0.140).

13.6.2.1.2.2.1 DEP

217. Guillemot mortality during the breeding season due to operational phase displacement from DEP is estimated to be between 9 to 210 individuals based on a mean peak abundance of 2,997 birds within the site and 2km buffer, displacement rates of 30% to 70% and mortality rates of 1% to 10% (**Table 13-32**).

218. This increases the annual mortality of the non-breeding component of the North Sea and Channel BDMPS population by 0.01% to 0.22%. The magnitude of increase in mortality is very small and would be undetectable in the context of natural variation, at all displacement and mortality rates.

219. Therefore, during the breeding season, the magnitude of effect of operational displacement at DEP is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, and because a 10% mortality rate is considered unrealistically precautionary the impact significance is **minor negative**.

Table 13-32: Displacement matrix for guillemot at DEP during the breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
Displacement (%)		1	2	3	4	5	10	20	30	50	80	100
	10	3	6	9	12	15	30	60	90	150	240	300
	20	6	12	18	24	30	60	120	180	300	480	599
	30	**9**	**18**	**27**	**36**	**45**	**90**	180	270	450	719	899
	40	**12**	**24**	**36**	**48**	**60**	**120**	240	360	599	959	1199
	50	**15**	**30**	**45**	**60**	**75**	**150**	300	450	749	1199	1499
	60	**18**	**36**	**54**	**72**	**90**	**180**	360	539	899	1439	1798
	70	**21**	**42**	**63**	**84**	**105**	**210**	420	629	1049	1678	2098
	80	24	48	72	96	120	240	480	719	1199	1918	2398
	90	27	54	81	108	135	270	539	809	1349	2158	2697
	100	30	60	90	120	150	300	599	899	1499	2398	2997

13.6.2.1.2.2.2 SEP

220. At SEP, guillemot mortality during the breeding season due to operational displacement is estimated to be between 2 to 42 individuals based on the same displacement and mortality rates as used for DEP, and a mean peak abundance of 599 birds within the site and 2km buffer (**Table 13-33**).

221. Adding this impact to existing mortality levels increases the annual mortality of the non-breeding component of the North Sea and Channel BDMPS population by 0.01% to 0.04%. This magnitude of increase in mortality is very small and would be undetectable in the context of natural variation

222. Therefore, during the breeding season, the magnitude of effect of operational displacement at SEP is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance the impact significance is **minor negative**.

Table 13-33: Displacement matrix for guillemot at SEP during the breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
Displacement (%)		1	2	3	4	5	10	20	30	50	80	100
	10	1	1	2	2	3	6	12	18	30	48	60
	20	1	2	4	5	6	12	24	36	60	96	120
	30	**2**	**4**	**5**	**7**	**9**	**18**	36	54	90	144	180
	40	**2**	**5**	**7**	**10**	**12**	**24**	48	72	120	192	240
	50	**3**	**6**	**9**	**12**	**15**	**30**	60	90	150	240	300
	60	**4**	**7**	**11**	**14**	**18**	**36**	72	108	180	288	359
	70	**4**	**8**	**13**	**17**	**21**	**42**	84	126	210	335	419
	80	5	10	14	19	24	48	96	144	240	383	479
	90	5	11	16	22	27	54	108	162	270	431	539
	100	6	12	18	24	30	60	120	180	300	479	599

13.6.2.1.2.2.3 DEP and SEP Combined

223. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 11 and 252 guillemots annually during the breeding season, based on the displacement and mortality rates used above, and a mean peak abundance of 3,596 birds at the sites and 2km buffers. This represents an increase of between 0.01% to 0.26% of existing guillemot mortality within the non-breeding component of the North Sea and Channel BDMPS population (695,441 individuals). The magnitude of increase in mortality is very small at all levels of displacement and mortality, and would be undetectable in the context of natural variation.

224. Therefore, during the breeding season, the magnitude of effect of operational displacement at DEP and SEP combined is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, and because the upper range of displacement and mortality rates are considered unrealistically precautionary, the impact significance is **minor negative**.

13.6.2.1.2.3 Guillemot: Year Round

225. At the published baseline annual mortality for this species averaged across all age classes (0.140; **Table 13-16**), the number of guillemots expected to die annually that are members of the UK North Sea and Channel BDMPS (**Appendix 13.1 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).

13.6.2.1.2.3.1 DEP

226. The estimated number of guillemots subject to displacement mortality throughout the year due to operational displacement at DEP is between 33 and 774 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS mortality rate by between 0.01% and 0.34%, and the biogeographic population mortality rate by between 0.01% and 0.13%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable in the context of natural variation, particularly since actual displacement and mortality levels will likely be at the lower end of the range included within the assessment (Vattenfall, 2019). Therefore, the year round magnitude of effect is assessed as negligible. As guillemot is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.3.2 SEP

227. The estimated number of guillemots subject to displacement mortality throughout the year due to operational displacement at SEP is between 4 and 85 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS mortality rate by between 0.00% and 0.04%, and the biogeographic population mortality rate by between 0.00% and 0.01%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable in the context of natural variation, particularly since actual displacement and mortality levels will likely be at the lower end of the range included within the assessment (Vattenfall, 2019). Therefore, the year round magnitude of effect is assessed as negligible. As guillemot is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.3.3 DEP and SEP Combined

228. The estimated number of guillemots subject to displacement mortality throughout the year due to operational displacement at DEP and SEP combined is between 37 and 859 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS mortality rate by between 0.02% and 0.38%, and the biogeographic population mortality rate by between 0.01% and 0.15%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable in the context of natural variation, particularly since actual displacement and mortality levels will likely be at the lower end of the range included within the assessment (Vattenfall, 2019). Therefore, the year round magnitude of effect is assessed as negligible. As guillemot is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.4 Razorbill: Autumn Migration

229. 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 baseline annual mortality averaged across all classes (0.174; **Table 13-16**), the number of razorbills expected to die annually from this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 102,986 (i.e. 591,874 x 0.174).

13.6.2.1.2.4.1 DEP

230. Razorbill mortality during the autumn migration season due to operational phase displacement from DEP is estimated to be between 11 to 255 individuals based on a mean peak abundance of 3,649 birds at the site and 2km buffer, displacement rates of 30% to 70% and mortality rates of 1% to 10% (**Table 13-34**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.01% to 0.25%. This magnitude of increase in mortality is very small and would be undetectable in the context of natural variation.

Table 13-34: Displacement matrix for razorbill at DEP during the autumn migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	4	7	11	15	18	36	73	109	182	292	365
	20	7	15	22	29	36	73	146	219	365	584	730
	30	**11**	**22**	**33**	**44**	**55**	**109**	219	328	547	876	1095
	40	**15**	**29**	**44**	**58**	**73**	**146**	292	438	730	1168	1460
	50	**18**	**36**	**55**	**73**	**91**	**182**	365	547	912	1460	1825
	60	**22**	**44**	**66**	**88**	**109**	**219**	438	657	1095	1752	2189
	70	**26**	**51**	**77**	**102**	**128**	**255**	511	766	1277	2043	2554
	80	29	58	88	117	146	292	584	876	1460	2335	2919
	90	33	66	99	131	164	328	657	985	1642	2627	3284
	100	36	73	109	146	182	365	730	1095	1825	2919	3649

231. Therefore, during the autumn migration season, the magnitude of effect of operational displacement at DEP individually on razorbill is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.4.2 SEP

232. At SEP, razorbill mortality during the autumn migration season due to operational displacement is estimated to be between 2 to 45 individuals based on the same displacement and mortality rates used for DEP, and a mean peak abundance of 646 birds at the site and 2km buffer (**Table 13-35**). Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea and Channel BDMPS population by 0% to 0.04%.

Table 13-35: Displacement matrix for razorbill at SEP during the autumn migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	1	1	2	3	3	6	13	19	32	52	65
	20	1	3	4	5	6	13	26	39	65	103	129
	30	**2**	**4**	**6**	**8**	**10**	**19**	39	58	97	155	194
	40	**3**	**5**	**8**	**10**	**13**	**26**	52	78	129	207	258
	50	**3**	**6**	**10**	**13**	**16**	**32**	65	97	162	258	323
	60	**4**	**8**	**12**	**16**	**19**	**39**	78	116	194	310	388
	70	**5**	**9**	**14**	**18**	**23**	**45**	90	136	226	362	452
	80	5	10	16	21	26	52	103	155	258	413	517
	90	6	12	17	23	29	58	116	174	291	465	581
	100	6	13	19	26	32	65	129	194	323	517	646

233. The predicted magnitude of increase in mortality for razorbill of the wider BDMPS is very small, would not materially alter the background mortality of the population, and would be undetectable in the context of natural variation. Therefore, during the autumn migration season, the magnitude of effect of operational displacement at SEP individually is assessed as negligible. As razorbill is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.4.3 DEP and SEP Combined

234. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 13 and 300 razorbills annually during the autumn migration season based on a mean peak abundance of 3,930 birds at the sites and 2km buffers. This represents an increase of between 0.01% to 0.29% of existing annual razorbill mortality within the UK North Sea and Channel BDMPS (102,986 individuals); a very small increase in predicted annually mortality within the wider population that would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement due to DEP and SEP is assessed as negligible. As the species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.5 Razorbill: Winter

235. 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 baseline annual mortality averaged across all classes (0.174; **Table 13-16**), the number of razorbills expected to die annually from this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 38,040 (i.e. 218,622 x 0.174).

13.6.2.1.2.5.1 DEP

236. Razorbill mortality during the winter season due to operational phase displacement from DEP is estimated to be between 2 to 50 individuals based on a mean peak abundance of 720 birds at the site and 2km buffer, displacement rates of 30% to 70% and mortality rates of 1% to 10% (**Table 13-36**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0% to 0.13%.

Table 13-36: Displacement matrix for razorbill at DEP during the winter season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	1	1	2	3	4	7	14	22	36	58	72
	20	1	3	4	6	7	14	29	43	72	115	144
	30	2	4	6	9	11	22	43	65	108	173	216
	40	3	6	9	12	14	29	58	86	144	230	288
	50	4	7	11	14	18	36	72	108	180	288	360
	60	4	9	13	17	22	43	86	130	216	346	432
	70	5	10	15	20	25	50	101	151	252	403	504
	80	6	12	17	23	29	58	115	173	288	461	576
	90	6	13	19	26	32	65	130	194	324	518	648
	100	7	14	22	29	36	72	144	216	360	576	720

237. The magnitude of increase in mortality within the wider razorbill population due to operational displacement impacts at DEP individually is very small, would not materially alter the background mortality of the population, and would be undetectable in the context of natural variation. The magnitude of effect of operational displacement at DEP is therefore assessed as negligible. As razorbill is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.5.2 SEP

238. At SEP, razorbill mortality during the winter season due to operational displacement is estimated to be between 2 to 41 individuals based on the same displacement and mortality rates (**Table 13-37**), and a peak mean abundance of 590 birds at the site and 2km buffer. Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea and Channel BDMPS population by 0% to 0.11%.

Table 13-37: Displacement matrix for razorbill at SEP during the winter season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	1	1	2	2	3	6	12	18	30	47	59
	20	1	2	4	5	6	12	24	35	59	94	118
	30	2	4	5	7	9	18	35	53	89	142	177
	40	2	5	7	9	12	24	47	71	118	189	236
	50	3	6	9	12	15	30	59	89	148	236	295
	60	4	7	11	14	18	35	71	106	177	283	354
	70	4	8	12	17	21	41	83	124	207	330	413
	80	5	9	14	19	24	47	94	142	236	378	472
	90	5	11	16	21	27	53	106	159	266	425	531
	100	6	12	18	24	30	59	118	177	295	472	590

239. The magnitude of increase in mortality within the wider razorbill population due to operational displacement impacts at SEP individually is very small, would not materially alter the background mortality of the population, and would be undetectable in the context of natural variation. The magnitude of effect of operational displacement at SEP is therefore assessed as negligible. As razorbill is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.5.3 DEP and SEP Combined

240. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 4 and 91 razorbills annually during the winter season, based on a peak mean abundance of 1,310 birds across both sites and 2km buffers. This represents an increase of between 0% to 0.24% of existing annual razorbill mortality within the UK North Sea and Channel BDMPS; a very small increase which would not materially affect the mortality rate, and would be undetectable in the context of natural variation. Therefore, the magnitude of effect of operational displacement of razorbill during the winter season due to DEP and SEP is assessed as negligible. As the species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.6 Razorbill: Spring Migration

241. 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 baseline annual mortality averaged across all classes (0.174; **Table 13-16**), the number of razorbills expected to die annually from this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 102,986 (i.e. 591,874 x 0.174).

13.6.2.1.2.6.1 DEP

242. Razorbill mortality during the spring migration season due to operational phase displacement from DEP is estimated to be between 1 to 19 individuals based on a mean peak abundance of 272 birds at the site and 2km buffer, displacement rates of 30% to 70% and mortality rates of 1% to 10% (**Table 13-38**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0% to 0.02%.

Table 13-38: Displacement matrix for razorbill at DEP during the spring migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
Displacement (%)		1	2	3	4	5	10	20	30	50	80	100
	10	0	1	1	1	1	3	5	8	14	22	27
	20	1	1	2	2	3	5	11	16	27	44	54
	30	1	2	2	3	4	8	16	24	41	65	82
	40	1	2	3	4	5	11	22	33	54	87	109
	50	1	3	4	5	7	14	27	41	68	109	136
	60	2	3	5	7	8	16	33	49	82	131	163
	70	2	4	6	8	10	19	38	57	95	152	190
	80	2	4	7	9	11	22	44	65	109	174	218
	90	2	5	7	10	12	24	49	73	122	196	245
	100	3	5	8	11	14	27	54	82	136	218	272

243. The magnitude of increase in mortality within the wider razorbill population due to operational displacement impacts at DEP individually is very small, would have no material effect on the mortality rate, and would be undetectable in the context of natural variation. Therefore, during the spring migration season, the magnitude of effect of operational displacement at DEP is assessed as negligible. As razorbill is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.6.2 SEP

244. At SEP, razorbill mortality during the spring migration season due to operational displacement is estimated to be between 0 to 10 individuals based on the same displacement and mortality rates as DEP (**Table 13-39**), and a mean peak abundance of 148 birds at the site and 2km buffer. Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea and Channel BDMPS population by 0% to 0.01%.

Table 13-39: Displacement matrix for razorbill at SEP during the spring migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
Displacement (%)		1	2	3	4	5	10	20	30	50	80	100
	10	0	0	0	1	1	1	3	4	7	12	15
	20	0	1	1	1	1	3	6	9	15	24	30
	30	**0**	**1**	**1**	**2**	**2**	**4**	9	13	22	36	44
	40	**1**	**1**	**2**	**2**	**3**	**6**	12	18	30	47	59
	50	**1**	**1**	**2**	**3**	**4**	**7**	15	22	37	59	74
	60	**1**	**2**	**3**	**4**	**4**	**9**	18	27	44	71	89
	70	**1**	**2**	**3**	**4**	**5**	**10**	21	31	52	83	104
	80	1	2	4	5	6	12	24	36	59	95	118
	90	1	3	4	5	7	13	27	40	67	107	133
	100	1	3	4	6	7	15	30	44	74	118	148

245. The magnitude of increase in mortality within the wider razorbill population due to operational displacement impacts at SEP individually is very small, would have no material effect on the mortality rate, and would be undetectable in the context of natural variation. Therefore the magnitude of effect of operational displacement at SEP is assessed as negligible. As razorbill is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.6.3 DEP and SEP Combined

246. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 1 and 29 razorbills annually during the spring migration season, based on a mean peak abundance of 420 birds across both sites and 2km buffers. This represents an increase of between 0% to 0.03% of existing annual razorbill mortality within the UK North Sea and Channel BDMPS.

247. This is a very small increase in mortality rates within the wider population which represents an immaterial change that would be undetectable in the context of natural variation. Therefore, during the spring migration season, the magnitude of effect of operational displacement due to DEP and SEP is assessed as negligible. As razorbill is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.7 Razorbill: Breeding

248. The non-breeding component of the winter UK North Sea and Channel BDMPS is considered to be the relevant razorbill background population for the breeding season. At the published baseline annual mortality for all age classes of razorbill (0.174; **Table 13-16**), the number of razorbills expected to die in the breeding season that are members of the non-breeding component of the winter UK North Sea and Channel BDMPS (**Appendix 13.1 Offshore Ornithology Technical Report**) is 38,040 (i.e. 218,622 x 0.174).

13.6.2.1.2.7.1 DEP

249. Razorbill mortality during the breeding season due to operational phase displacement from DEP is estimated to be between 2 to 58 individuals based on a mean peak abundance of 824 birds at the site and 2km buffer, displacement rates of 30% to 70% and mortality rates of 1% to 10% (**Table 13-40**). This increases the annual mortality of the non-breeding component of the UK North Sea and Channel BDMPS population by 0.01% to 0.15%. This is a very small increase in mortality rates within the wider population which represents an immaterial change that would be undetectable in the context of natural variation.

Table 13-40: Displacement matrix for razorbill at DEP during the breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	**2**	**3**	**4**	**5**	**10**	**20**	**30**	**50**	**80**	**100**
Displacement (%)	**10**	1	2	2	3	4	8	16	25	41	66	82
	20	2	3	5	7	8	16	33	49	82	132	165
	30	**2**	**5**	**7**	**10**	**12**	**25**	49	74	124	198	247
	40	**3**	**7**	**10**	**13**	**16**	**33**	66	99	165	264	330
	50	**4**	**8**	**12**	**16**	**21**	**41**	82	124	206	330	412
	60	**5**	**10**	**15**	**20**	**25**	**49**	99	148	247	396	494
	70	**6**	**12**	**17**	**23**	**29**	**58**	115	173	288	461	577
	80	7	13	20	26	33	66	132	198	330	527	659
	90	7	15	22	30	37	74	148	222	371	593	742
	100	8	16	25	33	41	82	165	247	412	659	824

250. Therefore, during the breeding season, the magnitude of effect of operational displacement at DEP individually for razorbill is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.7.2 SEP

251. At SEP, razorbill mortality during the breeding season due to operational displacement is estimated to be between 1 to 17 individuals based on the same displacement and mortality rates (**Table 13-41**), and a mean peak abundance of 240 birds within the site and 2km buffer. Adding this impact to existing mortality levels increases the annual mortality of the non-breeding component of the UK North Sea and Channel BDMPS population by 0.01% to 0.04%.

Table 13-41: Displacement matrix for razorbill at SEP during the breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

Displacement (%)	Mortality (%) 1	2	3	4	5	10	20	30	50	80	100
10	0	0	1	1	1	2	5	7	12	19	24
20	0	1	1	2	2	5	10	14	24	38	48
30	1	1	2	3	4	7	14	22	36	58	72
40	1	2	3	4	5	10	19	29	48	77	96
50	1	2	4	5	6	12	24	36	60	96	120
60	1	3	4	6	7	14	29	43	72	115	144
70	2	3	5	7	8	17	34	50	84	134	168
80	2	4	6	8	10	19	38	58	96	154	192
90	2	4	6	9	11	22	43	65	108	173	216
100	2	5	7	10	12	24	48	72	120	192	240

252. The predicted magnitude of increase in mortality due to operational displacement at SEP is very small and would be undetectable in the context of natural variation.

253. Therefore, during the breeding season, the magnitude of effect of operational displacement at SEP individually for razorbill is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.7.3 DEP and SEP Combined

254. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 3 and 75 razorbills annually during the breeding season, based on a mean peak abundance of 1,064 birds within the sites and 2km buffers, 30% to 70% displacement, and 1% to 10% mortality. This represents an increase of between 0.01% to 0.20% of existing razorbill mortality within the non-breeding component of the UK North Sea and Channel BDMPS population. The magnitude of increase in existing mortality is very small and would be undetectable in the context of natural variation.

255. Therefore, during the breeding season, the magnitude of effect of operational displacement at DEP is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.8 Razorbill: Year Round

256. At the published baseline annual mortality for this species (0.174; **Table 1 18**), the number of razorbills expected to die from the largest UK North Sea and Channel BDMPS population (the spring and autumn migration seasons) (**Appendix 13.1 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).

13.6.2.1.2.8.1 DEP

257. The estimated number of razorbills subject to displacement mortality throughout the year due to operational displacement at DEP is between 16 and 382 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS mortality rate by between 0.02% and 0.37%, and the biogeographic population mortality rate by between 0.01% and 0.13%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. The year round magnitude of effect is therefore assessed as negligible. As the species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.8.2 SEP

258. The estimated number of razorbills subject to displacement mortality throughout the year due to operational displacement at SEP is between 6 and 138 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS mortality rate by between 0.01% and 0.13%, and the biogeographic population mortality rate by between 0.00% and 0.05%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the year round magnitude of effect is assessed as negligible, and as the species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.2.8.3 DEP and SEP Combined

259. The estimated number of razorbills subject to displacement mortality throughout the year due to operational displacement at DEP and SEP combined is between 22 and 520 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS mortality rate by between 0.02% and 0.50%, and the biogeographic population mortality rate by between 0.01% and 0.18%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the year round magnitude of effect is assessed as negligible, and as the species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.3 Little gull

260. Whilst relatively insensitive to a range of anthropogenic activities in the marine environment (Fliessbach et al., 2019; Furness and Wade, 2012; Garthe and Hüppop, 2004), little gull is considered moderately susceptible to displacement by operational OWFs. Dierschke et al. (2016) classified them as a species that weakly avoids OWFs.

261. At the Thorntonbank OWF in Belgian waters, little gull showed a significant displacement response (87% displacement) in a Before After Control Impact (BACI) analysis that included the OWF and a 0.5km buffer (Vanermen et al., 2016). Whilst the same study noted no statistically significant displacement at the Bligh Bank OWF, the data suggested a displacement response might have occurred. Previously, Leopold et al. (2013) found that little gulls avoided the Princess Amalia OWF, but the same study found no evidence of avoidance at the Egmond Aan Zee OWF.

262. Operational phase monitoring information was available for two OWFs in the Greater Wash area. Evidence from the SOW OMP (Harwood et al., 2018) indicates that avoidance of the OWF by little gull occurred during operation according to some, but not all analyses, with the authors suggesting that displacement effects were confined to the OWF itself. Whilst no statistically significant operational displacement effects were detected for little gull at the LID/Lincs OWFs (Hi Def Aerial Surveying, 2017), some evidence of decreased abundance within operational OWFs was reported.

263. Assessments of operational OWF displacement suggest that effects on little gull, when they do occur, seem to be restricted to the OWF itself. In addition, effects seem challenging to detect with any degree of certainty. Little gull is a species that is not present for the vast majority of the year, occurring exclusively during migration, which can present difficulties in identifying operational displacement effects. This also means that as a passage species in the Greater Wash area, it is unlikely that displacement effects due to an operational OWF are likely to be as significant as would be the case for a resident species (**Section 13.6.2.1**).

264. Based on the information identified by the literature review, little gull is considered to possess a low sensitivity to disturbance and displacement from operational OWFs. Confidence in this level of sensitivity is considered to be moderate. The applicability and quality of data sources is considered to be high, but concordance is lower.

265. Based on the available evidence, abundance estimates for little gull for DEP and its 2km buffer, and SEP and its 2km buffer, for the relevant biological periods (**Table 13-14**) have been used to produce individual displacement matrices. This is considered highly precautionary. There is little empirical evidence to base displacement rates on, so a range of 30% to 100% is considered.

266. Mortality rates of displaced birds are assumed to be a maximum of 1%. This value has been selected for two reasons. Firstly, little gull are present in the Greater Wash area for a short period of time each year, which means that the potential for mortality due to displacement is considered to be low. Secondly, little gull is moderately flexible with respect to habitat (Furness and Wade, 2012), which suggests that displaced birds will readily find alternative habitats including foraging areas. This is particularly true for birds at DEP and SEP, which are situated in close proximity to the Greater Wash SPA, which contains areas within which little gull have previously been recorded at substantially higher densities than DEP, SEP, or their surrounding buffers. It is assumed that a large amount of alternative habitat exists within this SPA for displaced birds to utilise.

13.6.2.1.3.1 Non-breeding

267. The North Sea flyway population is considered to the relevant background population for this species on which impacts are based. At the published baseline average annual mortality for this species for all age classes (0.200; **Table 13-16**), the number of little gulls expected to die annually that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 15,000 (i.e. 75,000 x 0.200).

13.6.2.1.3.1.1 DEP

268. Little gull mortality during the non-breeding season due to operational phase displacement from DEP is estimated to be between 0 to 7 individuals annually, based on mean peak abundance within the site and 2km buffer, displacement rates of 30% to 100% and a mortality rate of 0% to 1% (**Table 13-42**). This increases the annual mortality of the North Sea flyway population by 0% to 0.05%. It is likely that this increase in the mortality rate would not materially alter the background mortality of the population and would be undetectable in the context of natural variation.

269. The magnitude of effect of operational displacement at DEP on little gull is therefore assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

Table 13-42: Displacement matrix for little gull at DEP during the non-breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	**2**	**3**	**4**	**5**	**10**	**20**	**30**	**50**	**80**	**100**
Displacement (%)	**10**	1	1	2	3	4	7	15	22	37	59	74
	20	1	3	4	6	7	15	30	45	74	119	148
	30	**2**	4	7	9	11	22	45	67	111	178	223
	40	**3**	6	9	12	15	30	59	89	148	237	297
	50	**4**	7	11	15	19	37	74	111	186	297	371
	60	**4**	9	13	18	22	45	89	134	223	356	445
	70	**5**	10	16	21	26	52	104	156	260	416	519
	80	**6**	12	18	24	30	59	119	178	297	475	594
	90	**7**	13	20	27	33	67	134	200	334	534	668
	100	**7**	15	22	30	37	74	148	223	371	594	742

13.6.2.1.3.1.2 SEP

270. At SEP, little gull mortality during the non-breeding season due to operational displacement is estimated to be between 0 to 1 individuals annually, based on the same displacement and mortality rates used for DEP (**Table 13-43**), and a mean peak abundance of 103 birds within the site and 2km buffer. Adding this impact to existing mortality levels increases the annual mortality of the North Sea flyway population by up to 0.01%. It is likely that this increase in the mortality rate would not materially alter the background mortality of the population and would be undetectable in the context of natural variation.

271. During the non-breeding season, the magnitude of effect of operational displacement at SEP is therefore assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

Table 13-43: Displacement matrix for little gull at SEP during the non-breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	**2**	**3**	**4**	**5**	**10**	**20**	**30**	**50**	**80**	**100**
Di spl ac em	**10**	0	0	0	0	1	1	2	3	5	8	10

	20	0	0	1	1	1	2	4	6	10	16	21
	30	0	1	1	1	2	3	6	9	15	25	31
	40	0	1	1	2	2	4	8	12	21	33	41
	50	1	1	2	2	3	5	10	15	26	41	51
	60	1	1	2	2	3	6	12	18	31	49	62
	70	1	1	2	3	4	7	14	22	36	57	72
	80	1	2	2	3	4	8	16	25	41	66	82
	90	1	2	3	4	5	9	18	28	46	74	92
	100	1	2	3	4	5	10	21	31	51	82	103

13.6.2.1.3.1.3 DEP and SEP Combined

272. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 0 and 8 non-breeding little gulls annually, based on a mean peak abundance of 845 birds within both sites and 2km buffers. This represents an increase of between 0% to 0.05% of existing annual little gull mortality within the North Sea flyway population of 75,000 birds. It is likely that this increase in the mortality rate would not materially alter the background mortality of the population and would be undetectable in the context of natural variation.

273. The magnitude of effect of operational displacement on little gull due to DEP and SEP combined is therefore assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.4 Red-throated diver

274. Red-throated divers have a very high general sensitivity to disturbance and displacement and commonly avoid disturbed areas such as shipping lanes, as well as 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 1.6.2.1,** 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; McGovern et al., 2016; Mendel et al., 2019; NIRAS Consulting, 2016; Percival, 2014; Percival and Ford, 2017; Petersen et al., 2014, 2006; Vilela et al., 2020; Welcker and Nehls, 2016). These sources have been considered during the preparation of this assessment.

275. 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 themselves. The majority of birds present before OWFs are constructed are displaced by the construction and operation of OWFs. It is expected (based on expert opinion), that this is due to a combination of anthropogenic activities (mainly vessel-based), as well as the presence of OWF infrastructure, of which the latter is considered to exert a greater effect. There is evidence from a minority of studies that indicates habituation could occur, but as a general rule (again 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) assessed some evidence suggesting that seabirds may habituate to OWFs over time.

276. 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 and makes the application of a single displacement distance across all OWFs problematic. Studies within the UK have ranged from no significant displacement effects being reported (McGovern et al., 2016), displacement effects being restricted to 1-2km of an the OWF (NIRAS Consulting, 2016; Percival, 2014; Percival and Ford, 2017), to clear displacement effects across many years, extending up to 9km from OWFs (Elston et al., 2016; Hi Def Aerial Surveying, 2017). Studies from other countries have also recorded variable displacement distances, ranging from 1.5-2km (Welcker and Nehls, 2016) to 10km and beyond (Dorsch et al., 2020; Vilela et al., 2020), with displacement effects being detectable up to 20km from OWFs in one case.

277. 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 lessens, until a distance is reached at which the effect is no longer detectable.

278. 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), though 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 be part of their existing non-breeding season range.

279. 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.

280. 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), with the aim to obtain the evidence required to make this assessment. 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.

281. 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.

282. Natural England has previously advised other OWF projects that for the assessment of red-throated diver operational displacement, a displacement rate of 100% within the OWF and 4km buffer and a mortality rate of up to 10% for displaced birds is used. The assessment below follows this advice.

283. Macarthur Green (2019) recommended a precautionary rate of 90% 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 0.228 (Horswill and Robinson (2015), **Table 13-16**); 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.

284. In addition, data from Lawson et al. (2016) and Bradbury (2014) has been assessed to provide an indication of the numbers of birds that could be displaced at distances beyond 4km from the OWF; notably within the Greater Wash SPA.

13.6.2.1.4.1 Assessment of Baseline Data

13.6.2.1.4.1.1 Autumn Migration

285. The UK North Sea and Channel 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 (0.228; **Table 13-16**), the number of red-throated divers expected to die annually that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 3,027 (i.e. 13,277 x 0.228).

13.6.2.1.4.1.1.1 DEP

286. Red-throated diver mortality during the autumn migration season due to operational phase displacement from DEP is estimated to be 1 to 6 individuals based on a mean peak abundance of 55 birds within the site and 4km buffer, a displacement rate of 100% and a mortality rate of 1% to 10% (**Table 13-44**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.02% to 0.18%.

Table 13-44: Displacement matrix for red-throated diver at DEP during the autumn migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	0	0	0	0	0	1	1	2	3	4	6
	20	0	0	0	0	1	1	2	3	6	9	11
	30	0	0	0	1	1	2	3	5	8	13	17
	40	0	0	1	1	1	2	4	7	11	18	22
	50	0	1	1	1	1	3	6	8	14	22	28
	60	0	1	1	1	2	3	7	10	17	26	33
	70	0	1	1	2	2	4	8	12	19	31	39
	80	0	1	1	2	2	4	9	13	22	35	44
	90	0	1	1	2	2	5	10	15	25	40	50
	100	**1**	**1**	**2**	**2**	**3**	**6**	11	17	28	44	55

287. The magnitude of increase in red-throated diver mortality due to operational displacement from DEP, when compared with predicted wider background mortality of the UK North Sea and Channel BDMPS population, is very small, would not result in material changes to the existing mortality of this population, and would be undetectable in the context of natural variation.

288. During the autumn migration season, the magnitude of effect of operational displacement at DEP individually is therefore assessed as negligible. As red-throated diver is considered to possess a high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.4.1.1.2 SEP

289. At SEP, red-throated diver mortality during the autumn migration season due to operational displacement is estimated to be between 1 to 8 individuals based on the same displacement and mortality rates (**Table 13-45**), and a mean peak abundance of 75 birds within the site and 4km buffer. Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.04% to 0.25%.

Table 13-45: Displacement matrix for red-throated diver at SEP during the autumn migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
Displacement (%)		1	2	3	4	5	10	20	30	50	80	100
	10	0	0	0	0	0	1	2	2	4	6	8
	20	0	0	0	1	1	2	3	5	8	12	15
	30	0	0	1	1	1	2	5	7	11	18	23
	40	0	1	1	1	2	3	6	9	15	24	30
	50	0	1	1	2	2	4	8	11	19	30	38
	60	0	1	1	2	2	5	9	14	23	36	45
	70	1	1	2	2	3	5	11	16	26	42	53
	80	1	1	2	2	3	6	12	18	30	48	60
	90	1	1	2	3	3	7	14	20	34	54	68
	100	**1**	**2**	**2**	**3**	**4**	**8**	15	23	38	60	75

290. The magnitude of increase in red-throated diver mortality due to operational displacement at SEP, when compared with predicted wider background mortality of the UK North Sea and Channel BDMPS population, is very small, would not result in material changes to the existing mortality of this population, and would be undetectable in the context of natural variation.

291. During the autumn migration season, the magnitude of effect of operational displacement at SEP individually is therefore assessed as negligible. As red-throated diver is considered to possess a high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.4.1.1.3 DEP and SEP Combined

292. When combined, operational displacement impacts on red-throated divers at DEP and SEP during the autumn migration season could result in the mortality of between 2 and 14 red-throated divers annually. This represents an increase of 0.07% to 0.46% of existing annual red-throated diver mortality within the UK North Sea and Channel BDMPS, which is such a small increase it will have no material effect on existing mortality, and would be undetectable in the context of natural variation. Therefore, the magnitude of effect is assessed as negligible. As this species is considered to possess a high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.4.1.2 Winter

293. 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 (0.228; **Table 13-16**), the number of red-throated divers expected to die that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 2,320 (i.e. 10,177 x 0.228).

13.6.2.1.4.1.2.1 DEP, SEP, and DEP and SEP Combined

294. Red-throated diver mortality during the winter season due to operational phase displacement from DEP is estimated to be between 0 to 1 individuals based on a mean peak abundance of 10 birds within the site and 4km buffer, a displacement rate of 100% and mortality rates of 1% to 10% (**Table 13-46**). This increases the annual mortality of the SW North Sea BDMPS population by 0% to 0.04%. At SEP, predicted red-throated diver mortality during the winter season due to operational displacement is estimated to be identical.

Table 13-46: Displacement matrix for red-throated diver at DEP and SEP individually (i.e. not combined) during the winter season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

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

295. This magnitude of increase in predicted annual mortality of the wider population is very small, would not materially increase the background mortality in the wider population, and would be undetectable in the context of natural variation for DEP and SEP individually. Therefore, the magnitude of effect of operational displacement at DEP and SEP individually on red-throated diver during the winter season is assessed as negligible. As this species is considered to possess a high sensitivity to disturbance, the impact significance is **minor negative**.

296. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 0 and 2 red-throated divers annually during the winter season based on a mean peak abundance of 20 birds across both sites and 4km buffers. This represents an increase of between 0% to 0.08% of existing annual red-throated diver mortality within the SW North Sea BDMPS, which is a very small and undetectable increase that will not materially impact the existing mortality rate of the background population.

297. During the winter season, the magnitude of effect of operational displacement due to DEP and SEP is therefore assessed as negligible. As red-throated diver is considered to possess a high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.4.1.3 Spring Migration

298. The UK North Sea and Channel 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 (0.228; **Table 13-16**), the number of red-throated divers expected to die annually that are members of this population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 3,027 (i.e. 13,277 x 0.228).

13.6.2.1.4.1.3.1 DEP

299. Red-throated diver mortality during the spring migration season due to operational phase displacement from DEP is estimated to be 1 to 5 individuals based on a mean peak abundance of 51 birds at the site and 4km buffer, a displacement rate of 100% and a mortality rate of 1% to 10% (**Table 13-47**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.02% to 0.17%.

Table 13-47: Displacement matrix for red-throated diver at DEP during the spring migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	0	0	0	0	0	1	1	2	3	4	5
	20	0	0	0	0	1	1	2	3	5	8	10
	30	0	0	0	1	1	2	3	5	8	12	15
	40	0	0	1	1	1	2	4	6	10	16	20
	50	0	1	1	1	1	3	5	8	13	20	26
	60	0	1	1	1	2	3	6	9	15	24	31
	70	0	1	1	1	2	4	7	11	18	29	36
	80	0	1	1	2	2	4	8	12	20	33	41
	90	0	1	1	2	2	5	9	14	23	37	46
	100	**1**	**1**	**2**	**2**	**3**	**5**	10	15	26	41	51

300. When considered individually, the predicted magnitude of increase in mortality of the UK North Sea and Channel BDMPS population due to operational displacement from DEP during this season is small, would not result in material changes to the existing mortality of this population and would be undetectable in the context of natural variation.

301. Therefore, during the spring migration season, the magnitude of effect of operational displacement at DEP individually 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 negative**.

13.6.2.1.4.1.3.2 SEP

302. At SEP, red-throated diver mortality during the spring migration season due to operational displacement is estimated to be between 1 to 12 individuals based on the same displacement and mortality rates (**Table 13-48**), and a mean peak abundance of 117 birds at the site and 4km buffer. Adding this impact to existing mortality levels increases the annual mortality of the UK North Sea and Channel BDMPS population by 0.04% to 0.39%.

Table 13-48: Displacement matrix for red-throated diver at SEP during the spring migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	0	0	0	0	1	1	2	4	6	9	12
	20	0	0	1	1	1	2	5	7	12	19	23
	30	0	1	1	1	2	4	7	11	18	28	35
	40	0	1	1	2	2	5	9	14	23	38	47
	50	1	1	2	2	3	6	12	18	29	47	59
	60	1	1	2	3	4	7	14	21	35	56	70
	70	1	2	2	3	4	8	16	25	41	66	82
	80	1	2	3	4	5	9	19	28	47	75	94
	90	1	2	3	4	5	11	21	32	53	84	106
	100	1	2	4	5	6	12	23	35	59	94	117

303. When considered individually, the predicted magnitude of increase in mortality of the UK North Sea and Channel BDMPS population due to operational displacement from SEP during this season is small, would not result in material changes to the existing mortality of this population and would be undetectable in the context of natural variation.

304. During the spring migration season, the magnitude of effect of operational displacement at SEP individually on red-throated diver is therefore assessed as negligible. As this species is considered to possess a high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.4.1.3.3 DEP and SEP Combined

305. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 2 and 17 red-throated divers annually during the autumn migration season, based on a mean peak abundance of 168 birds across both sites and 4km buffers. This represents an increase of 0.07% to 0.56% of existing red-throated diver mortality within the UK North Sea and Channel BDMPS. This increase in the predicted mortality of the wider BDMPS is small, and would be undetectable in the context of natural variation.

306. Therefore, during the spring migration season, the magnitude of effect of operational displacement due to DEP and SEP combined on red-throated diver is assessed as negligible. As the species is considered to possess a high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.4.1.4 Year Round

307. At the published baseline annual mortality for this species averaged across all age classes (0.228; **Table 13-16**), 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 13.1 Offshore Ornithology Technical Report**) is 3,027 (i.e. 13,277 x 0.228). The biogeographic population of red-throated diver 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).

13.6.2.1.4.1.4.1 DEP

308. The estimated number of red-throated divers subject to displacement mortality throughout the year due to operational displacement at DEP is between 2 and 12 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS mortality rate by between 0.07% and 0.39%, and the biogeographic population mortality rate by between 0.03% and 0.19%.

309. When DEP is considered individually, these predicted magnitudes of increase in the annual mortality of the wider populations considered would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the year round magnitude of effect of operational displacement on red-throated diver is assessed as negligible. As the species is considered to possess a high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.4.1.4.2 SEP

310. The estimated number of red-throated divers subject to displacement mortality throughout the year due to operational displacement at SEP is between 2 and 21 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS mortality rate by between 0.07% and 0.69%, and the biogeographic population mortality rate by between 0.03% and 0.34%.

311. When SEP is considered individually, these predicted magnitudes of increase in the annual mortality of these wider populations would not materially alter the background mortality of the population and would be undetectable in the context of natural variation. Therefore, the year round magnitude of effect of operational displacement on red-throated diver is assessed as negligible for SEP individually. As the species is considered to be of high sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.4.1.4.3 DEP and SEP Combined

312. The estimated number of red-throated diver subject to displacement mortality throughout the year due to operational displacement at DEP and SEP combined is between 4 and 33 individuals. The addition of the maximum displacement mortality to existing levels of mortality this increases the UK North Sea and Channel BDMPS mortality rate by between 0.13% and 1.08%, and the biogeographic population mortality rate by between 0.06% and 0.53%.

313. These magnitudes of increase in the annual mortality of the wider population would not materially alter the wider BDMPS population and would be undetectable in the context of natural variation.

314. Therefore, the year round magnitude of effect on red-throated diver of operational displacement at DEP and SEP combined is assessed as low. As the species is of high sensitivity to disturbance, the impact significance is moderate according to the methodology presented in **Section 13.4.3**. However, this is revised to **minor** on the basis of the literature on red-throated diver displacement effects covered in **Section 13.6.2.1.3** (i.e. it is considered that population effects at the BDMPS level are highly unlikely due to a lack of evidence of mortality due to the displacement).

13.6.2.1.4.2 Assessment of Other Data Sources

315. Red-throated diver displacement has been shown to occur beyond 4km from OWF boundaries, meaning that the baseline survey data cannot be used to evaluate the potential for such effects as this is the limit of its spatial extent.

316. Red-throated diver distribution within 12km of DEP and SEP, and potential impacts out to this distance from each OWF, has therefore been investigated by assessment of DSMs 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 DEP and SEP was not completely covered by the DSM of Lawson et al. (2016). This dataset was therefore excluded from further analysis.

317. Bradbury et al. (2014) presents a wide range of DSMs. 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; it was not possible to subdivide this dataset further into smaller seasons. Further details of the models produced are available in Bradbury et al. (2014) and WWT Consulting (2015).

318. Using a GIS, both DSMs were clipped to only include the extent of the dataset of DEP, SEP, 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 cell (the latter of which was recalculated where required due to the clipping).

13.6.2.1.4.2.1 Non-breeding

319. At the published baseline annual mortality for this species averaged across all age classes (0.228; **Table 13-16**), 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 13.1 Offshore Ornithology Technical Report**) is 3,027 (i.e. 13,277 x 0.228).

13.6.2.1.4.2.1.1 DEP

320. 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 DEP and its 12km buffer.

321. At a biologically unrealistic (based on the literature reviewed in **Section 13.6.2.1.4**) 100% displacement and mortality, the loss of seven birds would increase the mortality within the UK North Sea and Channel BDMPS by 0.2%. 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.

322. Therefore, 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 negative**.

13.6.2.1.4.2.1.2 SEP

323. The DSM based on visual aerial survey data suggested that within SEP and its 12km buffer, 8.33 birds would be expected to occur. The DSM that used boat-based survey data indicated that 20.00 birds would be expected to occur within DEP and its 12km buffer.

324. At a biologically unrealistic (based on the literature reviewed in **Section 13.6.2.1.4**) 100% displacement and mortality, the loss of 20 birds would increase the mortality within the UK North Sea and Channel BDMPS by 0.7%. 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.

325. Therefore, 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 negative**.

13.6.2.1.4.2.1.3 DEP and SEP Combined

326. The DSM based on visual aerial survey data suggested that within DEP, SEP 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 DEP and its 12km buffer.

327. At a biologically unrealistic (based on the literature reviewed in **Section 13.6.2.1.4**) 100% displacement and mortality, the loss of 23 birds would increase the mortality within the UK North Sea and Channel BDMPS by 0.8%. 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.

328. Therefore, 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 negative**.

13.6.2.1.5 Sandwich tern

329. Much of the previous work on the potential sensitivity of Sandwich terns to OWFs has focused on the risk of collision, though there is potential for disturbance and displacement effects to occur.

330. A review by Cook et al. (2014) suggested a macro-avoidance rate of 0.28 for tern species around operational OWFs. Evidence from the SOW OMP (Harwood et al., 2018) suggested that in three years of operational monitoring, the percentage reduction of Sandwich terns entering the OWF relative to the baseline (i.e. prior to OWF construction) was 36%, 37% and 45%. When additional analysis to recalculate the avoidance rate of Sandwich tern was undertaken, it was estimated that between 31% and 42% fewer Sandwich terns entered the SOW array during the three years of operation relative to the baseline. Some evidence of operational displacement effects were detected at the LID/Lincs OWF, though effects were inconsistent, and some comparisons indicated that in some years, abundance of Sandwich terns within the OWFs actually increased (Hi Def Aerial Surveying, 2017).

331. 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 general evidence base indicates that exact impact magnitudes are site-specific, and can be variable.

332. Following statutory guidance (UK SNCBs, 2017), abundance estimates for Sandwich tern for DEP and SEP only (i.e. no buffers), for the relevant biological seasons (**Table 13-14**) have been used to produce displacement matrices. This spatial extent has been selected as Perrow et al. (2010) suggests that displacement effects for this species are unlikely beyond 1km of an OWF boundary, Harwood et al. (2018), which provides evidence that birds continued to use areas of sea directly adjacent to SOW after the OWF had become operational, and data from Green et al. (2019), which do not show clear displacement beyond existing OWF boundaries.

333. Based on information presented by Cook et al. (2014) and Harwood et al. (2018), displacement rates of 30% to 50% are considered appropriate for Sandwich tern. The selection of these rates is considered to represent a precautionary approach since it is equally possible based on some previously published data that increases in abundance in operational OWFs are possible.

334. 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.

335. 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. However, 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 mortality levels closer to 1% than 5% would represent a realistic worst case scenario.

336. The published mortality rate for adult Sandwich terns is 0.102 (Horswill and Robinson, 2015) (**Table 13-16**), which is relevant given the assumption that all birds at DEP and SEP 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. 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).

337. Based on this information, a % mortality range of 1% to 5% due to displacement from DEP and SEP is considered to represent a highly precautionary assessment, although this seems likely to be unrealistic at its upper end in the context of the background population mortality rate.

13.6.2.1.5.1 Autumn Migration

338. 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 classes (0.240; **Table 13-16**), the number of Sandwich terns expected to die annually that are members of the UK North Sea and Channel BDMPS (**Appendix 13.1 Offshore Ornithology Technical Report**) is 9,132 (i.e. 38,051 x 0.240).

13.6.2.1.5.1.1 DEP

339. Sandwich tern mortality during the autumn migration season due to operational phase displacement from DEP is estimated to be 0 to 1 individuals based on a mean peak abundance of 45 birds within the OWF site, displacement rates of 30% to 50% and a mortality rate of 1% to 5% (**Table 13-49**). This increases the annual mortality of the UK North Sea and Channel BDMPS population by 0% to 0.01%.

Table 13-49: Displacement matrix for Sandwich tern at DEP during the autumn migration season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	0	0	0	0	0	0	1	1	2	4	5
	20	0	0	0	0	0	1	2	3	5	7	9
	30	**0**	**0**	**0**	**1**	**1**	1	3	4	7	11	14
	40	**0**	**0**	**1**	**1**	**1**	2	4	5	9	14	18
	50	**0**	**0**	**1**	**1**	**1**	2	5	7	11	18	23
	60	0	1	1	1	1	3	5	8	14	22	27
	70	0	1	1	1	2	3	6	9	16	25	32
	80	0	1	1	1	2	4	7	11	18	29	36
	90	0	1	1	2	2	4	8	12	20	32	41
	100	0	1	1	2	2	5	9	14	23	36	45

340. For DEP individually, the magnitude of increase in the mortality rates of the UK North Sea and Channel BDMPS population created by operational displacement is very small, would not materially alter the existing mortality of the wider population, and would be undetectable in the context of natural variation.

341. During the autumn migration season, the magnitude of effect of operational displacement at DEP individually on Sandwich tern is therefore assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.5.1.2 SEP

342. At SEP, Sandwich tern mortality during the autumn migration season due to operational displacement is estimated to be zero, on the basis that no birds were recorded.

343. Therefore, during the autumn migration season, the magnitude of effect of operational displacement at SEP individually on Sandwich tern is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.5.1.3 DEP and SEP Combined

344. When combined, operational displacement impacts at DEP and SEP impacting the UK North Sea and Channel BDMPS during the autumn migration season could result in the mortality of between 0 and 1 Sandwich terns annually, based on a mean peak abundance of 45 birds within the OWF sites, displacement rates of 30% to 50% and a mortality rate of 1% to 5%. This represents an increase of 0% to 0.01% of existing annual Sandwich tern mortality within the UK North Sea and Channel BDMPS. This is a small increase in mortality that would be undetectable in the context of natural variation.

345. During the autumn migration season, the magnitude of effect of operational displacement on Sandwich tern due to DEP and SEP is therefore assessed as negligible, which as this species is considered to possess a medium sensitivity to disturbance results in a **minor negative** impact significance.

13.6.2.1.5.2 Spring Migration

346. 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 classes (0.240; **Table 13-16**), the number of Sandwich terns expected to die annually that are members of the UK North Sea and Channel BDMPS (**Appendix 13.1 Offshore Ornithology Technical Report**) is 9,132 (i.e. 38,051 x 0.240).

13.6.2.1.5.2.1 DEP and SEP Combined

347. At DEP and SEP, 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.

348. Therefore, the magnitude of effect of operational displacement at DEP and SEP individually and combined on Sandwich tern during the spring migration season is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.5.3 Breeding

349. The breeding adult population of the North Norfolk Coast SPA is considered to be the relevant Sandwich tern background population for the breeding season. At the published baseline annual mortality for this species for adults only (given the assumption that all birds at DEP and SEP during this season are adults) (0.102; **Table 13-16**), the number of Sandwich terns expected to die during the breeding season that are members of the North Norfolk Coast SPA population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 989 (i.e. 9,700 x 0.102).

13.6.2.1.5.3.1 DEP

350. Sandwich tern mortality during the breeding season due to operational phase displacement from DEP is estimated to be between 1 to 4 individuals based on a mean peak abundance of 179 birds within the OWF, displacement rates of 30% to 50% and a mortality rate of 1% to 5% (**Table 13-50**). This increases the annual mortality of the North Norfolk Coast SPA population by 0.05% to 0.45%.

Table 13-50: Displacement matrix for Sandwich tern at DEP during the breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	0	0	1	1	1	2	4	5	9	14	18
	20	0	1	1	1	2	4	7	11	18	29	36
	30	**1**	**1**	**2**	**2**	**3**	5	11	16	27	43	54
	40	**1**	**1**	**2**	**3**	**4**	7	14	21	36	57	71
	50	**1**	**2**	**3**	**4**	**4**	9	18	27	45	71	89
	60	1	2	3	4	5	11	21	32	54	86	107
	70	1	2	4	5	6	12	25	37	62	100	125
	80	1	3	4	6	7	14	29	43	71	114	143
	90	2	3	5	6	8	16	32	48	80	129	161
	100	2	4	5	7	9	18	36	54	89	143	179

351. This magnitude of increase in mortality is small, does not substantially alter the existing mortality levels within the population, and would be undetectable in the context of natural variation.

352. During the breeding season, the magnitude of effect of operational displacement at DEP is therefore assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.5.3.2 SEP

353. At SEP, Sandwich tern mortality during the breeding season due to operational displacement is estimated to be 0 to 2 individuals based on the same displacement and mortality rates (**Table 13-51**), and a mean peak abundance of 77 birds. Adding this impact to existing mortality levels increases the annual mortality of the North Norfolk Coast SPA population by 0.02% to 0.19%.

Table 13-51: Displacement matrix for Sandwich tern at SEP during the breeding season, showing the number of birds predicted to die (rounded to the nearest integer) at a given rate of displacement and mortality. Mortality rates used by the assessment are highlighted in red.

		Mortality (%)										
		1	2	3	4	5	10	20	30	50	80	100
Displacement (%)	10	0	0	0	0	0	1	2	2	4	6	8
	20	0	0	0	1	1	2	3	5	8	12	15
	30	**0**	**0**	**1**	**1**	**1**	2	5	7	11	18	23
	40	**0**	**1**	**1**	**1**	**2**	3	6	9	15	24	31
	50	**0**	**1**	**1**	**2**	**2**	4	8	11	19	31	38
	60	0	1	1	2	2	5	9	14	23	37	46
	70	1	1	2	2	3	5	11	16	27	43	54
	80	1	1	2	2	3	6	12	18	31	49	61
	90	1	1	2	3	3	7	14	21	34	55	69
	100	1	2	2	3	4	8	15	23	38	61	77

354. This magnitude of increase in mortality is small and would be undetectable in the context of natural variation, as it does not materially alter the existing mortality rate of the population. Therefore, during the breeding season, the magnitude of effect of operational displacement at SEP is assessed as negligible. As this species is considered to possess a medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.1.5.3.3 DEP and SEP Combined

355. When combined, operational displacement impacts at DEP and SEP could result in the mortality of between 0 and 6 individuals annually during the breeding season, based on a mean peak abundance of 256 birds across both sites. This represents an increase of between 0% to 0.60% of existing Sandwich tern mortality within the North Norfolk Coast SPA population. This magnitude of increase in mortality is small, does not materially alter the existing mortality of the background population, and would be undetectable in the context of natural variation. For reasons discussed in **Section 13.6.2.1.5**, the upper mortality rate is also considered highly implausible.

356. During the breeding season, the magnitude of effect of operational displacement due to DEP and SEP on Sandwich tern is assessed as negligible. As the species is considered to possess a medium sensitivity to disturbance, the impact significance is predicted to be **minor negative**.

13.6.2.1.5.4 Year Round

357. At the published baseline annual mortality for this species averaged across all classes (0.240; **Table 13-16**), the number of Sandwich terns expected to die from the largest UK North Sea and Channel BDMPS (the spring and autumn migration seasons) (**Appendix 13.1 Offshore Ornithology Technical Report**) is 9,132 (i.e. 38,051 x 0.204). 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).

13.6.2.1.5.4.1 DEP, SEP, and DEP and SEP Combined

358. The estimated number of Sandwich terns subject to displacement mortality throughout the year due to operational displacement at DEP is between 0 and 5 individuals. For SEP the mortality level is between 0 and 2 individuals, meaning that combined, the total is 0 to 7 individuals. The addition of the maximum displacement mortality to existing levels of mortality increases the UK North Sea and Channel BDMPS and biogeographic population mortality rate by 0% to 0.05% for DEP, 0% to 0.02% for SEP, and 0% to 0.08% for DEP and SEP combined. The increase in the mortality within the biogeographic population is considerably smaller.

359. For DEP and SEP alone, and DEP and SEP combined, these magnitudes of increase in mortality would not materially alter the background mortality of either the UK North Sea and Channel BDMPS or relevant biogeographic population, and would be undetectable in the context of natural variation.

360. Therefore, the year round magnitude of effect is assessed as negligible. As the species is considered to be of medium sensitivity to disturbance, the impact significance is **minor negative**.

13.6.2.2 Impact 4: Collision Risk

13.6.2.2.1 Introduction

361. During the operational phase, offshore ornithology receptors flying through DEP and SEP 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.

362. CRM (Band, 2012) has been used to estimate the theoretical collision risk to birds flying through DEP and SEP when operational, both across biological seasons and annually. This focuses on birds recorded during the baseline surveys of DEP and SEP, and is detailed in **Section 13.6.2.2.2**.

363. Separately, an investigation into the theoretical collision risk posed by DEP and SEP 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 13.6.2.2.3**.

13.6.2.2.2 Band Model CRM

13.6.2.2.2.1 Overview

364. The approach to CRM is summarised here and further details are provided in **Appendix 13.1 Offshore Ornithology Technical Report**. On the basis of advice provided by Natural England (**Table 13-1**), 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.

365. In order to focus the assessment, a screening exercise was undertaken to identify offshore ornithology receptors most likely to be at risk of significant impacts (**Table 13-52**). CRM using Option 2 of Band (2012) was undertaken for all species recorded in flight at DEP or SEP. **Table 13-52** provides the annual predicted CRM and 95% confidence interval using mean input parameters, and SNCB-recommended avoidance rates (UK SNCBs, 2014) for DEP and SEP. Several species had very low predicted annual collision risk. As the magnitudes of predicted impact were so small, even for the worst case, no further assessment is considered necessary for these species. They are therefore screened out of further assessment.

366. Despite relatively low predicted collision rates some species were screened in on a precautionary basis due to the conservation value of the population that individuals present at DEP and SEP were predicted to originate from (common tern), or the relatively high sensitivity of the species to collision (herring gull and lesser black-backed gull).

367. A range of highly applicable existing information of high quality (encompassing peer-reviewed and other research, and 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; 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 13-52: Collision risk screening for DEP and SEP

Species	Estimated Sensitivity to Collision Risk	Confidence in Sensitivity Estimate	Annual Collision Rate DEP (mean and 95% confidence intervals)	Annual Collision Rate SEP (mean and 95% confidence intervals)	Screening Result
Arctic skua	Low	Medium	Absent	Absent	Out
Arctic tern	Low	Medium	0.37 (0.00 - 1.73)	Absent	Out
Black-headed gull	Medium	Medium	0.72 (0.00 - 3.39)	0.50 (0.00 - 3.00)	Out
Common gull	Medium	Medium	1.17 (0.00 - 6.07)	0.72 (0.00 - 4.05)	Out
Common scoter	Low	Medium	Absent	Absent	Out
Common tern	Low	Medium	3.01 (0.00 - 4.52)	0.43 (0.00 - 0.82)	In
Cormorant	Low	Medium	0.03 (0.00 - 1.09)	Absent	Out
Fulmar	Low	Medium	Absent	0.01 (0.00 - 0.10)	Out
Gannet	Medium	Medium	8.98 (0.00 - 30.31)	1.48 (0.60 - 3.83)	In
Golden plover	Unknown	N/A	Absent	Absent	Out
Great black-backed gull	Medium	Medium	1.88 (0.00 - 8.94)	5.25 (0.00 - 27.80)	In
Great crested grebe	Unknown	N/A	Absent	Absent	Out
Great skua	Medium	Medium	Absent	Absent	Out
Guillemot	Low	Medium	0.06 (0.00 - 3.26)	0.01 (0.00 - 0.55)	Out
Herring gull	High	Medium	0.25 (0.00 - 2.04)	Absent	In

Species	Estimated Sensitivity to Collision Risk	Confidence in Sensitivity Estimate	Annual Collision Rate DEP (mean and 95% confidence intervals)	Annual Collision Rate SEP (mean and 95% confidence intervals)	Screening Result
Kestrel	Unknown	N/A	Absent	Absent	Out
Kittiwake	Medium	Medium	27.99 (3.13 - 81.01)	2.80 (0.00 - 13.31)	In
Knot	Unknown	N/A	Not calculated	Not calculated	Out
Lapwing	Unknown	N/A	Absent	Absent	Out
Lesser black-backed gull	High	Medium	0.73 (0.00 - 3.46)	0.40 (0.00 - 2.96)	In
Little gull	Medium	Medium	8.21 (0.00 - 27.19)	1.68 (0.00 - 4.97)	In
Long-tailed duck	Medium	Medium	Absent	Absent	Out
Manx shearwater	Medium	Medium	Absent	Absent	Out
Oystercatcher	Unknown	N/A	Absent	Absent	Out
Pomarine skua	Medium	Medium	Absent	Absent	Out
Puffin	Low	Medium	Absent	Absent	Out
Razorbill	Low	Medium	0.41 (0.00 - 2.57)	0.16 (0.00 - 0.71)	Out
Red-throated diver	Low	Medium	0.16 (0.04 - 1.34)	0.10 (0.00 - 0.90)	Out
Sandwich tern	Low	Medium	9.52 (0.65 - 25.94)	2.00 (0.00 - 7.45)	In
Shag	Low	Medium	Absent	Absent	Out
Tufted duck	Unknown	N/A	Absent	Absent	Out

Species	Estimated Sensitivity to Collision Risk	Confidence in Sensitivity Estimate	Annual Collision Rate DEP (mean and 95% confidence intervals)	Annual Collision Rate SEP (mean and 95% confidence intervals)	Screening Result
Woodpigeon	Unknown	N/A	Absent	Absent	Out

13.6.2.2.2.2 Band Model CRM Inputs

13.6.2.2.2.2.1 Baseline Survey Densities

368. The mean densities and 95% confidence intervals of birds in flight within DEP and SEP were calculated as described in **Appendix 13.1 Offshore Ornithology Technical Report**.

369. CRM runs using the mean density value, as well as lower and upper 95% confidence interval density values have been undertaken.

13.6.2.2.2.2.2 Flight Height Distribution

370. The assessment is based on collision risk for each key seabird species using Option 2 of the CRM, as advised by Natural England during the ETG process (**Table 13-1**). 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).

371. CRM runs using the mean PCH value according to the Option 2 dataset, as well as lower and upper 95% confidence interval flight height distribution values from the same dataset, have been undertaken.

372. **Appendix 13.1 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.

13.6.2.2.2.2.3 Avoidance Rates

373. The avoidance rates and variation about them recommended by the SNCBs using Option 2 of CRM (UK SNCBs, 2014) are presented in **Table 13-53**. These were recommended following the review of Cook et al. (2014), and are used by this assessment.

374. Avoidance rates based on more recent research are also presented in **Table 13-53**. A review of the latest evidence concerning avoidance rates for key seabird species considered by the assessment is provided in **Appendix 13.1 Offshore Ornithology Technical Report**.

Table 13-53: Avoidance Rates Used in CRM, and alternative rates informed by more recent evidence

Species	UK SNCBs (2014) Recommended	Alternative Informed by Recent Evidence
Common tern	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)
Herring gull	0.995 (± 0.001)	0.995 (Bowgen and Cook, 2018)

Species	UK SNCBs (2014) Recommended	Alternative Informed by Recent Evidence
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	-
Sandwich tern	0.980	0.993 and 0.994 (Harwood et al., 2018) 0.9883 (DECC, 2012)

375. 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. 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.

13.6.2.2.2.2.4 Nocturnal Activity

376. 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.

377. 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, 2015a), which resulted in annual mortality estimate reductions of between 14.5% (lesser black-backed gull) and 27.7% (gannet).

378. The assessment uses the nocturnal activity factors presented in *Table 13-54*. 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 13.1 Offshore Ornithology Technical Report**.

Table 13-54: 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%)	10%

13.6.2.2.2.2.5 Biometric Parameters

379. The biometric parameters of the offshore ornithology receptors screened into CRM are presented in **Appendix 13.1 Offshore Ornithology Technical Report**.

13.6.2.2.2.2.6 OWF Inputs

380. For both DEP and SEP, two deployment scenarios have been considered, based around 14MW and 26MW turbines. The parameters that have been incorporated into the CRM are presented in **Table 13-55**. The approximate % of downtime (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, by month) are presented in **Table 13-56**.

Table 13-55: OWF parameters used in CRM for DEP

Parameter	DEP		SEP	
	14MW Scenario	26MW Scenario	14MW Scenario	26MW Scenario
Number of turbines	32	17	24	13
Rotor radius (m)	110	150	110	150

Parameter	DEP		SEP	
	14MW Scenario	26MW Scenario	14MW Scenario	26MW Scenario
Air gap (m above HAT)	26	30	26	30
Hub height (m)	136	180	136	180
Rotation speed (m/s)	7.8	6.4	7.8	6.4
Maximum blade width (m)	7.5			
Blade pitch (degrees)	15			
Latitude (decimal degrees)	53.19		53.48	
Tidal offset (m)	2.6		2.9	

Table 13-56: Wind resource parameters used in CRM for DEP and SEP

Month	% Time Wind Speed Between 3-35 m/s (DEP)	% Time Wind Speed Between 3-35 m/s (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

13.6.2.2.2.3 Band Model CRM Outputs

381. For each species screened into CRM (**Table 13-52**), a table has been produced which presents the outputs. These are arranged by biologically relevant season (**Table 13-14**), and present the predicted collision risk for DEP, SEP, and DEP and SEP combined, for both the 14MW and 26MW deployment scenarios (**Table 13-55**). The avoidance rate is presented in the top left hand cell of each table.

382. 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**).

383. The probability of the actual collision rate being equal to or greater than the upper 95% confidence interval is 0.025; or 2.5%, a scenario considered to be very unlikely. This probability is equal to the probability of the actual collision rate being equal to or lower than the 95% confidence interval. In the case of the upper 95% confidence interval, carrying out assessments based on this parameter is therefore considered extremely precautionary. For this reason, the assessment considers all outputs, not just the highest generated.

384. Only a single model input was changed at a time, so lower and upper limits are not 'stacked' at once in a single model run. Multiplying together the probability of two values which are both equal to or greater than the 95% upper confidence intervals occurring (i.e. 0.025 x 0.025) is 0.06%, a scenario considered too unlikely as to represent a realistic worst case scenario.

385. Whilst the Band spreadsheets used to calculate collision risk have not been provided as part of the assessment, they can be made available to stakeholders on request.

13.6.2.2.2.3.1 Common tern

Table 13-57: Common tern CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.980		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.215			0.215			0.215			0.117		
Reference Population		144,911			Unknown			144,911			1,016		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	2.01	2.89	0	0	0	0	0.70	2.25	0	0.30	0.49
	% increase in baseline mortality (14MW)	0%	0.01%	0.01%	0%	0%	0%	0%	0.00%	0.01%	0%	0.25%	0.41%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.70	1.08	0	0	0	0	0.25	0.79	0	0.11	0.17
	% increase in baseline mortality (26MW)	0%	0.00%	0.00%	0%	0%	0%	0%	0.00%	0.00%	0%	0.09%	0.14%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	0.43	0.82
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.36%	0.69%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	0.15	0.29
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.13%	0.24%
	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	2.01	2.89	0	0	0	0	0.70	2.25	0	0.73	1.31

AR: 0.980		Autumn Migration			Winter			Spring Migration			Breeding		
DEP and SEP	% increase in baseline mortality (14MW)	0%	0.01%	0.01%	0%	0%	0%	0%	0.00%	0.01%	0%	0.61%	1.10%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.70	1.08	0	0	0	0	0.25	0.79	0	0.26	0.46
	% increase in baseline mortality (26MW)	0%	0.00%	0.00%	0%	0%	0%	0%	0.00%	0.00%	0%	0.22%	0.39%

386. The mean collision rate for common tern at DEP under the worst case (14MW) scenario (**Table 13-57**) was 2.01 birds per autumn migration season, and 0.70 birds per spring migration season. The predicted increase in existing mortality of the relevant background population, in this case the UK North Sea and Channel BDMPS, is 0.01% or less due to these mortality levels for DEP. This is also the case if the outputs from the upper 95% confidence interval CRM are considered.

387. Flying common terns were absent from SEP during the spring and autumn migration seasons, and from both DEP and SEP during the winter. During these seasons, collision risk is considered to be zero for OWFs where flying birds were not recorded.

388. During the breeding season, predicted common tern mortality increases within the wider population (taken to be breeding adults of the North Norfolk Coast SPA) were larger. Based on the upper 95% confidence interval, an increase in existing mortality of 0.41% due to collision risk at DEP (0.49 collisions per season), 0.69% due to collision risk at SEP (0.82 collisions per season), and 1.10% due to the combined impact of DEP and SEP for the 14MW scenario. Using mean collision rates, mortality increases during the breeding season were 0.25% at DEP (collision rate of 0.30 per season), and 0.36% at SEP (collision rate of 0.43 per season). When combined, the mortality increase for DEP and SEP was 0.61% (collision rate of 0.73 per season).

389. The 26MW deployment produced predicted collision rates that were approximately 65% less than for the 14MW scenario.

390. At the published baseline annual mortality for this species averaged across all age classes (0.215; **Table 13-16**), the number of birds expected to die annually that are members of the largest BDMPS (in this case the autumn and spring UK North Sea and Channel BDMPS) (**Appendix 13.1 Offshore Ornithology Technical Report**) is 31,156 (i.e. 144,911 x 0.215). The biogeographic population of this species with connectivity to UK waters is 480,000 (Furness, 2015). The number of individuals expected to die annually from this population is 103,200 (i.e. 480,000 x 0.215).

391. The addition of the annual mean and upper 95% confidence interval collision mortalities for DEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by 0.01%, and the biogeographic population mortality rate by 0.003%. The addition of the annual mean and upper 95% confidence interval collision mortalities for SEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.001% and 0.003%, and the biogeographic population mortality rate by 0.001%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable, particularly since in any given year, mortality levels will likely be at the lower end of this range.

392. For all seasons and year round, the magnitude of increase in mortality due to the mean predicted collision mortality at DEP and SEP is small, would not materially impact the existing mortality rate, and would be undetectable in the context of natural variation. Whilst it is possible that upper 95% confidence interval collision rates occurring at both DEP and SEP during the breeding season could result in detectable effects (i.e. >1% increase in existing mortality), it is considered highly unlikely that this situation would occur (probability of 0.025 x 0.025 = 0.06).

393. On the basis that such impacts are possible, though very unlikely, the magnitude of effect of collision risk for this species at DEP and SEP combined is therefore assessed as low for both deployment scenarios, and negligible individually. As common tern is considered to possess a low sensitivity to collision risk, the impact significance is **minor negative**.

13.6.2.2.2.3.2 Gannet

Table 13-58: Gannet CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.987 - 0.991		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.191			0.191			0.191			0.088		
Reference Population		456,298			Unknown			248,385			26,784		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	4.99	15.71	0	0	0	0	0.36	1.68	0	3.63	18.42
	% increase in baseline mortality (14MW)	0%	0.01%	0.02%	0%	0%	0%	0%	0.00%	0.00%	0%	0.15%	0.78%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	1.89	5.96	0	0	0	0	0.14	0.64	0	1.38	6.99
	% increase in baseline mortality (26MW)	0%	0.00%	0.01%	0%	0%	0%	0%	0.00%	0.00%	0%	0.06%	0.30%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.49	1.44	3.22	0	0	0	0	0	0	0	0.33	1.30
	% increase in baseline mortality (14MW)	0.00%	0.00%	0.00%	0%	0%	0%	0%	0%	0%	0%	0.01%	0.06%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.19	0.44	1.25	0	0	0	0	0	0	0	0.13	0.50
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.00%	0%	0%	0%	0%	0%	0%	0%	0.01%	0.02%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.49	6.43	18.93	0	0	0	0	0.36	1.68	0	3.96	19.72
	% increase in baseline mortality (14MW)	0.00%	0.01%	0.02%	0%	0%	0%	0%	0.00%	0.00%	0%	0.17%	0.84%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.19	2.33	7.21	0	0	0	0	0.14	0.64	0	1.51	7.49
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.01%	0%	0%	0%	0.00%	0.00%	0.00%	0%	0.06%	0.32%

394. For gannet (**Table 13-58**), the worst case (14MW) mean collision rate at DEP was 4.99 birds per autumn migration season, and 0.36 birds per spring migration season. At SEP, the mean collision rate for the autumn migration season was 1.44 birds, with this species absent during spring migration (i.e. collision rate of zero). The predicted increase in existing mortality of the UK North Sea and Channel BDMPS, is no more than 0.01% due to autumn and spring migration season impacts for DEP, SEP, and DEP and SEP combined when mean collision rates are considered. If the upper 95% confidence interval model outputs are used for the assessment, the mortality increase for DEP and SEP combined relative to existing mortality of the UK North Sea Channel BDMPS increases to 0.02% for the 14MW scenario. Impacts were similar low at DEP during the spring migration season, whilst flying gannets were absent from DEP during this season, meaning no collisions are predicted.

395. Flying gannets were absent from both DEP and SEP during the winter. Collision risk is therefore considered to be zero for both OWFs during winter.

396. During the breeding season, predicted gannet mortality increases within the wider population (taken to be breeding adults of the Flamborough and Filey Coast SPA) were larger. Based on the upper 95% confidence interval outputs, an increase in existing mortality of 0.78% due to collision risk at DEP (18.42 collisions per season), 0.06% due to collision risk at SEP (1.30 collisions per season), and 0.84% due to the combined impact of DEP and SEP is predicted for the 14MW scenario. Using mean collision rates, mortality increases during the breeding season were reduced to 0.15% at DEP (collision rate of 3.63 per season), and 0.01% at SEP (collision rate of 0.33 per season). When combined, the mortality increase for DEP and SEP was 0.17% (collision rate of 3.96 per season).

397. The 26MW deployment produced predicted collision rates that were approximately 62% less than for the 14MW scenario.

398. At the published baseline annual mortality for this species averaged across all age classes (0.191; **Table 13-16**), the number of birds expected to die annually that are members of the largest BDMPS (in this case the autumn UK North Sea and Channel BDMPS) (**Appendix 13.1 Offshore Ornithology Technical Report**) is 87,153 (i.e. 456,298 x 0.191). 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 is 87,153 (i.e. 1,180,000 x 0.191).

399. The addition of the annual mean and upper 95% confidence interval collision mortalities for DEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.01% and 0.03%, and the biogeographic population mortality rate by between 0.004% and 0.01%. The addition of the annual mean and upper 95% confidence interval collision mortalities for SEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.002% and 0.004%, and the biogeographic population mortality rate by between 0.001% and 0.002%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable, particularly since in any given year, mortality levels will likely be at the lower end of this range.

400. For all seasons and year round, the magnitude of increase in mortality is small due to collision mortality at DEP and SEP, would not materially impact the existing mortality rate, and would likely be undetectable in the context of natural variation. This is the case even when the upper 95% confidence interval of collision rate is considered. The fact that impacts are small even when an extremely precautionary approach (i.e. the use of the upper 95% confidence interval for impact assessment) is employed means that the confidence in this assessment is high.

401. The magnitude of effect of collision risk for this species at DEP and SEP individually and combined is therefore assessed as negligible for both deployment scenarios. As gannet is considered to possess a medium sensitivity to collision risk, the impact significance is **minor negative**.

13.6.2.2.2.3.3 Great black-backed gull

Table 13-59: Great black-backed gull CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.994 - 0.996		Non-breeding			Breeding		
Mortality Rate		0.185			0.185		
Reference Population		91,399			52,829		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	1.57	7.74	0	0.30	2.99
	% increase in baseline mortality (14MW)	0%	0.01%	0.05%	0%	0.00%	0.03%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.71	3.52	0	0.14	1.36
	% increase in baseline mortality (26MW)	0%	0.00%	0.02%	0%	0.00%	0.01%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	5.25	33.36	0	0	0
	% increase in baseline mortality (14MW)	0%	0.03%	0.20%	0%	0%	0%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	2.43	15.44	0	0	0
	% increase in baseline mortality (26MW)	0%	0.01%	0.09%	0%	0%	0%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	6.82	41.10	0	0.30	2.99
	% increase in baseline mortality (14MW)	0%	0.04%	0.24%	0%	0.00%	0.03%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	3.14	18.96	0	0.14	1.36
	% increase in baseline mortality (26MW)	0%	0.02%	0.11%	0%	0.00%	0.01%

402. Predicted increases in mortality for great black-backed gull within the wider population due to collision risk with DEP, SEP, and DEP and SEP combined are small across both biologically relevant seasons (**Table 13-59**).

403. During the non-breeding season, predicted mortality increases within the wider population (UK North Sea BDMPS), based on the worst case mean collision mortality estimates for the 14MW scenario, were 0.01% for DEP (1.57 collisions per season) and 0.03% for SEP (5.25 collisions per season). When combined, collision mortality at DEP and SEP is predicted to result in a 0.04% increase in the existing mortality within the UK North Sea BDMPS population. Based on the upper 95% confidence interval CRM outputs, an increase in existing annual mortality of 0.24% due to collision risk at DEP (7.74 collisions per season) and SEP (33.36 collisions per season) combined is possible, but not likely on a regular basis.

404. During the breeding season, predicted great black-backed gull mortality increases within the wider population (taken to be non-breeding birds of the UK North Sea BDMPS), based on the upper 95% confidence interval and the 14MW deployment scenario, consists of an increase in existing mortality of 0.03% due to collision risk at DEP (2.99 collisions per season). Collision risk SEP is zero due to flying great black-backed gulls being absent during this season.

405. The 26MW deployment produced predicted collision rates that were approximately 54% less than for the 14MW scenario.

406. At the published baseline annual mortality for this species averaged across all age classes (0.185; **Table 13-16**), the number of birds expected to die annually that are members of the largest BDMPS (in this case the non-breeding UK North Sea and Channel BDMPS) (**Appendix 13.1 Offshore Ornithology Technical Report**) is 16,909 (i.e. 91,399 x 0.185). The biogeographic population of this species with connectivity to UK waters is 235,000 (Furness, 2015). The number of individuals expected to die annually from this population is 43,475 (i.e. 235,000 x 0.185).

407. The addition of the annual mean and upper 95% confidence interval collision mortalities for DEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.01% and 0.05%, and the biogeographic population mortality rate by between 0.004% and 0.02%. The addition of the annual mean and upper 95% confidence interval collision mortalities for SEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.03% and 0.22%, and the biogeographic population mortality rate by between 0.01% and 0.06%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable, particularly since in any given year, mortality levels will likely be at the lower end of this range.

408. For all seasons and year round, the magnitude of increase in mortality is small due to collision mortality at DEP and SEP, would not materially impact the existing mortality rate, and would be undetectable in the context of natural variation. This is the case even when the upper 95% confidence interval of collision rate is considered. The fact that impacts are very small even when an extremely precautionary approach (i.e. the use of the upper 95% confidence interval for impact assessment) is employed means that the confidence in this assessment is high.

409. The magnitude of effect of collision risk for this species at DEP and SEP individually and combined is therefore assessed as negligible for both deployment scenarios. As great-black backed gull is considered to possess a medium sensitivity to collision risk, the impact significance is **minor negative**.

13.6.2.2.2.3.4 Herring gull

Table 13-60: Herring gull CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.994 - 0.996		Non-breeding			Breeding		
Mortality Rate		0.184			0.166		
Reference Population		466,511			2,450		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0.25	2.45
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0.06%	0.60%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0.11	1.11
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0.03%	0.27%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0%	0%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0%	0%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0.25	2.45
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0.06%	0.60%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0.11	1.11
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0.03%	0.27%

410. Predicted increases in mortality for herring gull within the wider population due to collision risk with DEP, SEP, and DEP and SEP combined are small across both biologically relevant seasons (**Table 13-60**).

411. During the non-breeding season, predicted mortality increases within the wider population (UK North Sea and Channel BDMPS) were zero, are the species was absent from both DEP and SEP.

412. During the breeding season, predicted herring gull mortality increases within the wider population (taken to be breeding birds of a range of colonies on the Norfolk coast totally 2,450 breeding adults), based on the upper 95% confidence interval and the 14MW deployment scenario, consists of an increase in existing mortality of 0.60% due to collision risk at DEP (2.45 collisions per season). Collision risk SEP is zero due to flying herring gulls being absent during this season.

413. The 26MW deployment produced predicted collision rates that were approximately 56% less than for the 14MW scenario.

414. At the published baseline annual mortality for this species averaged across all age classes (0.184; **Table 13-16**), the number of birds expected to die annually that are members of the largest BDMPS (in this case the non-breeding UK North Sea and Channel BDMPS) (**Appendix 13.1 Offshore Ornithology Technical Report**) is 85,838 (i.e. 466,511 x 0.184). The biogeographic population of this species with connectivity to UK waters is 1,090,000 (Furness, 2015). The number of individuals expected to die annually from this population is 202,032 (i.e. 1,090,000 x 0.184).

415. The addition of the annual mean and upper 95% confidence interval collision mortalities for DEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by up to 0.002%, and the biogeographic population mortality rate by up to 0.001%. The addition of the annual mean and upper 95% confidence interval collision mortalities for SEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS and biogeographic population mortality rates by <0.001%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable.

416. For all seasons, the magnitude of increase in mortality is very small due to collision mortality at DEP and SEP, would not materially impact the existing mortality rate, and would be undetectable in the context of natural variation. This is the case even when the upper 95% confidence interval of collision rate is considered. The fact that impacts are very small even when an extremely precautionary approach (i.e. the use of the upper 95% confidence interval for impact assessment) is employed means that the confidence in this assessment is high.

417. The magnitude of effect of collision risk for this species at DEP and SEP individually and combined is therefore assessed as negligible for both deployment scenarios. As herring gull is considered to possess a medium sensitivity to collision risk, the impact significance is **minor negative**.

13.6.2.2.2.3.5 Kittiwake

Table 13-61: Kittiwake CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.987 - 0.991		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.156			0.156			0.156			0.146		
Reference Population		829,937			Unknown			627,816			91,008		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.46	8.55	26.10	0	0	0	0	2.20	6.36	2.09	17.24	63.28
	% increase in baseline mortality (14MW)	0.00%	0.01%	0.02%	0%	0%	0%	0%	0.00%	0.01%	0.02%	0.13%	0.48%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.17	3.33	10.18	0	0	0	0	0.86	2.48	0.62	6.73	24.68
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.01%	0%	0%	0%	0%	0.00%	0.00%	0.00%	0.05%	0.19%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	1.91	10.89	0	0	0	0	0	0	0	0.89	4.84
	% increase in baseline mortality (14MW)	0.00%	0.00%	0.01%	0%	0%	0%	0%	0%	0.%	0%	0.01%	0.04%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.76	4.33	0	0	0	0	0	0	0	0.35	1.92
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.00%	0%	0%	0%	0%	0%	0%	0%	0.00%	0.01%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.46	10.46	36.99	0	0	0	0	2.20	6.36	2.09	18.13	68.12
	% increase in baseline mortality (14MW)	0.00%	0.01%	0.03%	0%	0%	0%	0%	0.00%	0.01%	0.02%	0.14%	0.51%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.14	4.09	14.51	0	0	0	0	0.86	2.48	0.62	7.08	26.60
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.01%	0%	0%	0%	0%	0.00%	0.00%	0.00%	0.05%	0.20%

418. For kittiwake (**Table 13-61**), the mean worst case (14MW scenario) collision rate at DEP was 8.55 birds per autumn migration season, and 2.20 birds per spring migration season. At SEP, the mean collision rate for the autumn migration season was 1.91 birds, with this species absent during spring migration (i.e. collision mortality of zero). This means that the predicted increase in existing mortality of the UK North Sea BDMPS is 0.01% or less due to autumn and spring migration season impacts for DEP, SEP, and DEP and SEP combined when mean collision rates are considered. If the upper 95% confidence interval model outputs are used for the assessment, the mortality increase for DEP and SEP combined relative to existing mortality is marginally greater at a maximum of 0.03%.

419. Flying kittiwakes were absent from both DEP and SEP during the winter. Collision risk is therefore zero for both OWFs during winter.

420. During the breeding season, predicted kittiwake mortality increases within the wider population (taken to be breeding adults of the Flamborough and Filey Coast SPA) were larger. Based on the upper 95% confidence interval, an increase in existing mortality of 0.48% due to collision risk at DEP (63.28 collisions per season), 0.04% due to collision risk at SEP (4.84 collisions per season), and 0.51% due to the combined impact of DEP and SEP (68.12 collisions per season) is predicted for the 14MW scenario. Using mean collision rates, mortality increases during the breeding season were 0.13% at DEP (collision rate of 17.24 birds per season), and 0.01% at SEP (collision rate of 0.89 birds per season). When combined, the mortality increase for DEP and SEP was 0.14% (collision rate of 18.13 birds per season).

421. The 26MW deployment produced predicted collision rates that were approximately 63% less than for the 14MW scenario.

422. At the published baseline annual mortality for this species averaged across all age classes (0.156; **Table 13-16**), the number of birds expected to die annually that are members of the largest BDMPS (in this case the autumn UK North Sea and Channel BDMPS) (**Appendix 13.1 Offshore Ornithology Technical Report**) is 129,470 (i.e. 829,937 x 0.156). 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 is 795,600 (i.e. 5,100,000 x 0.156).

423. The addition of the annual mean and upper 95% confidence interval collision mortalities for DEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.02% and 0.06%, and the biogeographic population mortality rate by between 0.004% and 0.01%. The addition of the annual mean and upper 95% confidence interval collision mortalities for SEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.002% and 0.01%, and the biogeographic population mortality rate by up to 0.002%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable, particularly since in any given year, mortality levels will likely be at the lower end of this range.

424. For all seasons, the magnitude of increase in mortality is small due to collision mortality at DEP and SEP, would not materially impact the existing mortality rate, and would be undetectable in the context of natural variation. This is the case even when the upper 95% confidence interval of collision rate is considered. The fact that impacts are very small even when an extremely precautionary approach (i.e. the use of the upper 95% confidence interval for impact assessment) is employed means that the confidence in this assessment is high.

425. The magnitude of effect of collision risk for this species at DEP and SEP individually and combined is therefore assessed as negligible for both deployment scenarios. As kittiwake is considered to possess a medium sensitivity to collision risk, the impact significance is **minor negative**.

13.6.2.2.2.3.6 Lesser black-backed gull

Table 13-62 Lesser black-backed gull CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.994 - 0.996		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.126			0.126			0.126			0.115		
Reference Population		209,007			39,314			197,483			2,660		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0.28	1.55	0	0	0	0	0.45	1.91
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0.003%	0.02%	0%	0%	0%	0%	0.15%	0.62%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0.13	0.68	0	0	0	0	0.20	0.84
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0.001%	0.01%	0%	0%	0%	0%	0.07%	0.27%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	0.40	2.96
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.13%	0.97%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	0.18	1.33
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.06%	0.43%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0.28	1.55	0	0	0	0	0.85	4.87
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0.003%	0.02%	0%	0%	0%	0%	0.28%	1.59%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0.13	0.68	0	0	0	0	0.38	2.17
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0.001%	0.01%	0%	0%	0%	0%	0.12%	0.71%

426. Predicted increases in mortality for lesser black-backed gull within the wider population due to collision risk with DEP, SEP, and DEP and SEP combined are small across both biologically relevant seasons (**Table 13-62**).

427. During the autumn and spring migration seasons, predicted mortality increases within the wider population (UK North Sea and Channel BDMPS) were zero, are the species was absent from both DEP and SEP.

428. During the winter season, predicted lesser black-backed gull mortality increases within the wider (UK North Sea and Channel BDMPS), based on the upper 95% confidence interval and the 14MW deployment scenario, consists of an increase in existing mortality of 0.02% due to collision risk at DEP (1.55 collisions per season). Collision risk SEP is zero due to flying lesser black-backed gulls being absent during this season.

429. During the breeding season, predicted lesser black-backed gull mortality increases within the wider population (taken to be breeding birds of a range of colonies on the Norfolk coast totally 2,660 breeding adults), based on the upper 95% confidence interval and the 14MW deployment scenario, consists of an increase in existing mortality of 0.62% due to collision risk at DEP (1.91 collisions per season), and 0.97% due to collision risk at DEP (2.96 collisions per season). Combined, this represents a mortality increase of 1.59% (4.87 collisions per season). The mean values for DEP, SEP, and DEP and SEP combined for this season represent mortality increases of 0.15% (0.45 collisions per season), 0.13% (0.40 collisions per season), and 0.28% (0.85 collisions per season.

430. The 26MW deployment produced predicted collision rates that were approximately 55% less than for the 14MW scenario.

431. At the published baseline annual mortality for this species averaged across all age classes (0.126; **Table 13-16**), the number of birds expected to die annually that are members of the largest BDMPS (in this case the non-breeding UK North Sea and Channel BDMPS) (**Appendix 13.1 Offshore Ornithology Technical Report**) is 26,335 (i.e. 209,007 x 0.126). The biogeographic population of this species with connectivity to UK waters is 864,000 (Furness, 2015). The number of individuals expected to die annually from this population is 108,864 (i.e. 864,000 x 0.126).

432. The addition of the annual mean and upper 95% confidence interval collision mortalities for DEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.003% and 0.01%, and the biogeographic population mortality rate by between 0.001% and 0.003%. The addition of the annual mean and upper 95% confidence interval collision mortalities for SEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.002% and 0.01%, and the biogeographic population mortality rate by between 0.001% and 0.003%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable, particularly since in any given year, mortality levels will likely be at the lower end of this range.

433. For all seasons, the magnitude of increase in mortality is very small due to collision mortality at DEP and SEP, would not materially impact the existing mortality rate, and would be undetectable in the context of natural variation, with the exception of upper 95% collision rates for DEP and SEP combined during the breeding season. However, collision rates and increases in mortality are still low even in this highly precautionary scenario.

434. The magnitude of effect of collision risk for this species at DEP and SEP individually and combined is therefore assessed as negligible for both deployment scenarios. As lesser black-backed gull is considered to possess a medium sensitivity to collision risk, the impact significance is **minor negative**.

13.6.2.2.2.3.7 Little gull

Table 13-63: Little gull CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.980		Non-breeding			Breeding		
Mortality Rate		0.200			0.200		
Reference Population		75,000			Unknown		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	8.21	27.19	0	0	0
	% increase in baseline mortality (14MW)	0%	0.05%	0.18%	0%	0%	0%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	3.19	10.55	0	0	0
	% increase in baseline mortality (26MW)	0%	0.02%	0.07%	0%	0%	0%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	1.68	4.97	0	0	0
	% increase in baseline mortality (14MW)	0%	0.01%	0.03%	0%	0%	0%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.66	1.96	0	0	0
	% increase in baseline mortality (26MW)	0%	0.00%	0.01%	0%	0%	0%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	9.89	32.16	0	0	0
	% increase in baseline mortality (14MW)	0%	0.07%	0.21%	0%	0%	0%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	3.85	12.41	0	0	0
	% increase in baseline mortality (26MW)	0%	0.03%	0.08%	0%	0%	0%

435. For little gull (**Table 13-63**), predicted increases in mortality within the wider population due to collision risk with DEP, SEP, and DEP and SEP combined were small for the non-breeding season, which is the only season that this species was present at DEP and SEP.

436. Based on the upper 95% confidence interval collision risk and the worst case 14MW deployment scenario, baseline mortality increases within the wider population (North Sea flyway) of 0.18% for DEP (collision rate of 27.19 birds per season), 0.03% for SEP (collision rate of 4.97 birds per season), and 0.21% for DEP and SEP combined (32.16 collisions per season) are predicted.

437. The 26MW deployment produced predicted collision rates that were approximately 61% less than for the 14MW scenario.

438. The biogeographic population of this species with connectivity to UK waters is 864,000 (Furness, 2015) (**Appendix 13.1 Offshore Ornithology Technical Report**). At the published baseline annual mortality for this species averaged across all age classes (0.200; **Table 13-16**), the number of individuals expected to die annually from this population is 15,000 (i.e. 75,000 x 0.200).

439. The addition of the annual mean and upper 95% confidence interval collision mortalities for DEP (14MW scenario) to existing levels of mortality increases the biogeographic population mortality rate by between 0.05% and 0.18%. The addition of the annual mean and upper 95% confidence interval collision mortalities for SEP (14MW scenario) to existing levels of mortality increases the biogeographic population mortality rate by between 0.01% and 0.03%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable, particularly since in any given year, mortality levels will likely be at the lower end of this range.

440. The magnitude of increase in mortality is small due to collision mortality at DEP and SEP, would not materially impact the existing mortality rate, and would be undetectable in the context of natural variation. This is the case even when the upper 95% confidence interval of collision rate is considered. The fact that impacts are very small even when an extremely precautionary approach is employed means that the confidence in this assessment is high.

441. The magnitude of effect of collision risk for this species at DEP and SEP individually and combined is therefore assessed as negligible for both deployment scenarios. As little gull is considered to possess a medium sensitivity to collision risk, the impact significance is **minor negative**.

13.6.2.2.2.3.8 Sandwich tern

Table 13-64: Sandwich tern CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined (0.980 avoidance)

Avoidance: 0.980		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.240			0.240			0.240			0.102		
Reference Population		38,051			Unknown			38,051			9,700		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	1.25	3.09	0	0	0	0	0	0	0.65	8.27	22.85
	% increase in baseline mortality (14MW)	0.00%	0.01%	0.03%	0%	0%	0%	0%	0%	0%	0.07%	0.84%	2.31%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.38	1.07	0	0	0	0	0	0	0.23	2.53	7.92
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.01%	0%	0%	0%	0%	0%	0%	0.02%	0.26%	0.80%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	2.00	7.45
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.20%	0.75%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	0.71	2.63
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.07%	0.27%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	1.25	3.09	0	0	0	0	0	0	0.65	10.27	30.3
	% increase in baseline mortality (14MW)	0.00%	0.01%	0.03%	0%	0%	0%	0%	0%	0%	0.07%	1.04%	3.06%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.38	1.07	0	0	0	0	0	0	0.23	3.24	10.55
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.01%	0%	0%	0%	0%	0%	0%	0.02%	0.33%	1.07%

Table 13-65: Sandwich tern CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined (0.9883 avoidance)

Avoidance: 0.9883		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.240			0.228			0.240			0.102		
Reference Population		38,051			Unknown			38,051			9,700		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.73	1.91	0	0	0	0	0	0	0.38	4.84	13.36
	% increase in baseline mortality (14MW)	0.00%	0.01%	0.02%	0%	0%	0%	0%	0%	0%	0.04%	0.49%	1.35%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.22	0.67	0	0	0	0	0	0	0.13	1.48	4.63
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.01%	0%	0%	0%	0%	0%	0%	0.01%	0.15%	0.47%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	1.17	4.36
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.12%	0.44%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	0.41	1.54
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.04%	0.16%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.73	1.91	0	0	0	0	0	0	0.38	6.01	17.72
	% increase in baseline mortality (14MW)	0.00%	0.01%	0.02%	0%	0%	0%	0%	0%	0%	0.04%	0.61%	1.79%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.22	0.67	0	0	0	0	0	0	0.13	1.89	6.17
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.01%	0%	0%	0%	0%	0%	0%	0.01%	0.19%	0.62%

Table 13-66: Sandwich tern CRM outputs by season and predicted increases to existing mortality: DEP, SEP, and combined (0.993 avoidance)

Avoidance: 0.993		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.240			0.240			0.240			0.102		
Reference Population		38,051			Unknown			38,051			9,700		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.44	1.14	0	0	0	0	0	0	0.23	2.89	8.00
	% increase in baseline mortality (14MW)	0.00%	0.00%	0.01%	0%	0%	0%	0%	0%	0%	0.02%	0.29%	0.81%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.13	0.40	0	0	0	0	0	0	0.08	0.88	2.77
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.00%	0%	0%	0%	0%	0%	0%	0.01%	0.09%	0.28%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	0.70	2.61
	% increase in baseline mortality (14MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.07%	0.26%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	0.25	0.92
	% increase in baseline mortality (26MW)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.03%	0.09%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.44	1.14	0	0	0	0	0	0	0.23	3.59	10.61
	% increase in baseline mortality (14MW)	0.00%	0.00%	0.01%	0%	0%	0%	0%	0%	0%	0.02%	0.36%	1.07%
	Collision mortality (26MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.13	0.40	0	0	0	0	0	0	0.08	1.13	3.69
	% increase in baseline mortality (26MW)	0.00%	0.00%	0.00%	0%	0%	0%	0%	0%	0%	0.01%	0.11%	0.37%

442. For Sandwich tern, as described in **Appendix 13.1 Offshore Ornithology Technical Report**, a range of avoidance rates are presented. For this reason, multiple output tables are presented for this species.

443. During the autumn migration season, flying Sandwich terns were recorded at DEP at relatively low density and were absent from SEP. At an avoidance rate of 0.980 (**Table 13-64**), predicted increases in mortality within the wider population due to collision risk with DEP during this season were 0.03% (based on the upper 95% confidence interval collision rate of 3.26 birds per season). Mortality increases reduced to 0.02% when avoidance rates of 0.9883 (**Table 13-65**) or 0.993 (**Table 13-66**) were used, with upper 95% confidence interval collision rates of 1.91 and 1.14 birds per season respectively. Flying Sandwich tern were absent from both DEP and SEP during the spring migration season, therefore estimated collision mortality for this species during this season was zero.

444. During the breeding season, predicted mortality increases within the wider population (i.e. the breeding adult population of the North Norfolk Coast SPA) were larger than other seasons. For DEP, collision rates for the 14MW deployment scenario at an avoidance rate of 0.980 result in predicted mortality increases of 0.07% (collision rate of 0.65 birds per season) to 2.31% (collision rate of 22.85 birds per season) based on lower and upper 95% confidence intervals, with a mean value of 0.84% (collision rate of 8.27 birds per season) (**Table 13-64**). A higher avoidance rate of 0.9883 results in predicted mortality increases of 0.04% (collision rate of 0.38 birds per season) to 1.35% (collision rate of 13.36 birds per season), with a mean value of 0.49% (collision rate of 4.64 birds per season) (**Table 13-65**). At the highest avoidance rate under consideration, 0.993, the range of predicted mortality increase based on the 95% confidence intervals was 0.02% (collision rate of 0.23 birds per season) to 0.81% (collision rate of 8.00 birds per season), with a mean value of 0.29% (collision rate of 2.89 birds per season) (**Table 13-66**).

445. For SEP, breeding collision rates for the 14MW deployment scenario at an avoidance rate of 0.980 result in predicted mortality increases of 0% to 0.75% (collision rate of 7.45 birds per season) based on lower and upper 95% confidence intervals, with a mean value of 0.20% (collision rate of 2.00 birds per season) (**Table 13-64**). A higher avoidance rate of 0.9883 results in predicted mortality increases of 0% to 0.44% (collision rate of 4.36 birds per season), with a mean value of 0.12% (collision rate of 1.17 birds per season) (**Table 13-65**). At the highest avoidance rate under consideration, 0.993, the range of predicted mortality increase based on the 95% confidence intervals was 0% to 0..26% (collision rate of 2.61 birds per season), with a mean value of 0.07% (collision rate of 0.70 birds per season) (**Table 13-66**).

446. For DEP and SEP combined, mean worst case (14MW scenario) collision rates represented existing mortality rate increases of 1.04% (10.27 collisions) at an avoidance rate of 0.980, 0.61% (6.01 collisions) when the avoidance rate of 0.9883 was used, and 0.36% (3.59 collisions) at an avoidance rate of 0.993. The upper 95% confidence interval CRM output produced mortality rate increases of 3.06% (30.3 collisions), 1.79% (17.72 collisions) and 1.07% (10.61 collisions) at avoidance rates of 0.980, 0.9883 and 0.993 respectively.

447. The 26MW deployment produced predicted collision rates that were approximately 66% less than for the 14MW scenario. This means that for DEP and SEP combined, percentage increases in existing mortality were 1.07% (10.55 collisions per year) at an avoidance rate of 0.980, 0.62% (6.17 collisions per year) at an avoidance rate of 0.9883%, and 0.37% (3.69 collisions per year) when upper 95% confidence interval CRM outputs were considered.

448. At the published baseline annual mortality for this species averaged across all age classes (0.240; **Table 13-16**), the number of birds expected to die annually that are members of the largest BDMPS (in this case the autumn and spring UK North Sea and Channel BDMPS) (**Appendix 13.1 Offshore Ornithology Technical Report**) is 9,132 (i.e. 38,051 x 0.220). The biogeographic population of this species 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).

449. Using an avoidance rate of 0.980, the addition of the annual mean and upper 95% confidence interval collision mortalities for DEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.10% and 0.28%, and the biogeographic population mortality rate by between 0.03% and 0.07%. The addition of the annual mean and upper 95% confidence interval collision mortalities for SEP (14MW scenario) to existing levels of mortality increases the UK North Sea and Channel BDMPS mortality rate by between 0.02% and 0.08%, and the biogeographic population mortality rate by between 0.01% and 0.02%. These magnitudes of increase in mortality would not materially alter the background mortality of the population and would be undetectable, particularly since in any given year, mortality levels will likely be at the lower end of this range.

450. For all seasons except the breeding season, the magnitude of increase in mortality is very small due to collision mortality at DEP, and would be undetectable in the context of natural variation. This is the case even when the upper 95% confidence interval of collision rate is considered. The fact that impacts are very small even when an extremely precautionary approach (i.e. the use of the upper 95% confidence interval for impact assessment) is employed means that the confidence in this assessment is high. No collision mortality is predicted at SEP outside the breeding season.

451. During the breeding season at DEP, the use of two avoidance rates (0.980 and 0.9883), in conjunction with the upper 95% confidence interval collision estimate, under the 14MW deployment scenario results in a level of mortality which could be detectable (based on the fact that the potential impact results in a mortality increase of >1%), and result in potential impacts to the population of the North Norfolk Coast SPA. All other avoidance rate and confidence interval combinations result in annual mortality levels that increase the existing mortality rates by <1%, which are considered to be undetectable and within the natural variation expected within the population.

452. For SEP, the magnitude of increase in mortality under all avoidance rates is small due to collision mortality year round, and would be undetectable. This is the case even when the upper 95% confidence interval of collision rate is considered, at any avoidance rate under consideration. The fact that impacts are very small even when an extremely precautionary approach (i.e. the use of the upper 95% confidence interval for impact assessment) is employed means that the confidence in this assessment is high.

453. Whilst the combined 95% upper confidence interval CRM outputs for DEP and SEP produce mortality increases of >1% at all three avoidance rates under consideration, the probability of this occurring at both OWF sites is 0.06% (i.e. 0.025 x 0.025). This approach is considered to be excessively precautionary.

454. Using an avoidance rate of 0.980 and an upper 95% confidence interval collision rate for DEP, and a mean collision rate for SEP, a more realistic worst case (but still improbable) annual mortality rate for DEP and SEP combined would be 24.85 collisions, of which DEP contributes 22.85 collisions and SEP 2.00. Scenarios A and B of the PVA produced for this assessment considers an initial annual mortality of 10 and 35 birds respectively. In these scenarios, the median Counterfactual of Population Growth Rate (CPGR) is 0.999 and 0.997; in other words, the growth rate of the population compared with the baseline scenario is reduced by 0.1% to 0.3% due to these impacts. In the context of a population that has experienced a mean annual growth of 8.5% between 2010 and 2020 (**Appendix 13.1 Offshore Ornithology Technical Report**), it is not considered that a reduction in the growth rate of this magnitude represents a substantial effect on the population. Whilst the Counterfactual of Population Size (CPS) for these PVA scenarios suggest that relatively large impacts on the population may be possible after 35 years of OWF operation, the discussion in **Appendix 13.1 Offshore Ornithology Technical Report** indicates that for a number of reasons, this metric may be producing population level effect predictions that are excessively precautionary, and that CPGR may be a more appropriate measure of population level impacts.

455. The magnitude of effect of collision risk for this species at DEP individually is assessed as low for the 14MW deployment scenario. This is because the majority of scenarios considered result in mortality increases of <1%, though the use of upper 95% confidence interval CRM outputs in conjunction with avoidance rates of 0.980 and 0.9883 at the 14MW deployment scenario give greater mortality increases than 1%. The magnitude of effect is lower for other scenarios at 14MW (i.e. mean CRM outputs, and all outputs at an avoidance rate of 0.993), and all scenarios at the 26MW deployment scenario. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **minor negative** for the 14MW and 26MW deployment scenarios.

456. The magnitude of effect of collision risk for this species at SEP individually is assessed as negligible for both deployment scenarios. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **minor negative**.

457. Based on the conclusions of impact significance for DEP and SEP individually, the magnitude of effect of collision risk for this species at DEP and SEP combined is assessed as low for the 14MW and 26MW deployment scenarios. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **minor negative** for the 14MW and 26MW deployment scenarios.

13.6.2.2.3 SOSSMAT Assessment

13.6.2.2.3.1 SOSSMAT Inputs

458. The potential collision risk posed by DEP and SEP to a range of non-breeding waterbirds included in the review of migration activity by Wright et al. (2012) has been investigated using SOSSMAT.

459. Non-breeding waterbird species were screened into the assessment that are named as qualifying features of SPAs that support non-breeding waterbirds within 100km of DEP and SEP (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 impacts on these species at operational OWFs has not been extensively studied.

460. Population sizes and migration routes were obtained from Wright et al. (2012). To select the migration routes relevant to DEP and SEP, the site boundaries were overlaid on the migration route dataset in GIS, and any migration routes intersecting either or both site boundaries marked as relevant to each respective assessment.

461. The avoidance rate was set at 0.980 for all species, which was considered to be a precautionary figure for all species.

462. 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 OWF. From this, SOSSMAT generated a percentage of birds migrating through the southern North Sea which could encounter DEP and/or SEP 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.

463. 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 13-67**. OWF parameters were as for 14MW scenario of the Band model, as this scenario resulted in the highest collision rates for all seabird species considered in **Section 13.6.2.2.2** and is therefore the worst case. (**Table 13-55**).

Table 13-67: Biometric parameters for offshore ornithology receptors screened into SOSSMAT assessment for DEP and SEP

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

Species	Flight Type	Body Length (m)	Wingspan (m)	Flight Speed (m/s)	% PCH
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*	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*	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
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*	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*	Flapping	1.52	2.3	17.3	50

Species	Flight Type	Body Length (m)	Wingspan (m)	Flight Speed (m/s)	% PCH
Wigeon *Anas penelope*	Flapping	0.48	0.8	18.5	25

13.6.2.2.3.2 SOSSMAT Outputs

464. Collision risk for non-breeding waterbirds at DEP, SEP, and DEP and SEP combined, as estimated by SOSSMAT, is presented in **Table 13-68**, along with the national non-breeding populations of the species (as per Wright et al. (2012)), and the number of collisions expressed as a percentage of the national population.

Table 13-68: SOSSMAT-derived annual collision mortality for non-breeding waterbirds that are qualifying features of SPAs within 100km of DEP and SEP, based on 14MW deployment scenario

Species	National Population (Wright et al., 2012)	Annual Collision Rate, 0.980 Avoidance Rate			DEP and SEP Collisions as % of National Population
		DEP	SEP	DEP and SEP	
Avocet	7,500	0.06	0.05	0.12	0.002%
Bar-tailed godwit	54,280	0.38	0.23	0.61	0.001%
Bewick's swan	7,380	0.16	0.13	0.29	0.004%
Bittern	600	0.01	0.01	0.02	0.004%
Black-tailed godwit	56,880	0.34	0.20	0.54	0.001%
Common scoter	123,190	0.90	0.54	1.45	0.001%
Curlew	191,650	0.05	0.03	0.08	0.000%
Dark-bellied brent goose	91,000	0.95	0.86	1.82	0.002%
Dunlin	438,480	2.47	1.93	4.40	0.001%
Gadwall	25,630	0.10	0.08	0.18	0.001%
Golden plover	400,000	2.82	1.79	4.61	0.001%
Goldeneye	29,665	0.11	0.07	0.17	0.001%
Grey plover	49,315	0.29	0.18	0.47	0.001%
Knot	338,970	1.91	1.15	3.06	0.001%
Lapwing	465,000	4.17	2.54	6.72	0.001%
Mallard	718,250	2.72	1.63	4.35	0.001%
Oystercatcher	320,000	2.02	1.22	3.24	0.001%
Pink-footed Goose	360,000	2.74	1.32	4.07	0.001%
Pintail	30,235	0.12	0.07	0.19	0.001%
Pochard	75,780	0.08	0.06	0.13	0.000%

Species	National Population (Wright et al., 2012)	Annual Collision Rate, 0.980 Avoidance Rate			DEP and SEP Collisions as % of National Population
		DEP	SEP	DEP and SEP	
Redshank (britannica)	38,800	0.28	0.16	0.44	0.001%
Redshank (robusta)	400,000	2.76	1.65	4.41	0.001%
Redshank (totanus)	25,000	0.15	0.09	0.24	0.001%
Ringed plover	34,000	0.12	0.07	0.19	0.001%
Ruff	800	0.00	0.00	0.01	0.001%
Sanderling	22,680	0.12	0.07	0.19	0.001%
Shelduck	75,610	0.33	0.20	0.52	0.001%
Shoveler	20,545	0.07	0.06	0.13	0.001%
Teal	255,010	0.88	0.53	1.41	0.001%
Tufted duck	146,610	0.44	0.27	0.71	0.000%
Turnstone	59,810	0.33	0.20	0.52	0.001%
Whooper swan	23,730	0.61	0.34	0.95	0.004%
Wigeon	522,370	1.89	1.14	3.03	0.001%

465. The SOSSMAT outputs presented in **Table 13-68** demonstrate that this method of assessment does not predict large numbers of annual collisions for any species of non-breeding waterbird included within the assessment at DEP, SEP, or DEP and SEP combined.

466. No more than seven annual collisions are predicted for any species when the collision mortality for DEP and SEP is combined, and less than one annual collision due to DEP and SEP combined is predicted for the majority of species included in the assessment.

467. For all species under consideration, the predicted annual mortality due to collision mortality at DEP, SEP, and DEP and SEP combined represents <0.004% of the national population based on information presented in Wright et al. (2012). The magnitude of effect of collision risk for this species at DEP and SEP individually and combined is therefore assessed as negligible for both deployment scenarios. 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 negative**.

13.6.2.3 Combined Operational Displacement and Collision Risk

468. Three species have been scoped into the assessments for both operational disturbance, displacement and barrier effects, and collision risk: gannet, little gull and Sandwich tern. This is because they are the only species included within the assessment that are considered to be susceptible to both of these impacts (**Table 13-24** and **Table 13-52**). 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.

469. For each species, a table has been produced which presents the outputs of operational displacement and CRM. These are arranged by biologically relevant season (**Table 13-14**). Presented for the operational displacement are the full range of predicted mortalities described in **Section 13.6.2.1**. For collision risk, only the 14MW deployment scenario (**Table 13-55**), which is the worst case scenario producing the highest collision rates, is considered. The mean and upper collision risk prediction for each scenario is presented, along with percentage increases in background mortality rates of seasonal and annual populations. These calculations are based on the information provided in **Table 13-16.**

13.6.2.3.1 Gannet

Table 13-69: Gannet combined operational displacement and collision mortality by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.989		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.191			0.191			0.191			0.088		
Reference Population		456,298			Unknown			248,385			26,784		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	4.99	15.71	0	0	0	0	0.36	1.68	0	3.63	18.42
	Displacement mortality	3 - 3			0			0			3 - 4		
	% mortality increase (collisions plus max disp.)	0.002%	0.005%	0.01%	0%	0%	0%	0%	0.0004%	0.002%	0.08%	0.16%	0.47%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.49	1.44	3.22	0	0	0	0	0	0	0	0.33	1.30
	Displacement mortality	3 - 4			0			0			0		
	% mortality increase (collisions plus max disp.)	0.003%	0.003%	0.004%	0%	0%	0%	0%	0%	0%	0%	0.007%	0.03%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0.49	6.43	18.93	0	0	0	0	0.36	1.68	0	3.96	19.72
	Displacement mortality	6 - 7			0			0			3 - 4		
	% mortality increase (collisions plus max disp.)	0.0003%	0.004%	0.01%	0%	0%	0%	0%	0.0004%	0.002%	0.08%	0.17%	0.50%

470. Predicted increases in gannet mortality within the wider population due to operational displacement and collision risk are extremely small for the autumn and spring migration seasons (**Table 13-69**). The predicted increase in existing mortality of the UK North Sea and Channel BDMPS, is <0.01% due to autumn and spring migration season impacts for DEP, SEP, and DEP and SEP combined when mean collision rates are considered. If the upper 95% confidence interval model outputs are used for the assessment, the mortality increase for DEP and SEP combined relative to existing mortality is marginally greater than at 0.01%.

471. During the breeding season, predicted gannet mortality increases within the wider population (taken to be breeding adults of the Flamborough and Filey Coast SPA) due to operational displacement and collision mortality were larger. Based on the upper 95% confidence interval, an increase in existing mortality of 0.47% due to predicted mortality at DEP, 0.03% at SEP, and 0.50% due to the combined impact of DEP and SEP. Consideration of mean collision and displacement values results in a predicted mortality increase of 0.17% in the background population when impacts from both OWFs are summed.

472. For all seasons, the magnitude of increase in mortality is very small due to combined operational displacement and collision mortality at DEP and SEP, and would be undetectable in the context of natural variation. This is the case even when the upper 95% confidence interval of collision rate is considered. The fact that impacts are very small even when an extremely precautionary approach (i.e. the use of the upper 95% confidence interval collision rates for impact assessment) is employed means that the confidence in this assessment is high.

473. The magnitude of effect of operational displacement and collision risk for this species at DEP and SEP individually and combined is therefore assessed as low for both deployment scenarios. As gannet is considered to possess a medium sensitivity to collision risk and operational displacement, the impact significance is **minor negative**.

13.6.2.3.2 Little gull

Table 13-70: Little gull combined operational displacement and collision mortality by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.980		Non-breeding			Breeding		
Mortality Rate		0.200			0.200		
Reference Population		75,000			Unknown		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	8.21	27.19	0	0	0
	Displacement mortality	2 - 5			0		
	% mortality increase (collisions plus max displacement)	0.02%	0.04%	0.11%	0%	0%	0%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	1.68	4.97	0	0	0
	Displacement mortality	0 - 1			0		
	% mortality increase (collisions plus max displacement)	0.003%	0.009%	0.02%	0%	0%	0%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	9.89	32.16	0	0	0
	Displacement mortality	2 - 6			0		
	% mortality increase (collisions plus max displacement)	0.02%	0.05%	0.13%	0%	0%	0%

474. For little gull (**Table 13-70**), predicted increases in mortality within the wider population due to operational displacement and collision risk with DEP are small for the non-breeding season. The predicted increase in existing mortality of the relevant background population, the North Sea Flyway, is 0.05% or less due to non-breeding season impacts for DEP, SEP, and DEP and SEP combined when mean collision rates are considered. If the upper 95% confidence interval CRM outputs are used for the assessment, the mortality increase for DEP and SEP combined relative to existing mortality is 0.13%.

475. Little gull was absent from both DEP and SEP during the breeding season. The risk of operational phase displacement and collision is therefore zero for this season.

476. The magnitude of increase in mortality for little gull is small due to combined operational displacement and collision mortality at DEP and SEP, and would be undetectable in the context of natural variation. This is the case even when the upper 95% confidence interval of collision rate is considered. The fact that impacts are very small even when an extremely precautionary approach (i.e. the use of the upper 95% confidence interval collision rates for impact assessment) is employed means that the confidence in this assessment is high.

477. The magnitude of effect of operational displacement and collision risk for this species at DEP and SEP individually and combined is therefore assessed as low for both deployment scenarios. As little gull is considered to possess a medium sensitivity to collision risk and operational displacement, the impact significance is **minor negative**.

13.6.2.3.3 Sandwich tern

Table 13-71: Sandwich tern combined operational displacement and collision mortality (avoidance rate 0.980) by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.980		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.228			0.228			0.228			0.102		
Reference Population		30,051			Unknown			30,051			9,700		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	1.25	3.09	0	0	0	0	0	0	0.65	8.27	22.85
	Displacement mortality	0 - 1			0			0			1 - 4		
	% mortality increase (collisions plus min disp.)	0%	0.02%	0.05%	0	0	0	0	0	0	0.2%	0.9%	2.4%
	% mortality increase (collisions plus max disp.)	0.01%	0.03%	0.06%	0	0	0	0	0	0	0.5%	1.2%	2.7%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	2.00	7.45
	Displacement mortality	0			0			0			0 - 2		
	% mortality increase (collisions plus min disp.)	0	0	0	0	0	0	0	0	0	0%	0.2%	0.8%
	% mortality increase (collisions plus max disp.)	0	0	0	0	0	0	0	0	0	0.2%	0.4%	1.0%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	1.25	3.09	0	0	0	0	0	0	0.65	10.27	30.30
	Displacement mortality	0 - 1			0			0			1 - 5		
	% mortality increase (collisions plus min disp.)	0%	0.02%	0.05%	0	0	0	0	0	0	0.2%	1.1%	3.2%
	% mortality increase (collisions plus max disp.)	0.01%	0.03%	0.06%	0	0	0	0	0	0	0.6%	1.5%	3.6%

Table 13-72 Sandwich tern combined operational displacement and collision mortality (avoidance rate 0.9883) by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.9883		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.228			0.228			0.228			0.102		
Reference Population		30,051			Unknown			30,051			9,700		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.73	1.91	0	0	0	0	0	0	0.38	4.84	13.36
	Displacement mortality	0 - 1			0			0			1 - 4		
	% mortality increase (collisions plus min disp.)	0%	0.01%	0.03%	0	0	0	0	0	0	0.1%	0.6%	1.5%
	% mortality increase (collisions plus max disp.)	0.01%	0.03%	0.04%	0	0	0	0	0	0	0.4%	0.9%	1.8%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	1.17	4.36
	Displacement mortality	0			0			0			0 - 2		
	% mortality increase (collisions plus min disp.)	0	0	0	0	0	0	0	0	0	0%	0.1%	0.4%
	% mortality increase (collisions plus max disp.)	0	0	0	0	0	0	0	0	0	0.2%	0.3%	0.6%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.73	1.91	0	0	0	0	0	0	0.38	6.01	17.72
	Displacement mortality	0 - 1			0			0			1 - 5		
	% mortality increase (collisions plus min disp.)	0%	0.01%	0.03%	0	0	0	0	0	0	0.1%	0.7%	1.9%
	% mortality increase (collisions plus max disp.)	0.01%	0.03%	0.04%	0	0	0	0	0	0	0.5%	1.1%	2.3%

Table 13-73: Sandwich tern combined operational displacement and collision mortality (avoidance rate 0.993) by season and predicted increases to existing mortality: DEP, SEP, and combined

AR: 0.993		Autumn Migration			Winter			Spring Migration			Breeding		
Mortality Rate		0.228			0.228			0.228			0.102		
Reference Population		30,051			Unknown			30,051			9,700		
DEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.44	1.14	0	0	0	0	0	0	0.23	2.89	8.00
	Displacement mortality	0 - 1			0			0			1 - 4		
	% mortality increase (collisions plus min disp.)	0%	0.01%	0.02%	0	0	0	0	0	0	0.1%	0.4%	0.9%
	% mortality increase (collisions plus max disp.)	0.01%	0.02%	0.03%	0	0	0	0	0	0	0.4%	0.7%	1.2%
SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0	0	0	0	0	0	0	0	0	0.70	2.61
	Displacement mortality	0			0			0			0 - 2		
	% mortality increase (collisions plus min disp.)	0	0	0	0	0	0	0	0	0	0%	0.1%	0.3%
	% mortality increase (collisions plus max disp.)	0	0	0	0	0	0	0	0	0	0.2%	0.3%	0.5%
DEP and SEP	Collision mortality (14MW)	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
		0	0.44	1.14	0	0	0	0	0	0	0.23	3.59	10.61
	Displacement mortality	0 - 1			0			0			1 - 5		
	% mortality increase (collisions plus min disp.)	0%	0.01%	0.02%	0	0	0	0	0	0	0.1%	0.5%	1.2%
	% mortality increase (collisions plus max disp.)	0.01%	0.02%	0.03%	0	0	0	0	0	0	0.5%	0.9%	1.6%

478. Predictions of mortality for Sandwich tern for DEP, SEP and DEP and SEP combined, at the three avoidance rates used for this species, are presented in **Table 13-71**, **Table 13-72** and **Table 13-73**.

479. Outside the breeding season, predicted increases in Sandwich tern mortality within the wider population due to operational displacement and collision risk with DEP, SEP, and DEP and SEP combined are very small. The predicted increase in existing mortality of the relevant background population, the UK North Sea and Channel BDMPS, is a maximum of 0.06% due to non-breeding season impacts for DEP, SEP, and DEP and SEP combined when upper 95% confidence interval collision rates, and upper level displacement mortalities are considered at the lowest avoidance rate (**Table 13-71**).

480. During the breeding season, mortality predictions due to combined operational displacement and collision risk vary considerably depending on the avoidance rate. The use of the lowest avoidance rate under consideration (which does not have any empirical evidence to support it), in conjunction with the upper 95% confidence interval collision estimate, under the 14MW deployment scenario results in a level of mortality which could be detectable (based on the fact that the potential impact results in a mortality increase of >1%), and result in potential impacts to the population of the North Norfolk Coast SPA.

481. At DEP, using an avoidance rate of 0.980 (**Table 13-71**), predicted percentage increases in mortality rate for the breeding adult Sandwich tern population of the North Norfolk Coast SPA varied from 0.2% (predicted seasonal mortality of 1.65) to 2.7% (predicted seasonal mortality of 26.85), with mean collision rates added to minimum and maximum predicted displacement yielding increases of 0.9% to 1.2% (predicted seasonal mortality of 9.27 to 12.27). Using an avoidance rate of 0.9883 (**Table 13-72**), predicted percentage increases in mortality varied from 0.1% (predicted seasonal mortality of 1.38) to 1.8% (predicted seasonal mortality of 17.36), with mean collision rates added to minimum and maximum predicted displacement yielding increases of 0.6% to 0.9% (predicted seasonal mortality of 5.84 to 8.84). At an avoidance rate of 0.993 (**Table 13-73**), predicted percentage increases in mortality varied from 0.1% (predicted seasonal mortality of 1.23) to 1.2% (predicted seasonal mortality of 12.00), with mean collision rates added to minimum and maximum predicted displacement yielding increases of 0.4% to 0.7% (predicted seasonal mortality of 3.89 to 6.89).

482. At SEP, using an avoidance rate of 0.980 (**Table 13-71**), predicted percentage increases in mortality within the breeding adult Sandwich tern population of the North Norfolk Coast SPA varied from 0% to 1.0% (predicted seasonal mortality of 9.45), with mean collision rates added to minimum and maximum predicted displacement yielding increases of 0.2% to 0.4% (predicted seasonal mortality of 2.00 to 4.00). Using an avoidance rate of 0.9883 (**Table 13-72**), predicted percentage increases in mortality varied from 0% to 0.6% (predicted seasonal mortality of 6.36), with mean collision rates added to minimum and maximum predicted displacement yielding increases of 0.1% to 0.3% (predicted seasonal mortality of 1.17 to 3.17). At an avoidance rate of 0.993 (**Table 13-73**), predicted percentage increases in mortality varied from 0% to 0.5% (predicted seasonal mortality of 4.61), with mean collision rates added to minimum and maximum predicted displacement yielding increases of 0.1% to 0.3% (predicted seasonal mortality of 0.70 to 2.70).

483. Combining impacts for DEP and SEP, using an avoidance rate of 0.980, predicted percentage increases in mortality within the breeding adult Sandwich tern population of the North Norfolk Coast SPA varied from 0.2% (predicted seasonal mortality of 1.65) to 3.6% (predicted seasonal mortality of 35.30), with mean collision rates added to minimum and maximum predicted displacement yielding increases of 1.1% to 1.5% (mortality rates of 11.27 to 16.27). Using an avoidance rate of 0.9883 (**Table 13-72**), predicted percentage increases in mortality varied from 0.1% (predicted seasonal mortality of 1.38) to 2.3% (mortality rate of 22.72), with mean collision rates added to minimum and maximum predicted displacement yielding increases of 0.7% to 1.1% (predicted seasonal mortality of 7.01 to 12.01). At an avoidance rate of 0.993 (**Table 13-73**), predicted percentage increases in mortality varied from 0.1% (mortality rate of 1.23) to 1.6% (predicted seasonal mortality of 15.61), with mean collision rates added to minimum and maximum predicted displacement yielding increases of 0.5% to 0.9% (predicted seasonal mortality of 4.59 to 8.59).

484. For SEP, the magnitude of increase in mortality under all avoidance rates is small due to collision mortality year round, and would be undetectable. This is the case even when the upper 95% confidence interval of collision rate is considered. The fact that impacts are very small even when an extremely precautionary approach (i.e. the use of the upper 95% confidence interval for impact assessment) is employed means that the confidence in this assessment is high.

485. Using an avoidance rate of 0.980 and an upper 95% confidence interval collision rate, combined with a maximum predicted displacement rate, a worst case but highly improbable annual mortality rate for DEP and SEP combined would be 35.30, of which DEP contributes 26.85 and SEP 8.45. Scenario B of the PVA produced for this assessment considers an initial annual mortality of 35 birds. In this scenario, the Counterfactual of Population Growth Rate (CPGR) is 0.997; in other words, the growth rate of the population compared with the baseline scenario is reduced by 0.3% due to this impact. In the context of a population that has experienced a mean annual growth of 8.5% between 2010 and 2020 (**Appendix 13.1 Offshore Ornithology Technical Report**), it is not considered that a reduction in the growth rate of this magnitude represents a substantial effect. Whilst the Counterfactual of Population Size (CPS) for the PVA suggests that larger impacts on the population may be possible at this level of impact, the discussion in **Appendix 13.1 Offshore Ornithology Technical Report** indicates that for a number of reasons, this metric may be producing population level effect predictions that are excessively precautionary.

486. At higher avoidance and lower displacement rates, and particularly when mean collision rates are used, annual mortality rates for DEP and SEP combined are closer to 10 birds. At this level of impact (scenario A of the PVA), CPGR would be expected to be around 0.999, and CPS levels not so different from the baseline predictions that substantial population level effects would be expected (**Appendix 13.1 Offshore Ornithology Technical Report**).

487. The magnitude of effect of combined displacement and collision risk for this species at DEP individually is assessed as medium for the 14MW deployment scenario based on a worst case collision rate using the upper 95% confidence interval, with other scenarios resulting a low magnitude of effect (including the mean values, which are used by the assessment). The magnitude of effect is low for the 26MW deployment scenario. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **minor negative** for the 14MW deployment scenario and 26MW deployment scenario.

488. The magnitude of effect of combined displacement and collision risk for this species at SEP individually is assessed as negligible for both deployment scenarios. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **minor negative**.

489. Based on the conclusions of impact significance for DEP and SEP individually, the magnitude of effect of collision risk for this species at DEP and SEP combined is assessed as low for the 14MW and 26MW deployment scenarios. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **minor negative** for the 14MW and the 26MW deployment scenarios.

13.6.2.4 Impact 5: Indirect Effects

490. Indirect effects on offshore ornithology receptors may occur during the operational phase of DEP and SEP if there are impacts on prey species and/or their habitats.

491. 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 DEP and SEP 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.

492. Potential effects on benthic invertebrates and fish have been assessed in **Chapter 10 Benthic Ecology** and **Chapter 11 Fish and Shellfish Ecology** and the conclusions of those assessments inform this assessment of indirect effects on offshore ornithology receptors.

493. With regard to noise impacts, **Chapter 11 Fish and Shellfish Ecology** discusses the potential impacts of the operational phase of DEP and SEP 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 or negligible 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 DEP and SEP during the construction phase due to this impact is **minor negative**.

494. With regard to EMF effects, these are identified as highly localised with the majority of cables being buried, (**Chapter 10 Benthic Ecology**). The impact significance is considered negligible on benthic invertebrates and low on fish (elasmobranches). 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 DEP and SEP during the construction phase due to this impact is **minor negative**.

495. 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 negative** 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.

496. **Chapter 8 Marine Geology and Physical Processes** and **Chapter 10 Benthic Ecology** discusses the nature of any change and impacts on the seabed and benthic habitats during the operational phase of DEP and SEP. 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 DEP and SEP during the construction phase due to this impact is **minor negative**.

13.6.3 Potential Impacts during Decommissioning

13.6.3.1 Impact 6: Disturbance, Displacement and Barrier Effects

497. 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 bird species during construction (**Section 13.6.1.1**) and have been found to be of negligible to **minor negative** impact significance.

498. Any impacts generated during the decommissioning phase of DEP and SEP are expected to be similar, but likely of reduced magnitude compared to those generated during the construction phase; therefore, the magnitude of impact is predicted to be negligible. This magnitude of impact on a range of species of low to high sensitivity to disturbance is of negligible to **minor negative** impact significance.

13.6.3.2 Impact 7: Indirect Effects

499. Indirect effects such as displacement of seabird prey species are likely to occur during the decommissioning phase of DEP and SEP as structures are removed. The impact of such activities have already been assessed on relevant offshore ornithology receptors bird species during construction (**Section 13.6.1.2**) and have been found to be of minor to negligible impact significance.

500. Any impacts generated during the decommissioning phase of the proposed project are expected to be similar, but likely of reduced magnitude compared to those generated during the construction phase; therefore, the magnitude of effect is predicted to be negligible. This magnitude of impact on a range of species of low to high sensitivity to disturbance is of negligible to **minor negative** significance for DEP, SEP, and DEP and SEP combined.

13.7 Cumulative Impacts

13.7.1 Identification of Potential Cumulative Impacts

501. The first step in the cumulative impact assessment is the identification of which impacts assessed for DEP and/or SEP in isolation have the potential for a cumulative impact with other plans, projects and activities (described as ‘impact screening’). This information is set out in **Table 13-74**, together with a consideration of the confidence in the data available to inform a detailed assessment and the associated rationale.

502. Table 13-74 concludes that in relation to offshore ornithology receptors, the potential for cumulative impacts in conjunction with other developments exists for disturbance, displacement and barrier effects during the operation of DEP and/or SEP, and collision risk.

Table 13-74: Potential Cumulative Impacts (impact screening)

Impact	Potential for cumulative impact	Confidence	Rationale
Construction			
Disturbance, displacement and barrier effects	No	High	The likelihood of a cumulative impact is low because the significance of these impacts (for the project 'alone') is low, as well as being temporary, reversible and spatially limited.
Indirect effects	No	High	
Operation			
Disturbance, displacement and barrier effects	Yes	High	The likelihood of a cumulative impact is sufficiently high to justify a detailed assessment.
Collision risk	Yes	High	The likelihood of a cumulative impact is sufficiently high to justify a detailed assessment.
Indirect effects	No	High	The likelihood of a cumulative impact is low because the significance of this impact is low.
Decommissioning			
Disturbance, displacement and barrier effects	No	High	The likelihood of a cumulative impact is low because the significance of these impacts (for the project 'alone') is low, as well as being temporary, reversible and spatially limited.
Indirect effects	No	High	

13.7.2 Other Plans, Projects and Activities

503. The second step in the cumulative impact assessment is the identification of the other plans, projects and activities that may result in cumulative impacts for inclusion in the CIA (described as 'project screening').

504. The project screening has been informed by the development of a CIA Project List which forms an exhaustive list of plans, projects and activities in a very large study area relevant to DEP and SEP (i.e. the North Sea). The list has been appraised, based on the confidence in being able to undertake an assessment from the information and data available, enabling individual plans, projects and activities to be screened in or out.

505. 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.

506. In addition, 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 coincidence of similar impacts from other plans or projects, which does not exist.

507. OWFs included in the cumulative impact assessment of offshore ornithology receptors (**Table 13-75**) have been assigned to tiers following the approach proposed by Natural England and JNCC (Scottish Power Renewables, 2016) as follows:

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

Table 13-75 List of projects considered for the CIA in relation to offshore ornithology (project screening), minimum distances between projects and DEP and SEP, and whether the minimum distance includes a land crossing

Project	Tier	Minimum Distance to DEP (km)	Minimum Distance to SEP (km)	Land Crossing
Beatrice Demonstrator	1	594	603	DEP and SEP
Blyth Demonstration	1	255	261	N
Dudgeon	1	0	12	N
European Offshore Wind Deployment Centre (EOWDC)	1	473	482	N
Galloper	1	133	131	DEP and SEP
Greater Gabbard	1	134	131	DEP and SEP
Gunfleet Sands	1	157	148	DEP and SEP
Hornsea Project One	2	66	90	N
Humber Gateway	1	64	67	N
Hywind	1	485	494	N
Kentish Flats and Extension	1	188	180	DEP and SEP
Lincs	1	46	34	N
London Array	1	161	155	DEP and SEP
Lynn and Inner Dowsing	1	51	37	N
Race Bank	1	19	10	N
Rampion	1	296	284	DEP and SEP
Scroby Sands	1	58	58	N

Project	Tier	Minimum Distance to DEP (km)	Minimum Distance to SEP (km)	Land Crossing
Sheringham Shoal	1	16	0	N
Teesside	1	205	210	DEP and SEP
Thanet	1	188	182	DEP and SEP
Westermost Rough	1	81	85	N
Beatrice	2	594	603	DEP and SEP
Forth (Seagreen) Alpha and Bravo	2	403	411	N
East Anglia ONE	2	115	119	N
Hornsea Project Two	2	66	85	N
Kincardine	2	446	455	N
Moray Firth East	2	582	591	DEP and SEP
Neart na Gaoithe	2	383	391	N
Triton Knoll	2	13	19	N
Dogger Bank A and B (formerly Creyke Beck A and B)	3	149	168	N
Dogger Bank C (formerly Teesside A) and Sofia (formerly Teesside B)	3	194	214	N
East Anglia THREE	3	95	107	N
Hornsea Project Three	3	83	106	N
Inch Cape	3	401	409	N
Methil	3	436	448	DEP and SEP

Project	Tier	Minimum Distance to DEP (km)	Minimum Distance to SEP (km)	Land Crossing
Moray Firth West	3	584	592	DEP and SEP
East Anglia TWO	4	103	104	SEP
East Anglia ONE North	4	98	101	N
Norfolk Boreas	4	83	99	N
Norfolk Vanguard	4	89	103	N
Hornsea Project Four	5	52	66	N

13.7.3 Assessment of Cumulative Impacts

508. Having established the impacts from DEP and/or SEP with the potential to contribute to cumulative impact along with impacts from the other relevant plans, projects and activities (**Table 13-75**), the following sections provide an assessment of the predicted level of impact.

509. The level of data available and the ease with which impacts can be combined across OWFs included in the assessment is variable, reflecting the availability of relevant data for older projects and the approach to assessment taken. OWFs in tiers 5 and 6 cannot be included in a quantitative cumulative assessment due to a lack of available information on these projects.

510. **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment** provides detail on the data sources used to underpin the numbers ascribed to each project for each of the species assessed as part of the CIA.

13.7.3.1 Cumulative Impact 1: Operational Disturbance, Displacement and Barrier Effects

511. The species assessed for project alone operational displacement impacts (and the biologically relevant seasons (Furness, 2015)) 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), little gull (non-breeding season), red-throated diver (autumn migration, winter and spring migration), and Sandwich tern (autumn migration, spring migration and breeding season).

512. A review of the BDMPS regions for each species indicated that for gannet, guillemot and razorbill, all OWFs identified for inclusion in the CIA in **Table 13-75** and **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment** have the potential to contribute a cumulative effect.

513. Little gull is not considered further by the CIA. This species is a passage migrant and included in the project-alone assessment on the basis of its conservation value (i.e. birds are likely to be members of the Greater Wash SPA population). The species has a relatively low sensitivity to this impact, and the mortality levels predicted in **Section 13.6.2.1.3** are very low. Therefore, displacement and barrier effects in the North Sea are less likely to result in population level effects than for other species present for longer periods.

514. 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 near-shore shallow waters during the non-breeding season, OWFs further from the coast were also excluded. As many OWF assessments have previously not quantitatively considered red-throated diver, an alternative approach to examining the potential for cumulative impact has been followed in addition to the standard approach of extracting quantitatively expressed impacts from the assessments of other OWFs.

515. 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 13.6.2.1.5**), additional work to assess the potential for mortality within this population during the breeding season has been undertaken.

13.7.3.1.1 Gannet

516. 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 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**. The seasonal totals by tier, along with the contribution made by DEP and SEP, is presented in **Table 13-76**. 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.

Table 13-76: 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	14,025	3,228	17,193	34,506
4 to 6 (i.e. pre-determination)	8,042	2,882	4,621	15,545
DEP	343	47	361	753
SEP	295	0	40	335
Total	22,705	6,217	22,215	51,137

517. Based on the largest annual BDMPS of 456,298 (autumn migration; (Furness, 2015)), and a baseline mortality of 0.191 (**Table 13-16**), 87,153 individual gannets would be expected to die annually from this population.

518. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness, 2015), 225,380 individuals would be expected to die annually from this population.

519. At displacement rates of 60% to 80% and a 1% mortality rate (**Section 13.6.2.1.1**) between 0 and 409 gannets would be predicted to die from cumulative displacement annually.

520. The addition of a maximum of 409 individuals would represent a 0.47% increase in annual mortality within the largest BDMPS population. Within the annual biogeographic population with connectivity to UK waters, the maximum additional mortality of up to 409 individuals would represent an 0.18% increase in mortality.

521. These mortality increases would not be detectable at the population level within the context of natural variation, and are considered to be highly precautionary predictions. Although there is evidence that gannets avoid flying through OWFs (**Section 13.6.2.1.1**), they are wide ranging and highly flexible in their foraging requirements, so exclusion from OWFs in the North Sea, is very unlikely to represent a habitat loss of any importance.

522. Therefore, the year round magnitude of cumulative operational displacement on gannet is assessed as negligible. As gannet is of medium sensitivity to disturbance, the impact significance is **minor negative**.

523. The potential for DEP and SEP to contribute to a significant cumulative displacement effect on gannet is considered to be negligible both individually and combined.

13.7.3.1.2 Guillemot

524. The number of birds at risk of displacement from OWFs in the UK North Sea and Channel BDMPS is included in **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**. The seasonal totals by tier, along with the contribution made by DEP and SEP, is presented in **Table 13-77**.

Table 13-77: 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	150,895	156,087	306,982
4 to 6 (i.e. pre-determination)	81,036	28,151	109,187
DEP	8,061	2,977	11,038
SEP	610	599	1,209
Total	240,602	187,814	428,416

525. Based on the largest annual BDMPS of 1,617,306 (non-breeding; (Furness, 2015)), and baseline mortality of 0.140 (**Table 13-16**), 226,423 individual guillemots would be expected to die annually from this population.

526. With respect to the annual 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.

527. At displacement rates of 30% to 70%, and 1% to 10% mortality of displaced birds (**Section 13.6.2.1.2**) between 1,285 and 29,989 guillemots would be predicted to die from cumulative displacement annually.

528. This would represent an increase in annual mortality within the largest BDMPS population of between 0.56% and 11.70%. Within the annual biogeographic population with connectivity to UK waters, the additional mortality would represent an increase of between 0.22% and 4.94% in mortality.

529. Using a range of displacement of 30% to 70% and mortality of 1% to 10% for displaced birds predicts changes in population mortality rates which are likely to be undetectable at the lower end and may be detectable at the upper end of the range. On the basis of the worst case approach recommended by Natural England (70% displacement and a maximum 10% mortality), the cumulative operational displacement impact on guillemot is assessed as of medium impact magnitude.

530. Recommendations of an evidence-based review (Vattenfall, 2019) are for a displacement rate of 50% for auks within an OWF and 30% within a 1km buffer, both combined with a highly precautionary maximum mortality of 1%.

531. Using a 50% displacement rate for OWFs plus buffer zones, along with a 1% mortality rate results in a predicted mortality of 2,142 guillemots annually, representing a 0.94% increase in mortality within the largest BDMPS, and a 0.37% mortality increase within the biogeographic population. This, combined with the various additive sources of precaution in this assessment, indicates there is a very high likelihood that cumulative displacement would be lower than the worst case totals presented, resulting in increases in background mortality below 1%. The magnitude of cumulative displacement is assessed as low, as whilst below 1% in this assessment, the potential exists for mortality increases of >1%. As guillemot is of medium sensitivity to disturbance, the impact significance is **minor negative**.

532. The potential for DEP and SEP to contribute to a significant cumulative displacement effect on guillemot is considered to be negligible both individually and combined.

13.7.3.1.3 Razorbill

533. The number of birds at risk of displacement from OWFs in the UK North Sea and Channel BDMPS is included in **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**. The seasonal totals by tier, along with the contribution made by DEP and SEP, is presented in **Table 13-78**.

Table 13-78: Summary of cumulative numbers of razorbill potentially at risk of displacement for all OWFs included in CIA

Tiers	Autumn mig.	Winter	Spring mig.	Breeding	Annual
1 to 3 (i.e. consented, under construction or operational	34,733	20,188	30,846	29,931	115,698
4 to 6 (i.e. pre-determination)	3,527	1,898	3,455	1,208	14,822
DEP	3,649	720	272	824	5,321
SEP	646	590	148	240	1,624
Total	46,081	23,253	34,721	33,411	137,465

534. Based on the largest annual BDMPS of 591,874 (non-breeding; (Furness, 2015)), and baseline mortality of 0.174 (**Table 13-16**), 102,986 individual razorbills would be expected to die annually from this population.

535. With respect to the annual 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.

536. At displacement rates of 30% to 70%, and 1% to 10% mortality of displaced birds (**Section 13.6.2.1.2**) between 412 and 9,623 razorbills would be predicted to die from cumulative displacement annually.

537. This would represent an increase in annual mortality within the largest BDMPS population of between 0.40% and 8.55%. Within the annual biogeographic population with connectivity to UK waters, the additional mortality would represent an increase of between 0.14% and 3.14% in mortality.

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

539. Recommendations of an evidence-based review (Vattenfall, 2019) are for a displacement rate of 50% for auks within an OWF and 30% within a 1km buffer, both combined with a highly precautionary maximum mortality of 1%.

540. Using a 50% displacement rate for OWFs plus buffer zones, along with a 1% mortality rate results in a predicted mortality of 687 razorbills annually, representing a 0.66% increase in mortality within the largest BDMPS, and a 0.23% mortality increase within the biogeographic population. This, combined with the various additive sources of precaution in this assessment, indicates there is a very high likelihood that cumulative displacement would be lower than the worst case totals presented, resulting in increases in background mortality below 1%. The magnitude of cumulative displacement is assessed as low, as whilst below 1% in this assessment, the potential exists for mortality increases of >1%. As razorbill is of medium sensitivity to disturbance, the impact significance is **minor negative**.

541. The potential for DEP and SEP to contribute to a significant cumulative displacement effect on razorbill is considered to be negligible both individually and combined.

13.7.3.1.4 Red-throated diver

542. Using the SeaMAST data (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, assuming total displacement of birds from all OWFs plus a 4km buffer. Full details are presented in **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.

543. The number of birds at risk of displacement from these OWFs (arranged by tier), in addition to DEP and SEP is presented in **Table 13-80**.

Table 13-79 Summary of cumulative numbers of red-throated diver potentially at risk of displacement for all OWFs included in CIA, based on data extracted 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	2,749	13.8%
4 to 6 (i.e. pre-determination)	427	2.1%
DEP	0	0%
SEP	1	0%
Total	3,176	15.9%

544. 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 is 15.9% of the total reference population of red-throated divers in this area in the non-breeding season. Under the worst case scenario of 100% displacement from OWFs and a 4km buffer, 15.9% of the population of the southern North Sea would be displaced.

545. DEP and SEP 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.

546. Based on data from OWFs in the southern North Sea that have carried out a quantitative assessment of displacement, assuming a range of 90% to 100% displacement from the OWF and a 4km buffer, and 1% to 10% mortality of displaced birds, is between 28 and 316 birds per year (**Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**).

547. The largest BDMPS for red-throated diver is 13,277 during spring and autumn migration (Furness, 2015). At the average baseline mortality rate for red-throated diver of 0.228 (**Table 13-16**), the number of individuals expected to die annually is 3,027 (13,277 x 0.228). The addition of between 28 and 316 additional birds to this would increase the mortality rate by 0.9% to 10.4%.

548. The biogeographic population for red-throated diver with connectivity to UK waters is 27,000 (Furness, 2015). At the average baseline mortality rate for red-throated diver of 0.228 the number of individuals expected to die annually is 6,156 (27,000 x 0.228). The addition of between 28 and 316 additional birds to this would increase the mortality rate by 0.5% to 5.1%.

549. This assessment is considered highly precautionary for a number of reasons. Firstly, the displacement and mortality rates of 100% and 10% are considered excessively precautionary based on a review of evidence (Macarthur Green, 2019). Displacement mortality may be less than 1% and could be as low as zero.

550. Secondly, populations include an unknown degree of double counting across seasons since some individuals will be present within more than one season and could also potentially move between sites.

551. Thirdly, the vast majority of the total annual mortality is predicted to occur during the autumn and spring migration periods when the potential consequences of displacement are expected to be much lower due to the brief duration that birds spend in the area during these seasons.

552. Finally, it is probable that the estimated population of the SW North Sea BDMPS for spring and autumn migration (13,277) is an underestimate. Aerial surveys of the Outer Thames Estuary SPA in 2013 and 2018 produced respective peak population estimates of 14,161 and 22,280 birds (Goodship et al., 2015; Irwin et al., 2019). The SPA lies within the wider BDMPS region, which also includes the Greater Wash SPA.

553. On the basis of the approach recommended by Natural England (100% displacement from the site and a 4km buffer and 10% mortality of displaced birds), the cumulative red-throated diver operational displacement impact magnitude is assessed as medium. However, on the basis of the evidence review both in the above paragraphs, and **Section 13.6.2.1.4**, it is considered that the most realistic, and still precautionary combination of displacement and consequent mortality rates is 90% and 1%. This, combined with the various additive sources of precaution in this assessment suggests there is a very high likelihood that cumulative displacement would be lower than the worst case totals presented here, resulting in increases in background mortality below 1%, and thus the magnitude of cumulative displacement is assessed as low. Therefore, as the species is of high sensitivity to disturbance, the cumulative impact significance would be **moderate negative**.

13.7.3.1.5 Sandwich tern

554. Due to the fact that Sandwich terns were only recorded in the aerial survey study area in large numbers during the breeding season, predicted impacts outside this season were very small (**Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**). For this reason, the CIA for this species focuses on breeding season impacts.

555. 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 DEP and SEP in **Section 13.6.2.1.5**. The reason that these OWFs were selected is that they were the same OWFs considered by the DECC (2012) appropriate assessment for Sandwich tern. All are within the breeding season foraging range of this species from the North Norfolk Coast SPA.

556. For this assessment, only flying bird densities were available, however, on the basis that Sandwich terns spend the overwhelming majority of their time at sea in flight (Garthe and Hüppop, 2004; Perrow et al., 2017), this is not considered to materially affect the assessment.

557. The number of birds at risk of displacement from these OWFs, in addition to DEP and SEP is presented in **Table 13-80**.

Table 13-80 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 (30% to 50%)	Predicted mortality (1% to 5%)
DOW	47	14 - 23	0 - 1
SOW	15	5 - 8	0
Race Bank	43	13 - 22	0 - 1
Triton Knoll	18	5 - 9	0
DEP	179	54 - 89	1 - 4
SEP	77	23 - 38	0 - 2
Total	379	121 - 199	1 - 8

558. At the published baseline annual mortality for this species for adults only (given the assumption that all birds at DEP and SEP during this season are adults) (0.102; **Table 13-16**), the number of Sandwich terns expected to die during the breeding season that are members of the North Norfolk Coast SPA population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 989 (i.e. 9,700 x 0.102).

559. Sandwich tern mortality during the breeding season due to operational phase displacement from the OWFs listed in **Table 13-80** is estimated to be between 1 to 8 individuals based on displacement rates of 30% to 50% and a mortality rate of 1% to 5%. This increases the annual mortality of the North Norfolk Coast SPA population by 0.13% to 0.81%.

560. These mortality increases would not be detectable at the population level within the context of natural variation, and for reasons discussed in **Section 13.6.2.1.5**, it is considered that the lower end of the mortality rate (1%) represents a precautionary scenario, therefore this is the displacement rate used to draw conclusions.

561. The magnitude of cumulative displacement for Sandwich tern is considered to be negligible and the impact significance of cumulative displacement on a receptor of medium sensitivity is **minor negative**.

13.7.3.2 Cumulative Impact 2: Collision Risk

562. Cumulative collision risk was assessed for gannet, great black-backed gull, kittiwake, lesser black-backed gull and Sandwich tern.

563. It is considered that all OWFs identified for inclusion in the CIA in **Table 13-75** and **Appendix 13.2 Supplementary 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 that 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 13.6.2.1.5**), additional work to update this assessment has been undertaken.

564. **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment** provides detail of the projects that have been included in the CIA and which of the design options (e.g. non-material change or consented) were used in the assessment.

13.7.3.2.1 Gannet

565. Seasonal annual cumulative collision predictions for gannet at OWFs by tier, along with the contribution made by the mean collision mortalities for DEP and SEP (14MW scenario), is presented in **Table 13-81**. A more detailed explanation of how these cumulative collision totals were derived is included in **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.

Table 13-81 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	761	316	1,760	2,837
4 to 6 (i.e. pre-determination)	76	23	89	188
DEP	5	0	4	9
SEP	1	0	0	2
Total	844	339	1,853	3,036

566. The annual cumulative total of predicted collisions is 3,036, of which DEP and SEP contribute 11 birds (0.3%).

567. Based on the largest annual BDMPS of 456,298 (autumn migration; (Furness, 2015)), and a baseline mortality of 0.191 (**Table 13-16**), 87,153 individual gannets would be expected to die annually from that population.

568. The biogeographic gannet population with connectivity to UK waters is 1,180,000 (Furness, 2015). Based on the above mortality rate, 225,380 individuals would be expected to die annually from this population.

569. The addition of 3,036 annual collisions would represent a 3.5% increase in the annual mortality of the largest BDMPS population, and a 1.3% increase in the annual mortality of the annual biogeographic population with connectivity to UK waters. These percentage increases could cause detectable effects on population sizes. However, this assessment is considered to incorporate a higher degree of precaution (with respect to both avoidance and nocturnal activity) than the latest evidence suggests represents a realistic yet still precautionary approach.

570. A review of gannet avoidance rates (**Section 13.6.2.2.2.2.3**) indicates that the avoidance rate used by this assessment (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 is reduced for this species by 62%, to 1,147. Overall predicted collision mortality would also be reduced if evidence-based nocturnal activity rates were applied; for DEP and SEP, this reduction was approximately 19%. If applied to other projects, cumulative collision risk would be substantially reduced.

571. Many of the collision estimates for other OWFs were calculated for designs with higher numbers of turbines (and therefore total rotor swept areas) than have been installed (or are planned), which is a key factor in the determination of collision risk. A method for updating collision estimates to account for changes in windfarm design has been developed (Macarthur Green and Royal HaskoningDHV, 2019), which uses ratios of consented and as-built turbine parameters to adjust the collision risk mortality estimates for consented OWFs where this information is provided by developers. Updating the collision estimates for OWFs included in the CIA which have been or will be constructed with a smaller rotor swept area than the consented worst-case reduces the cumulative annual mortality for gannet to 1,723 (**Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**). The values presented in **Table 13-81**, as well as being based on precautionary calculation methods (**Section 13.6.2.2.2**), overestimate the total collision risk by approximately 40% due to the reduced collision risks for projects which undergo design revisions post-consent.

572. Demographic data were collated for the British gannet population to produce a population model which was used to consider the potential impact of additional mortality (WWT Consulting et al., 2012). A density independent version of this model was considered to provide more reliable predictions since it predicted baseline growth at a rate close to that recently observed (1.28% per year compared with an observed rate of 1.33%) while a density dependent version predicted baseline growth of 0.9%. The UK's gannet population has been increasing for many decades, suggesting that the population has not yet reached a level where density-dependent regulation is a major influence on its dynamics. The study concluded that, using the density independent model, population growth, on average, would remain positive until additional mortality exceeded 10,000 individuals per year while the lower 95% confidence interval on population growth remained positive until additional mortality exceeded 3,500 individuals. Both values are substantially greater than the cumulative collision total (**Table 13-81**).

573. WWT Consulting et al. (2012) calculated that 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. The model was based on the British population, so collisions at OWFs on the west coast of the UK have been reviewed for predicted gannet mortality. need to be considered. A review of applications in the Irish Sea and Solway Firth (comprising the following OWFs: Barrow, Burbo Bank, Burbo Bank Extension, Gwynt Y Mor, North Hoyle, Ormonde, Rhyl Flats, Robin Rigg, Walney 1 and 2, Walney Extension and West of Duddon Sands) gave a gannet annual collision cumulative total of 32.4 at an avoidance rate of 0.989. Inclusion of this additional mortality in the assessment does not alter the conclusion that cumulative collisions are below a level at which a significant impact on the British gannet population would result.

574. The work of WWT Consulting et al. (2012) used an estimated gannet population of 261,000 breeding pairs. The most recent census indicates the equivalent number of breeding pairs is now approximately one third higher at 349,498 (Murray et al., 2015). This increase in size will raise the thresholds at which impacts would be predicted and therefore further reduces the risk of significant impacts.

575. In conclusion, the cumulative impact on the gannet population due to collisions both year round and within individual seasons is considered to be of low magnitude, and the relative contribution of DEP and SEP to this cumulative total is very small. Gannets are considered to be of medium sensitivity to collision mortality and the impact significance is therefore **minor negative**.

13.7.3.2.2 Great black-backed gull

576. Seasonal cumulative collision predictions for great black-backed gull by tier, along with the contribution made by the mean collision mortalities for DEP and SEP (14MW scenario), is presented in **Table 13-89**. A more detailed explanation of how these collision rates were derived is included in **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.

577. 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, which is also considered to be appropriate for great black backed gull. For OWFs where a seasonal split was not presented, annual numbers have been multiplied by 0.8 to estimate the non-breeding component and 0.2 to estimate the breeding component.

Table 13-82: 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	713	157	870
4 to 6 (i.e. pre-determination)	115	41	156
DEP	2	0	2
SEP	5	0	5
Total	834	199	1,033

578. The annual cumulative total of predicted collisions is 1,033, of which DEP and SEP contribute seven birds (0.7%).

579. Based on the largest BDMPS population of 91,399 (non-breeding season, Furness (2015)), and baseline mortality of 0.185 (**Table 13-16**), 16,909 individual great black-backed gulls would be expected to die each year from this population. The addition of 1,033 individuals would represent a 6.1% increase in annual mortality.

580. The annual biogeographic population with connectivity to UK waters is 235,000 (Furness, 2015). Using the above mortality rate, 43,475 individuals would be expected to die annually from this population. The addition of 984 individuals would represent a 2.4% increase in mortality.

581. Both of these percentage increases in mortality could cause detectable effects on population sizes. However, this assessment is considered to incorporate a higher degree of precaution (with respect to both avoidance and nocturnal activity) than the latest evidence suggests represents a realistic yet still precautionary approach.

582. Updating the collision estimates for OWFs included in the CIA which have been or will be constructed with a smaller rotor swept area than the consented worst-case (Macarthur Green and Royal HaskoningDHV, 2019) reduces the cumulative annual mortality for great black-backed gull to 844 (**Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**). The values presented in **Table 13-82**, as well as being based on precautionary calculation methods (**Section 13.6.2.2.2**), overestimate the total collision risk by approximately 20% due to the reduced collision risks for projects which undergo design revisions post-consent.

583. A review of nocturnal activity in seabirds (Macarthur Green, 2015a) indicated that the value currently used for this parameter (50%) to estimate collision risk at night for great black-backed gull is almost certainly an overestimate, possibly by as much as a factor of two (i.e. study data suggest that 25% is more appropriate). Reducing the nocturnal activity factor to 25% reduced collision estimates for great black-backed gull at DEP and SEP by approximately 20%. A similar correction applied to the other OWFs included in the CIA would substantially reduce the overall collision mortality for all OWFs by a significant amount (e.g. between 7% and 25%; note the magnitude of reduction varies depending on the time of year and windfarm latitude due to the variation in day and night length). This further emphasises the precautionary nature of the current assessment.

584. A 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). The species has been subject to relatively little research and estimates of demographic rates have been categorised as low quality (Horswill and Robinson, 2015). Comparison of the historical population trend (considered to be stable) with the outputs from a range of models indicated that the density dependent versions generated population predictions which were much more closely comparable to the empirical population trend, and were less sensitive to which set of demographic rates was used. The density dependent versions were therefore considered to provide a more reliable predictive tool.

585. Using the density dependent model, application of an additional annual mortality of 900 to the great black-backed gull North Sea BDMPS 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. The equivalent density independent predictions generated population reductions of 21.3% to 21.5%.

586. To provide context, JNCC population trend data for great black-backed gull indicate that the annual UK population estimate has varied substantially over the last five decades (JNCC, 2020b). For all modelled scenarios the 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.

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

13.7.3.2.3 Kittiwake

588. Seasonal cumulative collision predictions for kittiwake by tier, along with the contribution of the mean collision mortalities made by DEP and SEP (14MW scenario), is presented in **Table 13-83**. A more detailed explanation of how these collision rates were derived is included in **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.

Table 13-83: 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	1,481	1,272	1,327	3,980
4 to 6 (i.e. pre-determination)	99	69	239	407
DEP	9	2	17	28
SEP	2	0	1	3
Total	1,491	1,343	1,584	4,419

589. The annual cumulative total of predicted collisions is 4,419, of which DEP and SEP contribute 31 birds (0.7%).

590. Based on the largest annual BDMPS of 829,937 (autumn migration; (Furness, 2015)), and a baseline mortality of 0.156 (**Table 13-16**), 129,470 individual kittiwakes would be expected to die annually from that population.

591. The biogeographic kittiwake population with connectivity to UK waters of 5,100,000 (Furness, 2015). Based on the same mortality rate, 795,600 individuals would be expected to die annually from this population.

592. The addition of 4,419 annual collisions would represent a 3.4% increase in the annual mortality of the largest BDMPS population, and a 0.6% increase in the annual mortality of the annual biogeographic population with connectivity to UK waters. The percentage increase in mortality for the kittiwake UK North Sea autumn passage BDMPS could cause detectable effects on population size. However, this assessment is considered to incorporate a higher degree of precaution (with respect to both avoidance and nocturnal activity) than the latest evidence suggests represents a realistic yet still precautionary approach.

593. Many of the collision estimates for other OWFs were calculated for designs with higher numbers of turbines (and therefore total rotor swept areas) than have been installed (or are planned), which is a key factor in the determination of collision risk. A method for updating collision estimates to account for changes in windfarm design has been developed (Macarthur Green and Royal HaskoningDHV, 2019), which uses ratios of consented and as-built turbine parameters to adjust the collision risk mortality estimates for consented OWFs where this information is provided by developers. Updating the collision estimates for OWFs included in the CIA which have been or will be constructed with a smaller rotor swept area than the consented worst-case reduces the cumulative annual mortality for kittiwake to 3,340 (**Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**). The values presented in **Table 13-81**, as well as being based on precautionary calculation methods (**Section 13.6.2.2.2**), overestimate the total collision risk by approximately 24% due to the reduced collision risks for projects which undergo design revisions post-consent.

594. A review of kittiwake avoidance rates (**Section 13.6.2.2.2.2.3**) indicates that the avoidance rate used by this assessment (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 is reduced for this species by 10%, meaning that cumulative kittiwake collision mortality would be 2,892, or 2,219 if as-built corrections were made to existing OWF collision rates. Overall predicted collision mortality would be further reduced if evidence-based nocturnal activity rates were applied; for DEP and SEP, this reduction was approximately 22%. If applied to other projects, cumulative collision risk would be substantially reduced.

595. Nocturnal activity values of 50% have been used in the kittiwake CRM. However, 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

596. For the assessment of the East Anglia THREE OWF, density dependent and independent population models were developed to assess the potential effects of cumulative OWF collision mortality on the kittiwake BDMPS populations (Macarthur Green, 2015a). At an annual mortality of 4,000 birds, the density dependent model predicted the population after 25 years would be 3.6% to 4.4% smaller than that predicted in the absence of the additional mortality, while the more precautionary density independent model predicted declines of 10.3% to 10.9%. There is evidence that kittiwake populations are limited by food supply, and therefore are subject to density-dependent regulation (Carroll et al., 2017; Cury et al., 2011; Frederiksen et al., 2007, 2005, 2004; Sandvik et al., 2012). The summary of evidence presented in Macarthur Green (2015a) indicates that the density dependent model is more appropriate for this species in the North Sea.

597. To place these predicted magnitudes of change in context, over three approximately 15 year periods (between censuses) the British kittiwake population changed by +24% (1969 to 1985), -25% (1985 to 1998) and -44% (2000 to 2015) (JNCC, 2020b). When considered within this context, it seems likely that declines of between 3-4% (using the density dependent model) across a longer (25 year) period against a background of changes an order of magnitude larger will almost certainly be undetectable. It is possible that the longer term decline will continue and the population is unlikely to recover over this period, which on the basis that climate change seems to be a key driver in kittiwake declines (Descamps et al., 2017), seems inevitable. 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.

598. Evidence for density dependent regulation of the North Sea kittiwake population was summarised in Macarthur Green (2015a). Density dependence for kittiwake was further explored in a previous PVA for the Flamborough and Filey Coast SPA (Macarthur Green, 2015b). This work identified model parameters which produced population predictions consistent with patterns of seabird population growth which have been observed across a wide range of taxa, including kittiwake (Cury et al., 2011). There is a substantial body of robust evidence for density dependent regulation of the North Sea kittiwake population (and for seabirds more widely), and its inclusion in the kittiwake population model (Macarthur Green, 2015a) balanced this evidence with reasonable precaution. Consequently, the density dependent kittiwake model results are considered to be the more robust ones on which to base this assessment. In relation to this modelling therefore, the precautionary annual mortality predicted in this cumulative assessment (3,214) falls within the level of change likely to be undetectable given the historic fluctuations in the kittiwake population described above.

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

13.7.3.2.4 Lesser black-backed gull

600. Seasonal cumulative collision predictions for lesser black-backed gull by tier, along with the contribution made by the mean collision mortalities of DEP and SEP (14MW scenario), are presented in **Table 13-84**. A more detailed explanation of how these collision rates were derived is included in **Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**.

601. Not all projects included in the CIA provided a seasonal breakdown of collision impacts for this species. For this reason, the breakdown in the CIA is restricted to breeding and non-breeding seasons, as opposed to the full complement of biologically relevant seasons (**Table 13-14**). 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. For OWFs where a seasonal split was not presented, annual numbers have been multiplied by 0.8 to estimate the non-breeding component and 0.2 to estimate the breeding component.

Table 13-84: Summary of cumulative collision rates 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	358	130	488
4 to 6 (i.e. pre-determination)	39	13	52
DEP	0	0	1
SEP	0	0	0
Total	371	168	540

602. The annual cumulative total of predicted collisions is 540, of which DEP and SEP contribute a single bird (0.2%).

603. Based on the largest BDMPS population of 209,007 (autumn migration season, Furness (2015)), and baseline mortality of 0.126 (**Table 13-16**), 26,335 individual lesser black-backed gulls would be expected to die each year from this population. The addition of 540 individuals would represent a 2.1% increase in annual mortality.

604. The annual biogeographic population with connectivity to UK waters is 864,000 (Furness, 2015). Using the above mortality rate, 108,864 individuals would be expected to die annually from this population. The addition of 539 individuals would represent a 0.5% increase in mortality.

605. The percentage increase in mortality could cause detectable effects on the BDMPS population. However, this assessment is considered to incorporate a higher degree of precaution than the latest evidence may suggest is appropriate.

606. Updating the collision estimates for OWFs included in the CIA which have been or will be constructed with a smaller rotor swept area than the consented worst-case (Macarthur Green and Royal HaskoningDHV, 2019) reduces the cumulative annual mortality for lesser black-backed gull to 405 (**Appendix 13.2 Supplementary Information to Inform the Offshore Ornithology Cumulative Impact Assessment**). The values presented in **Table 13-84**, as well as being based on precautionary calculation methods (**Section 13.6.2.2.2**), overestimate the total collision risk by approximately 25% due to the reduced collision risks for projects which undergo design revisions post-consent.

607. A review of nocturnal activity in seabirds (Macarthur Green, 2015a) indicated that the value currently used for this parameter (50%) to estimate collision risk at night for lesser black-backed gull is almost certainly an overestimate, possibly by as much as a factor of two (i.e. study data suggest that 25% is more appropriate). Reducing the nocturnal activity factor to 25% reduced collision estimates for lesser black-backed gull at DEP and SEP by approximately 17%. A similar correction applied to the other OWFs included in the CIA would substantially reduce the overall collision mortality for all OWFs by a significant amount (e.g. between 7% and 25%; note the magnitude of reduction varies depending on the time of year and windfarm latitude due to the variation in day and night length). This further emphasises the precautionary nature of the current assessment.

608. The current cumulative total is considerably lower than previously consented cumulative totals (as much as three times lower), and yet this total still includes several sources of precaution (e.g. consented versus built impacts, overestimated nocturnal activity).

609. In conclusion, the cumulative impact on the lesser black-backed gull population due to predicted collisions both year round and within individual seasons is considered to be of low magnitude, and the relative contribution of DEP and SEP to this cumulative total is very small. Great black-backed gull is considered to be of medium sensitivity to collision, therefore the impact significance is **minor negative**.

13.7.3.2.5 Sandwich tern

610. Due to the fact that Sandwich terns were only recorded in the aerial survey study area in large numbers during the breeding season, predicted impacts outside this season were very small. For this reason, the CIA for this species focuses on breeding season impacts. The approach to Sandwich tern CIA is considered to be above and beyond what is normally undertaken for OWF assessment. The reasons are discussed below.

611. 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 assessment of DEP and SEP in **Section 13.6.2.2.2**. This information was reanalysed as previous calculations had used a CRM which is no longer recommended for the assessment of OWF impacts. These OWFs were also considered by the DECC (2012) appropriate assessment for Sandwich tern. All are within the breeding season foraging range of this species from the North Norfolk Coast SPA.

612. The number of birds at risk of collision from these OWFs based on consented designs presented in DECC (2012) is presented in **Table 13-85**. Also included are the mean collision risk estimates at DEP and SEP calculated for the 14MW deployment scenario. Equivalent values for as-built designs are presented in **Table 13-86**. 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, however unlikely.

Table 13-85: Summary of cumulative operational collision predictions for Sandwich tern for all OWFs included in CIA, based on turbine parameters assessed within DECC (2012)

OWF	Annual collisions (0.980 avoidance rate)	Annual collisions (0.9883 avoidance rate)	Annual collisions (0.993 avoidance rate)
DOW	16.64	9.74	5.82
SOW	9.86	5.77	3.45
Race Bank	42.25	24.71	14.79
Triton Knoll	9.14	5.35	3.20
DEP	9.52	5.57	3.33
SEP	2.00	1.17	0.70
Total	**89.41**	**52.31**	**31.29**

Table 13-86: Summary of cumulative operational collision predictions for Sandwich tern for all OWFs included in CIA, based on as-built turbine parameters

OWF	Annual collisions (0.980 avoidance rate)	Annual collisions (0.9883 avoidance rate)	Annual collisions (0.993 avoidance rate)
DOW	5.65	3.31	1.98
SOW	5.11	2.99	1.79
Race Bank	11.08	6.48	3.88
Triton Knoll	1.31	0.77	0.39
DEP	9.52	5.57	3.33
SEP	2.00	1.17	0.70
Total	**34.67**	**20.29**	**12.07**

613. Depending on avoidance rate used, the existing annual collision mortality for Sandwich terns (upon completion of construction of Triton Knoll OWF) is between 8.04 to 23.15 birds per year when as-built OWF parameters are used. This increases by approximately 40% when collisions from DEP are added, and 10% when collisions from SEP are added, or a total increase in collisions of 50% when worst case, 14MW scenario collision rates from DEP and SEP are added to the existing totals. With DEP and SEP added, total annual collision rates are predicted to be between 12.07 to 34.67 depending on the avoidance rate used.

614. The breeding adult population of the North Norfolk Coast SPA is considered to be the relevant Sandwich tern background population for the breeding season, when almost all of these collisions are predicted. At the published baseline annual mortality for this species for adults only (given the assumption that all birds at DEP and SEP during this season are adults) (0.102; **Table 13-16**), the number of Sandwich terns expected to die during the breeding season that are members of the North Norfolk Coast SPA population (**Appendix 13.1 Offshore Ornithology Technical Report**) is 989 (i.e. 9,700 x 0.102). Using the as-built scenarios, the predicted mortality increase is therefore 1.2% to 3.5%. These effects are potentially large enough to be detectable at the population level.

615. According to Scenario A of the PVA produced for this assessment, an initial annual mortality of 10 birds reduces the annual growth rate by 0.1%. Scenario B (initial mortality of 35 birds) reduces the annual growth rate by 0.3%. In the context of a population that has experienced a mean annual growth of 8.5% between 2010 and 2020 (**Appendix 13.1 Offshore Ornithology Technical Report**), a reduction in the growth rate of this magnitude may not represent a substantial effect on the population, which would likely still be in favourable condition even after a substantial time period of this impact. However, CPS values for these PVA scenarios suggest that detectable impacts on the population may be possible after 25 years of OWF operation (CPS of 0.977 and 0.923 for Scenarios A and B respectively).

616. The use of consented OWF designs from DECC (2012) increases the predicted number of annual collisions by over 200% for the existing OWFs in the Greater Wash area when compared with the as-built scenarios. Depending on avoidance rate used, the existing annual collision mortality for Sandwich terns (upon completion of construction of Triton Knoll OWF) is between 27.26 to 77.89 birds per year. This increases by approximately 12% when collisions from DEP are added, and 3% when collisions from SEP are added, or a total increase in collisions of 15% when worst case, 14MW scenario collision rates from DEP and SEP are added to the existing totals. With DEP and SEP added, total annual collision rates are predicted to be between 31.29 to 89.41 depending on the avoidance rate used. Using the consented scenarios, the predicted mortality increase is therefore 3.2% to 9.0%. These effects are large enough to be detectable at the population level.

617. According to Scenarios B, C and D of the PVA produced for this assessment, an initial annual mortality of 35, 60 and 85 birds reduces the median annual growth rate by 0.3%, 0.6% and 0.8% respectively. In the context of a population that has experienced a mean annual growth of 8.5% between 2010 and 2020 (**Appendix 13.1 Offshore Ornithology Technical Report**), a reduction in the growth rate of this magnitude may not represent a substantial effect on the population, which would likely still be in favourable condition even after a substantial time period of this impact. However, CPS values for these PVA scenarios suggest that relatively large impacts on the population may be possible after 25 years of OWF operation (CPS of 0.923, 0.872 and 0.822 for Scenarios B, C and D respectively).

618. The magnitude of effect of cumulative collision risk for this species is assessed as medium, though it may be low if higher avoidance rates are applicable. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **moderate negative**.

13.7.3.3 Cumulative Impact of Combined Operational Displacement and Collision Risk

619. Two species have been scoped into the assessments for both operational disturbance, displacement and barrier effects, and collision risk: gannet and Sandwich tern. This is because they are the only species included within the cumulative impact assessment 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.

13.7.3.3.1 Gannet

620. The estimated cumulative annual collision mortality for gannet is 3,036 individuals (**Section 13.7.3.2.1**), whilst at displacement rates of 60% to 80% and a 1% mortality rate (**Section 13.6.2.1.1**) between 0 and 409 gannets would be predicted to die from cumulative displacement annually. In total, up to 3,445 gannets could die annually due to these combined cumulative impacts.

621. Based on the largest annual BDMPS of 456,298 (autumn migration; (Furness, 2015)), and a baseline mortality of 0.191 (**Table 13-16**), 87,153 individual gannets would be expected to die annually from this population.

622. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness, 2015), 225,380 individuals would be expected to die annually from this population.

623. The addition of a maximum of 3,445 individuals would represent a 3.95% increase in annual mortality within the largest BDMPS population, and a 1.53% increase in annual mortality within the annual biogeographic population with connectivity to UK waters. These percentage increases could cause detectable effects on population sizes. However, this assessment is considered to incorporate a higher degree of precaution (with respect to both avoidance and nocturnal activity) than the latest evidence suggests represents a realistic yet still precautionary approach. The details provided in **Section 13.7.3.2.1** with respect to sources of precaution within the assessment, and previous modelling work carried out on gannet to establish potential likelihood of population level effects at different mortality levels is relevant to the cumulative impact of combined operational displacement and collision risk.

624. In conclusion, the cumulative impact on the gannet population due to the cumulative impact of combined operational displacement and collision risk year round is considered to be of low magnitude, and the relative contribution of DEP and SEP to this cumulative total is small. Gannets are considered to be of medium sensitivity to collision mortality and medium sensitivity to displacement, and the impact significance is therefore **minor negative**.

13.7.3.3.2 Sandwich tern

625. The estimated cumulative annual collision mortality for Sandwich tern is between 12.07 to 89.41 individuals (**Section 13.7.3.2.5**), whilst at displacement rates of 30% to 50% and a 1% to 5% mortality rate (**Section 13.7.3.1.5**) between one and eight Sandwich terns would be predicted to die from cumulative displacement annually. In total, between 13.07 and 97.41 Sandwich terns could die annually due to these combined cumulative impacts.

626. The discussion included in **Section 13.7.3.2.5** regarding the conclusions of the PVA are also relevant to this combined impact.

627. The magnitude of effect of cumulative combined displacement and collision risk for this species is assessed as medium. As Sandwich tern is of medium sensitivity to collision risk, the impact significance is **moderate negative**.

13.8 Transboundary Impacts

628. In addition to the CIA undertaken in **Section 13.7**, collisions and displacement at OWFs located outside UK territorial waters will also occur, meaning that potential transboundary impacts are greater than that quantitatively assessed here. 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). Whilst a useful indicator of the level of potential impacts on offshore ornithology receptors beyond UK waters, there are a range of limitations that make the approach unsuitable for impact assessment purposes in its current form.

629. Furthermore, the spatial scale and hence seabird reference populations sizes for a transboundary assessment would be much larger, and this information is not presently available. Because of the increased reference populations, it is anticipated that the inclusion of non-UK OWFs is highly likely to reduce the cumulative impact assessed for each species.

13.9 Inter-relationships

630. The construction, operation and decommissioning of DEP and SEP 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 DEP and SEP (**Section 13.6**), this is considered to be the case for indirect impacts through effects on habitats and prey species only.

631. Inter-relationships are summarised in **Table 13-87**, which indicates where assessments carried out in other ES chapters have been used to inform the offshore ornithology assessment.

Table 13-87: Offshore ornithology inter-relationships

Impact	Related chapter	Where addressed in this chapter	Rationale
Construction			
Impact 2: Indirect effects	**Chapter 11: Fish and Shellfish Ecology** **Chapter 10: Benthic Ecology**	**Section 13.6.1.2**	Potential impacts on fish, shellfish and benthic ecology during construction could affect prey resource for offshore ornithology receptors
Operation			
Impact 5: Indirect effects	**Chapter 11: Fish and Shellfish Ecology** **Chapter 10: Benthic Ecology**	**Section 13.6.2.4**	Potential impacts on fish, shellfish and benthic ecology during operation could affect prey resource for offshore ornithology receptors

Impact	Related chapter	Where addressed in this chapter	Rationale
Decommissioning			
Impact 7: Indirect effects	**Chapter 11: Fish and Shellfish Ecology** **Chapter 10: Benthic Ecology**	**Section 13.6.3.2**	Potential impacts on fish, shellfish and benthic ecology during decommissioning could affect prey resource for offshore ornithology receptors

13.10 Interactions

632. The impacts identified and assessed in this chapter have the potential to interact with each other. The areas of potential interaction between impacts are presented in **Table 13-88**. This provides a screening tool for which impacts have the potential to interact, and provides an assessment for each receptor (or receptor group) as related to these impacts. the impacts are assessed relative to each development phase (i.e. construction, operation or decommissioning) to see if (for example) multiple construction impacts affecting the same receptor could increase the level of impact upon that receptor. Following this, a lifetime assessment is undertaken which considers the potential for impacts to affect receptors across all development phases.

633. The significance of each individual impact is determined by the sensitivity of the receptor and the magnitude of effect; the sensitivity is constant whereas the magnitude may differ. Therefore, when considering the potential for impacts to be additive it is the magnitude of effect which is important – the magnitudes of the different effects are combined upon the same sensitivity receptor.

Table 13-88: 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.

13.11 Potential Monitoring Requirements

634. Monitoring requirements will be described in the In-Principle Monitoring Plan (IPMP) submitted alongside the DCO application and further developed and agreed with stakeholders prior to construction based on the IPMP and taking account of the final detailed design of the Projects. It is recognised that monitoring is an important element in the management and verification of the actual impacts predicted in **Section 13.6**.

635. Post-consent, the final detailed design of DEP and SEP will refine the worst-case parameters assessed in **Section 13.6**. 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.

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

13.12 Assessment Summary

637. 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 (offshore windfarm site and export cable corridor to the landfall site) of DEP and SEP.

638. It describes the consultation that has occurred with stakeholders, which has included detailed discussions regarding the overall approach to the impact assessment on offshore ornithology receptors through the ornithology ETG, which involved Natural England and the RSPB.

639. The chapter also describes 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).

640. The aerial survey study area was surveyed using high resolution digital aerial surveys over periods of 24 months (a total of 29 surveys). Data from these surveys have been used to estimate the abundance and assemblage of birds using or passing across the area.

641. The impacts that could potentially occur on offshore ornithology receptors during the construction, operation and decommissioning of DEP and SEP were discussed with Natural England and the RSPB as part of the Evidence Plan process. As a result of those discussions it was agreed that the potential impacts that required detailed assessment were:

642. 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.

643. 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.
644. 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.
645. During the construction and decommissioning phases of the proposed project, no impacts have been assessed to be greater than minor negative 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; guillemot, razorbill and red-throated diver.
646. During the operational phase of DEP and SEP, disturbance, displacement and barrier effects on the more sensitive receptors screened into detailed assessment (gannet, little gull, guillemot, razorbill, red-throated diver and Sandwich tern) would not create impacts of more than minor negative significance during any biological season.
647. The risk to offshore ornithology receptors from collisions with wind turbines at DEP and SEP is assessed as no greater than minor negative significance for all species recorded in flight at the OWF 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). For Sandwich tern, potential project alone impacts of DEP and SEP were evaluated using a PVA.
648. The identified impacts for the project alone assessment are summarised in **Table 13-89**.

649. Two potential effects were screened in for cumulative assessment for DEP and SEP; operational displacement and collision risk. 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 negative significance for all species. This includes Sandwich tern, for which CRM was recalculated for other OWFs within mean maximum foraging range of the North Norfolk Coast SPA, and a PVA undertaken to assess the potential for population level effects.

650. The identified impacts for the cumulative impact assessment are summarised in **Table 13-90**.

651. 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 13-89 Summary of potential impacts of DEP and SEP combined on offshore ornithology receptors

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Construction						
Disturbance, displacement and barrier effects (OWFs)	Guillemot	Medium	Negligible	Minor Negative	None	Minor Negative
	Razorbill	Medium	Negligible	Minor Negative	None	Minor Negative
	Red-throated diver	High	Negligible	Minor Negative	None	Minor Negative
Disturbance, displacement and barrier effects (export and interlink cable corridors)	Red-throated diver	High	Negligible	Minor Negative	None	Minor Negative
Indirect effects	All offshore ornithology receptors	Medium	Negligible	Minor Negative	None	Minor Negative
Operation						
Disturbance, displacement and barrier effects	Gannet	Medium	Negligible	Minor Negative	None	Minor Negative
	Guillemot	Medium	Negligible	Minor Negative	None	Minor Negative
	Razorbill	Medium	Negligible	Minor Negative	None	Minor Negative
	Little gull	Medium	Negligible	Minor Negative	None	Minor Negative
	Red-throated diver	High	Negligible	Minor Negative	None	Minor Negative
	Sandwich tern	Medium	Negligible	Minor Negative	None	Minor Negative

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Collision risk	Common tern	Low	Low	Minor Negative	None	Minor Negative
	Gannet	Medium	Negligible	Minor Negative	None	Minor Negative
	Great black-backed gull	Medium	Negligible	Minor Negative	None	Minor Negative
	Herring gull	Medium	Negligible	Minor Negative	None	Minor Negative
	Kittiwake	Medium	Negligible	Minor Negative	None	Minor Negative
	Lesser black-backed gull	Medium	Negligible	Minor Negative	None	Minor Negative
	Little gull	Medium	Negligible	Minor Negative	None	Minor Negative
	Sandwich tern	Medium	Low	Minor Negative	None	Minor Negative
	Non-breeding waterbirds	Low	Negligible	Minor Negative	None	Minor Negative
Disturbance, displacement and barrier effects combined with collision risk	Gannet	Medium	Negligible	Minor Negative	None	Minor Negative
	Little gull	Medium	Negligible	Minor Negative	None	Minor Negative
	Sandwich tern	Medium	Low	Minor Negative	None	Minor Negative
Indirect effects	All offshore ornithology receptors	Medium	Negligible	Minor Negative	None	Minor Negative
Decommissioning						

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Disturbance, displacement and barrier effects (OWFs)	Guillemot	Medium	Negligible	Minor Negative	None	Minor Negative
	Razorbill	Medium	Negligible	Minor Negative	None	Minor Negative
	Red-throated diver	High	Negligible	Minor Negative	None	Minor Negative
Disturbance, displacement and barrier effects (export and interlink cable corridors)	Red-throated diver	High	Negligible	Minor Negative	None	Minor Negative
Indirect effects	All offshore ornithology receptors	Medium	Negligible	Minor Negative	None	Minor Negative
Disturbance, displacement and barrier effects (OWFs)	Guillemot	Medium	Negligible	Minor Negative	None	Minor Negative
	Razorbill	Medium	Negligible	Minor Negative	None	Minor Negative

Table 13-90 Summary of potential cumulative impacts on offshore ornithology receptors

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Operation						
	Gannet	Medium	Negligible	Minor Negative	None	Minor Negative

Potential impact	Receptor	Sensitivity	Magnitude	Pre-mitigation impact	Mitigation measures proposed	Residual impact
Disturbance, displacement and barrier effects	Guillemot	Medium	Low	Minor Negative	None	Minor Negative
	Razorbill	Medium	Low	Minor Negative	None	Minor Negative
	Red-throated diver	High	Low	Moderate Negative	None	Moderate Negative
	Sandwich tern	Medium	Negligible	Minor Negative	None	Minor Negative
Collision risk	Gannet	Medium	Low	Minor Negative	None	Minor Negative
	Great black-backed gull	Medium	Low	Minor Negative	None	Minor Negative
	Kittiwake	Medium	Low	Minor Negative	None	Minor Negative
	Lesser black-backed gull	Medium	Low	Minor Negative	None	Minor Negative
	Sandwich tern	Medium	Moderate	Moderate Negative	None	Moderate Negative
Disturbance, displacement and barrier effects combined with collision risk	Gannet	Medium	Low	Minor Negative	None	Minor Negative
	Sandwich tern	Medium	Moderate	Moderate Negative	None	Moderate Negative

13.13References

Alerstam, T., Rosén, M., Bäckman, J., Ericson, P.G.P., Hellgren, O., 2007. Flight Speeds among Bird Species: Allometric and Phylogenetic Effects. PLOS Biology 5, e197. https://doi.org/10.1371/journal.pbio.0050197

APEM, 2017. Mainstream Kittiwake and Auk Displacement Report (APEM Scientific Report No. P000001836).

Band, W., 2012. SOSS-02: Using a Collision Risk Model to Assess Bird Collision Risks For Offshore Wind Farms (No. SOSS-02).

Bellebaum, J., Diederichs, A., Kube, J., Schulz, A., Nehls, G., 2006. Flucht- und Meidedistanzen überwinternder Seetaucher und Meeresenten gegenüber Schiffen auf See. Orn. Newsletter Meckl.-Vorp. 45, 86–90.

Black, J., Cook, A.S.C.P., Anderson, O.R., 2019. Better estimates of collision mortality to black-legged kittiwakes at offshore windfarms (JNCC Report No. 644).

Bowgen, K., Cook, A., 2018. Bird Collision Avoidance: Empirical evidence and impact assessments (JNCC Report No. 614). JNCC, Peterborough.

Box, J., Dean, M., Oakley, M., 2017. An Alternative Approach to the Reporting of Categories of Significant Residual Ecological Effects in Environmental Impact Assessment. CIEEM In Practice.

Bradbury, G., Shackshaft, M., Scott-Hayward, L., Rexstad, E., Miller, D., Edwards, D., 2017. Risk assessment of seabird bycatch in UK waters (No. MB0126). WWT.

Bradbury, G., Trinder, M., Furness, B., Banks, A.N., Caldow, R.W.G., Hume, D., 2014. Mapping Seabird Sensitivity to Offshore Wind Farms. PLOS ONE 9, e106366. https://doi.org/10.1371/journal.pone.0106366

Brander, K.M., Ottersen, G., Bakker, J.P., Beaugrand, G., Herr, H., Garthe, S., Gilles, A., Kenny, A., Siebert, U., Skjoldal, H.R., Tulp, I., 2016. Environmental Impacts - Marine Ecosystems, in: Quante, M., Colijn, F. (Eds.), North Sea Region Climate Change Assessment. Springer International Publishing, Cham, pp. 241–274. https://doi.org/10.1007/978-3-319-39745-0_8

Carroll, M.J., Bolton, M., Owen, E., Anderson, G.Q.A., Mackley, E.K., Dunn, E.K., Furness, R.W., 2017. Kittiwake breeding success in the southern North Sea correlates with prior sandeel fishing mortality. Aquatic Conservation: Marine and Freshwater Ecosystems 27, 1164–1175. https://doi.org/10.1002/aqc.2780

Centrica Energy, 2009a. Race Bank Offshore Wind Farm Environmental Statement Chapter 6: Biological Environment.

Centrica Energy, 2009b. Race Bank Offshore Wind Farm Environmental Statement Chapter 6: Biological Environment, Appendix A23: Bird Counts and Densities.
Christensen, T.K., Hounisen, J.P., Clausager, I., Petersen, I.K., 2004. Visual and radar observations of birds in relation to collision risk at the Horns Rev offshore wind farm: Annual status report 2003 (Report commissioned by Elsam Engineering A/S 2003). National Environmental Research Institute, Denmark.
CIEEM, 2018. Guidelines for Ecological Impact Assessment in the UK and Ireland. CIEEM, Winchester.
Cleasby, I.R., Owen, E., Wilson, L.J., Bolton, M., 2018. Combining habitat modelling and hotspot analysis to reveal the location of high density seabird areas across the UK (Research Report No. 63). RSPB Centre for Conservation Science.
ClimeFish, 2019. Climate Change Virtual Fact Sheets.
Cook, A.S.C.P., Humphreys, E.M., Bennet, F., Masden, E.A., Burton, N.H.K., 2018. Quantifying avian avoidance of offshore wind turbines: Current evidence and key knowledge gaps. Marine Environmental Research 140, 278–288. https://doi.org/10.1016/j.marenvres.2018.06.017
Cook, A.S.C.P., Humphreys, E.M., Masden, E.A., Burton, N.H.K., 2014. The Avoidance Rates of Collision Between Birds and Offshore Turbines (No. Volume 5 Number 16), Scottish Marine and Freshwater Science.
Corrigendum, 2014. . Journal of Applied Ecology 51, 1126–1130. https://doi.org/10.1111/1365-2664.12260
Cramp, S., Simmons, K.E.L. (Eds.), 1983. Handbook of the Birds of Europe, the Middle East and North Africa: The Birds of the Western Palearctic. Volume 3: Waders to Gulls. Oxford University Press.
Crowell, S.E., Wells-Berlin, A.M., Carr, C.E., Olsen, G.H., Therrien, R.E., Yannuzzi, S.E., Ketten, D.R., 2015. A comparison of auditory brainstem responses across diving bird species. Journal of comparative physiology. A, Neuroethology, sensory, neural, and behavioral physiology 201, 803–815. https://doi.org/10.1007/s00359-015-1024-5
Cury, P.M., Boyd, I.L., Bonhommeau, S., Anker-Nilssen, T., Crawford, R.J.M., Furness, R.W., Mills, J.A., Murphy, E.J., Österblom, H., Paleczny, M., Piatt, J.F., Roux, J.-P., Shannon, L., Sydeman, W.J., 2011. Global Seabird Response to Forage Fish Depletion - One-Third for the Birds. Science 334, 1703. https://doi.org/10.1126/science.1212928
Daunt, F., Mitchell, I., 2013. Impacts of climate change on seabirds. MCCIP Science Review 2013 125–133. https://doi.org/10.14465/2013.arc14.125-133

Daunt, F., Mitchell, I., Frederiksen, M., 2017. Seabirds. MCCIP Science Review 2017 42–46.
Daunt, F., Wanless, S., Greenstreet, S.P.R., Jensen, H., Hamer, K.C., Harris, M.P., 2008. The impact of the sandeel fishery closure on seabird food consumption, distribution, and productivity in the northwestern North Sea. Can. J. Fish. Aquat. Sci. 65, 362–381. https://doi.org/10.1139/f07-164
DECC, 2012. Record of the Appropriate Assessment Undertaken for Applications Under Section 36 of the Electricity Act 1989: Docking Shoal Offshore Wind Farm (as amended), Race Bank Offshore Wind Farm (as amended), Dudgeon Offshore Wind Farm. DECC.
DECC, 2011a. Overarching National Policy Statement for Energy (EN-1).
DECC, 2011b. National Policy Statement for Renewable Energy Infrastructure (EN-3).
DECC, 2011c. National Policy Statement for Electricity Networks Infrastructure (EN-5).
DEFRA, 2019. Marine strategy part one: UK updated assessment and Good Environmental Status: Consultation document.
Deppe, L., Rowley, O., Rowe, L.K., Shi, N., McArthur, N., Gooday, O., Goldstien, S.J., 2017. Investigation of fallout events in Hutton's shearwaters (Puffinus huttoni) associated with artificial lighting. Notornis 64, 181–191.
Descamps, S., Anker-Nilssen, T., Barrett, R.T., Irons, D.B., Merkel, F., Robertson, G.J., Yoccoz, N.G., Mallory, M.L., Montevecchi, W.A., Boertmann, D., Artukhin, Y., Christensen-Dalsgaard, S., Erikstad, K.-E., Gilchrist, H.G., Labansen, A.L., Lorentsen, S.-H., Mosbech, A., Olsen, B., Petersen, A., Rail, J.-F., Renner, H.M., Strøm, H., Systad, G.H., Wilhelm, S.I., Zelenskaya, L., 2017. Circumpolar dynamics of a marine top-predator track ocean warming rates. Global Change Biology 23, 3770–3780. https://doi.org/10.1111/gcb.13715
DHI, 2020a. SEANSE: Cumulative displacement impacts on seabirds.
DHI, 2020b. SEANSE: Seabird cumulative collision risk.
Dias, M.P., Martin, R., Pearmain, E.J., Burfield, I.J., Small, C., Phillips, R.A., Yates, O., Lascelles, B., Borboroglu, P.G., Croxall, J.P., 2019. Threats to seabirds: A global assessment. Biological Conservation 237, 525–537. https://doi.org/10.1016/j.biocon.2019.06.033
Dierschke, V., Furness, R.W., Garthe, S., 2016. Seabirds and offshore wind farms in European waters: Avoidance and attraction. Biological Conservation 202, 59–68. https://doi.org/10.1016/j.biocon.2016.08.016

Dierschke, V., Furness, R.W., Gray, C.E., Petersen, I.K., Schmutz, J., Zydelis, R., Daunt, F., 2017. Possible Behavioural, Energetic and Demographic Effects of Displacement of Red-throated Divers (JNCC Report No. 605). JNCC, Peterborough.

Dooling, R.J., Therrien, S.C., 2012. Hearing in Birds: What Changes From Air to Water, in: Popper, A.N., Hawkins, A. (Eds.), The Effects of Noise on Aquatic Life. Springer New York, pp. 77–82.

Dorsch, M., Burger, C., Heinänen, Kleinschmidt, B., Morkūnas, J., Nehls, G., Quillfedlt, P., Schubert, A., Žydelis, R., 2020. DIVER: German tracking study of seabirds in areas of planned Offshore Wind Farms at the example of divers (Funded by the Federal Ministry of Economics and Energy (BMWi) on the basis of a decision by the German Bundestag. No. 0325747A/B).

Duckworth, J., Green, J., Daunt, F., Johnson, L., Lehikoinen, P., Okill, D., Petersen, A., Petersen, I.K., Väisänen, R., Williams, J., Williams, S., O'Brien, S., 2020. Red-throated Diver Energetics Project: Preliminary Results from 2018/19 (JNCC Report No. 638). JNCC.

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

Elston, D.A., Sales, D.I., Gill, J.P., 2016. Analysis of ornithological data for Greater Gabbard Offshore Wind Farm to August 2015 (Report for Greater Gabbard Offshore Winds Limited).

Fijn, R.C., Gyimesi, A., 2018. Behaviour related flight speeds of Sandwich Terns and their implications for wind farm collision rate modelling and impact assessment. Environmental Impact Assessment Review 71, 12–16. https://doi.org/10.1016/j.eiar.2018.03.007

Fliessbach, K.L., Borkenhagen, K., Guse, N., Markones, N., Schwemmer, P., Garthe, S., 2019. A Ship Traffic Disturbance Vulnerability Index for Northwest European Seabirds as a Tool for Marine Spatial Planning. Frontiers in Marine Science 6, 192. https://doi.org/10.3389/fmars.2019.00192

Frederiksen, M., Edwards, M., Mavor, R., Wanless, S., 2007. Regional and annual variation in Black-legged Kittiwake breeding productivity is related to sea surface temperature. Marine Ecology Progress Series 350, 137–143. https://doi.org/10.3354/meps07126

Frederiksen, M., Wanless, S., Harris, M.P., Rothery, P., Wilson, L.J., 2004. The role of industrial fisheries and oceanographic change in the decline of North Sea black-legged kittiwakes. Journal of Applied Ecology 41, 1129–1139. https://doi.org/10.1111/j.0021-8901.2004.00966.x

Frederiksen, M., Wright, P.J., Harris, M.P., Mavor, R.A., Heubeck, M., Wanless, S., 2005. Regional patterns of kittiwake Rissa tridactyla breeding success are related to variability in sandeel recruitment. Mar Ecol Prog Ser 300, 201–211.

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

Furness, R.W., Tasker, M.L., 2000. Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. Mar Ecol Prog Ser 202, 253–264.

Furness, R.W., Wade, H.M., 2012. Vulnerability of Scottish seabirds to offshore wind turbines. Marine Scotland Science.

Furness, R.W., Wade, H.M., Masden, E.A., 2013. Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management 119, 56–66. https://doi.org/10.1016/j.jenvman.2013.01.025

Garthe, S., Hüppop, O., 2004. Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology 41, 724–734. https://doi.org/10.1111/j.0021-8901.2004.00918.x

Gill, P., Elston, D., Grant, M., Sales, D., Clough, R., McMyn, I., 2018. Operational and Construction Monitoring and Analysis of Nine Years of Ornithological Data at Greater Gabbard Offshore Wind Farm.

Goodship, N., Caldow, R., Clough, S., Korda, R., Mcgovern, S., Rowlands, N., Rehfisch, M., 2015. Surveys of red-throated divers in the outer Thames estuary SPA. British Birds 108, 506–513.

Grandgeorge, M., Wanless, S., Dunn, T., Myriam, M., Beaugrand, G., Grémillet, D., 2008. Resilience of the British and Irish seabird Community in the twentieth century. Aquatic Biology 4, 187–199. https://doi.org/10.3354/ab00095

Green, R., Thaxter, C.B., Collier, M.P., Burton, N.H.K., Taylor, R., Bowgen, K., Cook, A.S.C.P., Fijn, R.C., 2019. Tracking breeding Sandwich terns on the North Norfolk Coast: Results report 2019 (No. 19–193). Bureau Waardenburg bv.

Green, R.E., Langston, R.H.W., McCluskie, A., Sutherland, R., Wilson, J.D., 2016. Lack of sound science in assessing wind farm impacts on seabirds. Journal of Applied Ecology 53, 1635–1641. https://doi.org/10.1111/1365-2664.12731

Greenstreet, S., Fraser, H., Armstrong, E., Gibb, I., 2010. Monitoring the consequences of the northwestern North Sea sandeel fishery closure (Scottish Marine and Freshwater Science No. Volume 1, Number 6).

Guse, N., Garthe, S., Schirmeister, B., 2009. Diet of red-throated divers Gavia stellata reflects the seasonal availability of Atlantic herring Clupea harengus in the southwestern Baltic Sea. Journal of Sea Research 62, 268–275. https://doi.org/10.1016/j.seares.2009.06.006

Harwood, A.J.P., Perrow, M.R., Berridge, R.J., Tomlinson, M.L., 2018. Ornithological monitoring during the construction and operation of Sheringham Shoal Offshore Wind Farm: February 2009 – February 2016 inclusive. ECON Ecological Consultancy Ltd.

Hayhow, D.B., Ausden, M.A., Bradbury, R.B., Burnell, D., Copeland, A.I., Crick, H.Q.P., Eaton, M.A., Frost, T., Grice, P.V., Hall, C., Harris, S.J., Morecroft, M.D., Noble, D.G., Pearce-Higgins, J.W., Watts, O., Williams, J.M., 2017. The state of the UK's birds 2017. he RSPB, BTO, WWT, DAERA, JNCC, NE and NRW, Sandy, Bedfordshire.

Heinänen, S., Skov, H., 2018. Offshore Wind Farm Eneco Luchterduinen Ecological Monitoring of Seabirds T3 (Final) Report. DHI.

Hi Def Aerial Surveying, 2017. Lincs Wind Farm: Third annual post-construction aerial ornithological monitoring report.

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

Irwin, C., Scott, M.S., Humphries, G., Webb, A., 2019. HiDef report to Natural England - Digital video aerial surveys of red-throated diver in the Outer Thames Estuary Special Protection Area 2018 (Natural England Commissioned Reports No. 260).

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

Jenouvrier, S., 2013. Impacts of climate change on avian populations. Global Change Biology 19, 2036–2057. https://doi.org/10.1111/gcb.12195

JNCC, 2020a. Seabird Monitoring Programme Online Database (Online Database). JNCC.

JNCC, 2020b. Seabird Population Trends and Causes of Change: 1986-2018 Report. Joint Nature Conservation Committee, Peterborough.

Johansen, S., Larsen, O.N., Christensen-Dalsgaard, J., Seidelin, L., Huulvej, T., Jensen, K., Lunneryd, S.-G., Boström, M., Wahlberg, M., 2016. In-Air and Underwater Hearing in the Great Cormorant (Phalacrocorax carbo sinensis). The Effects of Noise on Aquatic Life II 875, 505–512.

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M., Burton, N.H.K., 2014. Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology 51, 31–41. https://doi.org/10.1111/1365-2664.12191

Kleinschmidt, B., Burger, C., Dorsch, M., Nehls, G., Heinänen, S., Morkūnas, J., Žydelis, R., Moorhouse-Gann, R.J., Hipperson, H., Symondson, W.O.C., Quillfeldt, P., 2019. The diet of red-throated divers (Gavia stellata) overwintering in the German Bight (North Sea) analysed using molecular diagnostics. Marine Biology 166, 77. https://doi.org/10.1007/s00227-019-3523-3

Kleinschmidt, B., Dorsch, M., Zydelis, R., Heinänen, S., Morkūnas, J., Nehls, G., Quillfedlt, P., 2016. Ecological diet analysis of red-throated divers wintering in the German North Sea based on molecular methods.

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

Krijgsveld, K.L., Fijn, R.C., Heunks, C., van Horssen, P.W., de Fouw, J., Collier, M.P., Poot, M.J.M., Beuker, D., Dirksen, S., Japink, M., 2011. Effect studies Offshore Wind Farm Egmond aan Zee: Final report on fluxes, flight altitudes and behaviour of flying birds (Commissioned by Noordzeewind No. NoordzeeWind report nr OWEZ_R_231_T1_20111114_flux&flight). Bureau Waardenburg bv.

Langston, R., Teuten, E., Butler, A., 2013. Foraging ranges of northern gannets Morus bassanus in relation to proposed offshore wind farms in the UK: 2010-2012 (Report to DECC). RSPB.

Lawson, J., Kober, K., Win, I., Allcock, Z., Black, J., Reid, J.B., Way, L., O'Brien, S.H., 2016. An assessment of the numbers and distributions of wintering red-throated diver, little gull and common scoter in the Greater Wash (JNCC Report No. 574). JNCC, Peterborough.

Leopold, M.F., van Bemmelen, R.S.A., Zuur, A.F., 2013. Responses of Local Birds to the Offshore Wind Farms PAWP and OWEZ off the Dutch mainland coast (No. C151/12). IMARES - Institute for Marine Resources & Ecosystem Studies, Texel.

Leopold, M.F., Verdaat, H.J.P., 2018. Pilot field study: observations from a fixed platform on occurrence and behaviour of common guillemots and other seabirds in offshore wind farm Luchterduinen (WOZEP Birds-2) (Wageningen Marine Research report No. C068/18). Wageningen Marine Research (University & Research centre).

Lindegren, M., Van Deurs, M., MacKenzie, B.R., Worsoe Clausen, L., Christensen, A., Rindorf, A., 2018. Productivity and recovery of forage fish under climate change and fishing: North Sea sandeel as a case study. Fisheries Oceanography 27, 212–221. https://doi.org/10.1111/fog.12246

Macarthur Green, 2019. Norfolk Vanguard Offshore Wind Farm The Applicant Responses to First Written Questions Appendix 3.1 - Red-throated diver displacement (No. ExA;WQApp3.1;10.D1.3).

Macarthur Green, 2018. Douglas West Wind Farm Extension: Environmental Statement, Appendix 8.1: Ornithology Technical Appendix.

Macarthur Green, 2015a. East Anglia THREE: Environmental Statement Volume 1 - Chapter 13, Offshore Ornithology (No. 6.1.13).
Macarthur Green, 2015b. Flamborough and Filey Coast pSPA Seabird PVA Report (No. Appendix M to the Response submitted for Deadline IIA Application Reference: EN010053).
Macarthur Green, 2014. Dudgeon Offshore Wind Farm Draft Ornithological Monitoring Programme: Revised Collision Risk Modelling.
Macarthur Green, Royal HaskoningDHV, 2019. Cumulative Ornithological Collision Risk Database: May 2019.
MacDonald, A., Heath, M., Edwards, M., Furness, R., Pinnegar, J.K., Wanless, S., Speirs, D., Greenstreet, S., 2015. Climate driven trophic cascades affecting seabirds around the British Isles. Oceanography and Marine Biology - An Annual Review 53, 55–79. https://doi.org/10.1201/b18733-3
MacDonald, A., Heath, M.R., Greenstreet, S.P.R., Speirs, D.C., 2019. Timing of Sandeel Spawning and Hatching Off the East Coast of Scotland. Frontiers in Marine Science 6, 70. https://doi.org/10.3389/fmars.2019.00070
MacDonald, A., Speirs, D.C., Greenstreet, S.P.R., Heath, M.R., 2018. Exploring the Influence of Food and Temperature on North Sea Sandeels Using a New Dynamic Energy Budget Model. Frontiers in Marine Science 5, 339. https://doi.org/10.3389/fmars.2018.00339
Masden, E.A., Haydon, D.T., Fox, A.D., Furness, R.W., 2010. Barriers to movement: Modelling energetic costs of avoiding marine wind farms amongst breeding seabirds. Marine Pollution Bulletin 60, 1085–1091. https://doi.org/10.1016/j.marpolbul.2010.01.016
Masden, E.A., Haydon, D.T., Fox, A.D., Furness, R.W., Bullman, R., Desholm, M., 2009. Barriers to movement: impacts of wind farms on migrating birds. ICES Journal of Marine Science 66, 746–753. https://doi.org/10.1093/icesjms/fsp031
Masden, E.A., Reeve, R., Desholm, M., Fox, A.D., Furness, R.W., Haydon, D.T., 2012. Assessing the impact of marine wind farms on birds through movement modelling. Journal of the Royal Society, Interface 9, 2120–2130. https://doi.org/10.1098/rsif.2012.0121
McGovern, S., Goddard, B., Rehfisch, M., 2016. Assessment of Displacement Impacts of Offshore Windfarms and Other Human Activities on Red-throated Divers and Alcids (Natural England Commissioned Report No. NECR227). APEM Ltd.
McGregor, R.M., King, S., Donovan, C.R., Caneco, B., Webb, A., 2018. A Stochastic Collision Risk Model for Seabirds in Flight. Marine Scotland.
Mendel, B., Schwemmer, P., Peschko, V., Müller, S., Schwemmer, H., Mercker, M., Garthe, S., 2019. Operational offshore wind farms and associated ship traffic cause profound

changes in distribution patterns of Loons (Gavia spp.). Journal of Environmental Management 231, 429–438. https://doi.org/10.1016/j.jenvman.2018.10.053

Mitchell, I., Daunt, F., Frederiksen, M., Wade, K., 2020. Impacts of climate change on seabirds, relevant to the coastal and marine environment around the UK. MCCIP Science Review 2020 382–399. https://doi.org/10.14465/2020.arc17.sbi

MMO, 2018. Displacement and habituation of seabirds in response to marine activities (No. MMO 1139). Marine Management Organisation.

Morley, T.I., Fayet, A.L., Jessop, H., Veron, P., Veron, M., Clark, J., Wood, M.J., 2016. The seabird wreck in the Bay of Biscay and South-Western Approaches in 2014: A review of reported mortality. Seabird 29.

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

Nehls, G., Burger, C., Kleinschmidt, B., Quillfeldt, P., Heinänen, S., Morkunas, J., Zydelis, R., 2018. From effects to impacts: Analysing displacement of Red-throated Divers in relation to their wintering home ranges. Presented at the Actes du Séminaire Eolien et Biodiversité, Artigues-près-Bordeaux.

Newell, M., Wanless, S., Harris, M.P., Daunt, F., 2015. Effects of an extreme weather event on seabird breeding success at a North Sea colony. Marine Ecology Progress Series 532, 257–268. https://doi.org/10.3354/meps11329

NIRAS Consulting, 2016. Gunfleet Sands 1&2 Offshore Wind Farms Ornithology Statistical Analysis Annex (No. 2550158).

O'Brien, S., Ruffino, L., Lehikoinen, P., Johnson, L., Lewis, M., Petersen, A., Petersen, I.K., Okill, D., Väisänen, R., Williams, J., Williams, S., 2018. Red-Throated Diver Energetics Project - 2018 Field Season Report (JNCC Report No. 627). JNCC, Peterborough.

Palmer, M., Howard, T., Tinker, J., Lowe, J., Bricheno, L., Calvert, D., Edwards, T., Gregory, J., Harris, G., Krijnen, J., Pickering, M., Roberts, C., Wolf, J., 2018. UKCP18 Marine report November 2018. Met Office.

Pennycuick, C., 1997. Actual and “optimum” flight speeds: field data reassessed. J. Exp. Biol. 200, 2355.

Pennycuick, C.J., 1987. Flight of Auks (Alcidae) and Other Northern Seabirds Compared with Southern Procellariiformes: Ornithodolite Observations. J. Exp. Biol. 128, 335.

Percival, S., 2014. Kentish Flats Offshore Wind Farm: Diver Surveys 2011-12 and 2012-13. Ecology Consulting, Durham.

Percival, S., Ford, J., 2017. Kentish Flats Offshore Wind Farm Extension: Ornithological survey annual report, October 2016 - March 2017 (post-construction year 2) (Report for Vattenfall).

Pérez-Domínguez, R., Barrett, Z., Busch, M., Hubble, M., Rehfisch, M., Enever, R., 2016. Designing and applying a method to assess the sensitivities of highly mobile marine species to anthropogenic pressures (Natural England Commissioned Report No. 213).

Perrow, M., Harwood, A., Berridge, R., Skeate, E., 2017. The foraging ecology of Sandwich terns in north Norfolk. British Birds 110, 257–277.

Perrow, M.R., Gilroy, J.J., Skeate, E.R., Mackenzie, A., 2010. Quantifying the relative use of coastal waters by breeding terns: towards effective tools for planning & assessing the ornithological impact of offshore wind farms (No. COWRIE TERN-07-08).

Petersen, I.K., Christensen, T.K., Kahlert, J., Desholm, M., Fox, A.D., 2006. Final results of bird studies at the offshore wind farms at Nysted and Horns Rev, Denmark. National Environmental Research Institute.

Petersen, I.K., Nielsen, R.D., Mackenzie, M.L., 2014. Post-construction evaluation of bird abundances and distributions in the Horns Rev 2 offshore wind farm area, 2011 and 2012 (Report commissioned by DONG Energy).

Planning Inspectorate, 2018. Advice note nine: Using the Rochdale Envelope.

Raine, H., Borg, J.J., Raine, A., Bairner, S., Cardona, M.B., 2007. Light pollution and its effect on Yelkouan Shearwaters in Malta; causes and solutions (EU LIFE Yelkouan Shearwater Project Report). Birdlife Malta.

Régnier, T., Gibb, F.M., Wright, P.J., 2019. Understanding temperature effects on recruitment in the context of trophic mismatch. Scientific Reports 9, 15179. https://doi.org/10.1038/s41598-019-51296-5

Rehfisch, M., Barrett, Z., Brown, L., Buisson, R., Perez-Dominguez, R., Clough, S., 2014. Assessing Northern Gannet Avoidance of Offshore Wind Farms (Report on behalf of East Anglia Offshore Wind Ltd). APEM Ltd.

Rodríguez, A., García, D., Rodríguez, B., Cardona, E., Parpal, L., Pons, P., 2015. Artificial lights and seabirds: is light pollution a threat for the threatened Balearic petrels? Journal of Ornithology 156, 893–902. https://doi.org/10.1007/s10336-015-1232-3

Royal HaskoningDHV, 2019. Assessment of relative impact of anthropogenic pressures on marine species (Part of baseline studies for EU SEANSE Project No. BG8825WATRP2001231026).

Royal HaskoningDHV, 2016. East Anglia THREE: Applicant's Comments on Written Representations (No. Deadline 3 / Applicant's Comments / WR).

RWE NPower Renewables, 2011. Triton Knoll Offshore Wind Farm: Environmental Statement, Volume 3 (Annex H): Ornithology Technical Report, Refined CRM Results and PBR Data.
Sandvik, H., Erikstad, K.E., Sæther, B.-E., 2012. Climate affects seabird population dynamics both via reproduction and adult survival. Marine Ecology Progress Series 454, 273–284.
Sandvik, H., Erikstand, K.E., Barratt, R.T., Yoccoz, N.G., 2005. The effect of climate on adult survival in five species of North Atlantic seabirds. Journal of Animal Ecology 74, 817–831. https://doi.org/10.1111/j.1365-2656.2005.00981.x
Sansom, A., J. Wilson, L., Caldow, R., Bolton, M., 2018. Comparing marine distribution maps for seabirds during the breeding season derived from different survey and analysis methods. PLOS ONE 13, e0201797. https://doi.org/10.1371/journal.pone.0201797
Schwemmer, P., Mendel, B., Sonntag, N., Dierschke, V., Garthe, S., 2011. Effects of ship traffic on seabirds in offshore waters: implications for marine conservation and spatial planning. Ecological Applications 21, 1851–1860. https://doi.org/10.1890/10-0615.1
SCIRA Offshore Energy Ltd, 2006a. Sheringham Shoal Offshore Wind Farm Environmental Statement Chapter 8: Biological Environment, Appendix 8.4: Collision Risk Modelling.
SCIRA Offshore Energy Ltd, 2006b. Sheringham Shoal Offshore Wind Farm Environmental Statement Chapter 8: Biological Environment, Appendix 8.2: Boat-based surveys.
Scottish Power Renewables, 2016. East Anglia THREE Offshore Wind Farm: JNCC and Natural England Suggested Tiers for Cumulative Impact Assessment (No. Deadline 5/ Second Written Questions/ JNCC and NE suggested tiers for CIA/ HRA12).
Searle, K., Mobbs, D., Butler, A., Bogdanova, M., Freeman, S., Wanless, S., Daunt, F., 2014. Population consequences of displacement from proposed offshore wind energy developments for seabirds breeding at Scottish SPAs (No. Vol. 5 No. 13), Scottish Marine and Freshwater Science. Marine Scotland Science.
Searle, K., Mobbs, D., Butler, A., Furness, R.W., Trinder, M., Daunt, F., 2017. Finding out the Fate of Displaced Birds (No. Vol. 9 No. 8), Scottish Marine and Freshwater Science. Marine Scotland Science.
Searle, K., Mobbs, D., Daunt, F., Butler, A., 2019. A Population Viability Analysis Modelling Tool for Seabird Species (Natural England Commissioned Report No. ITT_4555).
Searle, K.R., Butler, A., Mobbs, D.C., Trinder, M., Waggitt, J., Evans, P., Daunt, F., 2020. Scottish Waters East Region Regional Sectoral Marine Plan Strategic Ornithology Study: final report (No. NEC07184). Centre for Ecology & Hydrology.

Skov, H., Heinänen, S., Norman, T., Ward, R.M., Méndez-Roldán, R.S., Ellis, I., 2018. ORJIP Bird Collision and Avoidance Study. Final report – April 2018. The Carbon Trust.
Speakman, J.R., Gray, H., Furness, L., Energy, G.B.D. of, Change, C., Great Britain. Department for Business, I., Skills, Biological, U. of A.I. of, Sciences, E., 2009. University of Aberdeen Report on Effects of Offshore Wind Farms on the Energy Demands on Seabirds. Department for Business, Innovation & Skills.
Topping, C., Petersen, I.K., 2011. Report on a Red-throated Diver Agent-Based Model to assess the cumulative impact from offshore wind farms. Report commissioned by the Environment Group. Aarhus University. Danish Centre for Environment and Energy.
UK SNCBs, 2017. Joint SNCB Interim Displacement Advice Note: Advice on how to present assessment information on the extent and potential consequences of seabird displacement from Offshore Wind Farm (OWF) developments.
UK SNCBs, 2014. Joint Response from the Statutory Nature Conservation Bodies to the Marine Scotland Science Avoidance Rate Review.
Vanermen, N., Courtens, W., Van De Walle, M., Verstraete, H., Stienen, E.W.M., 2016. Seabird monitoring at offshore wind farms in the Belgian part of the North Sea - Updated results for the Bligh Bank & first results for the Thorntonbank (No. INBO.R.2016.11861538). Instituut voor Natuur- en Bosonderzoek.
Vattenfall, 2019. Norfolk Vanguard Deadline 1: Applicants Submission.
Vilela, R., Burger, C., Diederichs, A., Nehls, G., Bachl, F., Szostek, L., Freund, A., Braasch, A., Bellebaum, J., Beckers, B., Piper, W., 2020. Divers (Gavia spp.) in the German North Sea: Changes in Abundance and Effects of Offshore Wind Farms: A study into diver abundance and distribution based on aerial survey data in the German North Sea (Prepared for Bundesverband der Windparkbetreiber Offshore e.V).
Wade, H.M., Masden, E.A., Jackson, A.C., Furness, R.W., 2016. Incorporating data uncertainty when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments. Marine Policy 70, 108–113. https://doi.org/10.1016/j.marpol.2016.04.045
Waggitt, J.J., Evans, P.G.H., Andrade, J., Banks, A.N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C.J., Durinck, J., Felce, T., Fijn, R.C., Garcia-Baron, I., Garthe, S., Geelhoed, S.C.V., Gilles, A., Goodall, M., Haelters, J., Hamilton, S., Hartny-Mills, L., Hodgins, N., James, K., Jessopp, M., Kavanagh, A.S., Leopold, M., Lohrengel, K., Louzao, M., Markones, N., Martínez-Cedeira, J., Ó Cadhla, O., Perry, S.L., Pierce, G.J., Ridoux, V., Robinson, K.P., Santos, M.B., Saavedra, C., Skov, H., Stienen, E.W.M., Sveegaard, S., Thompson, P., Vanermen, N., Wall, D., Webb, A., Wilson, J., Wanless, S., Hiddink, J.G., 2019. Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology n/a. https://doi.org/10.1111/1365-2664.13525

Wakefield, E.D., Bodey, T.W., Bearhop, S., Blackburn, J., Colhoun, K., Davies, R., Dwyer, R.G., Green, J.A., Grémillet, D., Jackson, A.L., Jessopp, M.J., Kane, A., Langston, R.H.W., Lescroël, A., Murray, S., Le Nuz, M., Patrick, S.C., Péron, C., Soanes, L.M., Wanless, S., Votier, S.C., Hamer, K.C., 2013. Space Partitioning Without Territoriality in Gannets. Science 341, 68. https://doi.org/10.1126/science.1236077
Wakefield, E.D., Owen, E., Baer, J., Carroll, M.J., Daunt, F., Dodd, S.G., Green, J.A., Guilford, T., Mavor, R.A., Miller, P.I., Newell, M.A., Newton, S.F., Robertson, G.S., Shoji, A., Soanes, L.M., Votier, S.C., Wanless, S., Bolton, M., 2017. Breeding density, fine-scale tracking, and large-scale modeling reveal the regional distribution of four seabird species. Ecological Applications 27, 2074–2091. https://doi.org/10.1002/eap.1591
Welcker, J., Nehls, G., 2016. Displacement of seabirds by an offshore wind farm in the North Sea. Marine Ecology Progress Series 554, 173–182. https://doi.org/10.3354/meps11812
Wilson, L.J., Black, J., Brewer, M.J., Potts, J.M., Kuepfer, A., Win, I., Kober, K., Bingham, C., Mavor, R., Webb, A., 2014. Quantifying usage of the marine environment by terns Sterna sp. around their breeding colony SPAs (JNCC Report No. 500). JNCC.
Wischnewski, S., Fox, D.S., McCluskie, A., Wright, L.J., 2017. Seabird tracking at the Flamborough & Filey Coast: Assessing the impacts of offshore wind turbines (Pilot study 2017 Fieldwork report & recommendations: Report to Orsted). RSPB Centre for Conservation Science, Sandy.
Woodward, I., Thaxter, C.B., Owen, E., Cook, A.S.C.P., 2019. Desk-based revision of seabird foraging ranges used for HRA screening.
Wright, L.J., Ross-Smith, V.H., Austin, G.E., Massimino, D., Dadam, D., Cook, A.S.C.P., Calbrade, N.A., Burton, N.H.K., 2012. SOSS-05: Assessing the risk of offshore wind farm development to migratory birds designated as features of UK Special Protection Areas (and other Annex 1 species) (BTO Research Report No. 590), SOSS05. British Trust for Ornithology.
Wright, P., Regnier, T., Eerkes-Medrano, D., Gibb, F., 2018. Sandeels and their availability as seabird prey. MCCIP.
WWT Consulting, 2015. SeaMaST II: Updates to databases and modelling.
WWT Consulting, Furness, R.W., Trinder, M., 2012. SOSS-04: Gannet Population Viability Analysis: Demographic data, population model and outputs, SOSS04.