RWE

RWE Renewables UK Dogger Bank South (West) Limited

RWE Renewables UK Dogger Bank South (East) Limited

Dogger Bank South Offshore Wind Farms

Preliminary Environmental Information Report
Chapter 12 – Offshore Ornithology

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Glossary

Term	Definition
Array Areas	The DBS East and DBS West offshore array areas, where the wind turbines and array cables will be located. The array areas do not include the offshore export cable corridor.
Array Cables	Cables which link the wind turbine generators to the offshore substation/converter/collector platform(s).
Collision Risk Model (CRM)	Quantitative means to estimate the number of predicted collisions between seabirds recorded in the DBS Array area and rotating wind turbines.
Dogger Bank South (DBS) Offshore Wind Farms	The collective name for the two Projects, DBS East and DBS West.
Effect	The consequences of an impact combing with a receptor, defined in terms of significance (significance being dependent on magnitude of impact x sensitivity / value / importance of receptor).
Impact	Used to describe a change resulting from an activity via the Projects, i.e. increased suspended sediments / increased noise.
Landfall	The point on the coastline at which the offshore export cables are brought onshore, connecting to the onshore export cables at the Transition Joint Bay.
Offshore Development Area	The Offshore Development Area encompasses the wind farm site and the options for the offshore transmission works.
Offshore Export Cable Corridor	This is the area which will contain the offshore export cables (and potentially the ESP and / or RCP) between the offshore substation/converter platforms and Transition Joint Bays at the landfall.
Offshore Export Cables	The cables which would bring electricity from the offshore substation platform(s) to the landfall.

Term	Definition
Offshore Ornithology Study Area	Area considered for seabird species with potential connectivity to the Project areas and hence subject to assessment. Comprises the North Sea and breeding colonies located along the British coastline of the North Sea.
Offshore Ornithology Survey Area	The offshore ornithology survey area comprises the array areas plus a 4km buffer.
Scoping Opinion	The report adopted by the Planning Inspectorate on behalf of the Secretary of State.
Scoping Report	The report that was produced in order to request a Scoping Opinion from the Secretary of State.
The Applicant	RWE Renewables UK Dogger Bank South (West) Limited and RWE Renewables UK Dogger Bank South (East) Limited as the owners of DBS West and DBS East respectively are the named undertakers that will have the benefit of the Development Consent Order. References in this document to obligations on, or commitments by, 'the Applicant' are given on behalf of RWE Renewables UK Dogger Bank South (West) Limited and RWE Renewables UK Dogger Bank South (East) Limited.
The Projects	DBS East and DBS West (collectively referred to as the Dogger Bank South offshore wind farms).

Acronyms

Term	Definition
BDMPS	Biologically Defined Minimum Population Scale
BoCC	Birds of Conservation Concern
BTO	British Trust for Ornithology
CEA	Cumulative Effects Assessment
CRM	Collision Risk Model
DBS	Dogger Bank South
DCO	Development Consent Order
EIA	Environmental Impact Assessment
ECC	Export Cable Corridor
EPP	Evidence Plan Process
ETG	Expert Topic Group
HRA	Habitats Regulations Assessment
JNCC	Joint Nature Conservation Committee
MMO	Marine Management Organisation
PEIR	Preliminary Environmental Information Report
RSPB	Royal Society for the Protection of Birds
SPA	Special Protection Area

12 Offshore Ornithology

12.1 Introduction

1. This chapter of the Preliminary Environmental Information Report (PEIR) considers the likely significant effects of the Projects on Offshore Ornithology. The chapter provides an overview of the existing environment for the proposed Offshore Development Area, followed by an assessment of likely significant effects for the construction, operation, and decommissioning phases of the Projects.

2. Additional information to support the Offshore Ornithology assessment includes:

- **Appendix 12.1 Offshore Ornithology Technical Appendix**;
- **Appendix 12.2 Offshore Ornithology Seabird abundances – monthly**;
- **Appendix 12.3 Offshore Ornithology Seabird densities – monthly**:
- **Appendix 12.4 Offshore Ornithology Seabird abundances – seasonal**;
- **Appendix 12.5 Offshore Ornithology Seabird densities – seasonal**;
- **Appendix 12.6 Offshore Ornithology Collision Risk Modelling**;
- **Appendix 12.7 Offshore Ornithology Seabird distributions**; and
- **Appendix 12.8 – Consequences for Birds of Obstruction Lighting on Offshore Wind Turbines**.

12.2 Consultation

3. Consultation with regard to Offshore Ornithology has been undertaken in line with the general process described in **Chapter 6 EIA Methodology**. The key elements of consultation to date have included scoping and the ongoing Evidence Plan Process (EPP) via the Offshore Ornithology Expert Topic Group (ETG). The feedback received has been considered in preparing the PEIR. **Table 12-1** provides a summary of how the consultation responses received to date have influenced the approach that has been taken.

4. Early engagement began with Natural England in autumn 2020, with calls held between representatives of the Applicant and Natural England on the 14th September and 27th November 2020, at which ornithology baseline requirements for potential future offshore wind sites under consideration by the Applicant were discussed.

5. An introductory, pre-scoping ETG meeting was held on 13 October 2021, attended by the Applicant, Natural England, the Royal Society for the Protection of Birds (RSPB) and the Marine Management Organisation (MMO). This meeting was an opportunity to introduce the Projects to key stakeholders and outline at a comparatively high-level the baseline and assessment methods to be used. No official responses were received from any stakeholders at this meeting and therefore details from this meeting have not been included in **Table 12-1**.

6. This chapter will be updated following consultation on PEIR in order to produce the final assessment in the Environmental Statement (ES) 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.

Table 12-1 Consultation Responses

Comment	Project Response
Planning Inspectorate scoping responses 02/09/2022	
Direct temporary habitat loss/disturbance due to construction (arrays and export cable(s)). Table 2-24 indicates that this impact is to be scoped out of the operational phase. The Inspectorate understands that this impact is specific to the construction / decommissioning phases and agrees with this approach. The ES should however assess the likely significant effects of temporary habitat loss/disturbance and define clearly what 'temporary' means in the context of the assessment.	Consideration has been given to the potential for construction effects in this PEIR (section 12.6.1).
Indirect impacts through effects on prey species and habitats: accidental pollution (all project phases) Based on the information provided on the proposed mitigation and control measures, the Inspectorate agrees that significant effects from accidental release of pollution during all project phases are unlikely. The ES should provide full details of the proposed mitigation measures for all project phases and describe how they are to be secured.	Project level mitigations are discussed in **Chapter 8 Marine Physical Environment** and referenced in **Table 12-3**.

Comment	Project Response
Barrier effects during construction and decommissioning. The Table indicates that these impacts are to be scoped out of the construction and decommissioning phases. The Inspectorate does not consider that barrier effects are exclusive to the operational phase and cannot agree to scope this matter out. The ES should provide information on the sources of impact and the receptors e.g., migratory birds which could be subject to barrier effects during construction and assess the likely significance of such effects.	Following review of the most recent Natural England guidance (Parker *et al*. 2022c), barrier effects have not been assessed separately. In summary, Parker et al. (2022c) recognises that there is currently insufficient evidence to permit separating barrier effects from displacement effects, and that as a result the recommended displacement assessment approach (which is based on estimates of birds in flight and on the sea and which has been followed in this PEIR) is intended to be sufficiently general that it incorporates both potential effects (i.e. this makes the assumption that birds on the water are more likely to be subject to displacement and birds in flight are more likely to be at risk of barrier effects).
Cumulative effects, including transboundary effects, during construction and decommissioning. The Scoping Report states that the assessment will focus on operational displacement and collision risk, and Table 2-24 shows 'cumulative effects' as scoped out for construction and decommissioning. The Inspectorate considers that the potential exists for cumulative effects during construction given the large number of other developments in the area, and in the absence of construction timescales and locations for the Proposed Development does not agree to	Cumulative construction and decommissioning effects have not been considered in this PEIR since there is currently limited information on the potential for overlap of construction activities across wind farms which could contribute to such cumulative effects. However, on the assumption that further information will become available before the ES is submitted, further consideration will be provided for impacts during

Comment	Project Response
scope out cumulative construction effects. A similar rationale applies to the decommissioning phase. The ES should provide an assessment of likely significant cumulative effects for all project phases.	these phases in the ES. In addition, the Applicant has discussed and agreed the approach to cumulative effects assessment presented in this PEIR with Natural England. **Chapter 6 EIA Methodology** of this report provides further details of the general framework and approach to the CIA, with preliminary assessment being presented in section 12.7.
Study area, surveys, and Characterisation of baseline. The Inspectorate notes the reference to the EPP in the Scoping Report. In the context of offshore ornithology, the Inspectorate advises that, amongst other matters, effort is made to agree via the EPP the extent of study area, the methodologies for data collection and characterisation of the baseline, and the assumptions made around connectivity of the populations within the study area to designated sites. The ES should fully explain how the baseline has been established and the outcomes of consultation undertaken in relation to these matters.	These aspects have been discussed via the EPP, and a method statement outlining proposed approaches submitted to Natural England on the 11 November 2022 (ref: 004569689-01). The PEIR includes summary details of the discussions held to date.
Natural England Scoping Responses 2nd September 2022	
The extent of connectivity between seabird SPAs and offshore wind farms during the breeding season is largely a function of distance and will be informed through review of species specific foraging ranges (see Woodward et al. 2019). The scoping report acknowledges the export cable corridor (ECC) will pass through the Greater Wash SPA.	Colony specific data has been referred to throughout the chapter as appropriate. However, this comment is of primary relevance to matters which will be covered in the Habitats Regulations Assessment.

Comment	Project Response
NE welcome this and advise that colony specific data, where available and appropriate should also be referred to.	
Data collected for the Dogger Bank Creyke Beck and Dogger Bank Teesside projects. In addition to data collected for the Round 3 Dogger Bank Projects NE advise that data collected at the Round 3 Hornsea projects may also be useful and relevant. (Hornsea 1, 2, 3 and 4).	Other data have been considered as appropriate in the assessment.
Flight height data NE acknowledge the difficulties obtaining flight height data from current digital aerial imagery, and hence there has been a dependence on established generic flight height data collected via visual boat-based methods (i.e. Johnston *et al.*2014a, 2014b). However, we would welcome working with all Round 4 developers to improve the knowledge base on flight height either at a project specific or generic level, and encourage further engagement on this.	The Applicant has continued to engage with Natural England on this topic through the ETG and EPP. Natural England has agreed that use of generic flight height data for collision risk modelling remains the most appropriate option.
Other guidance documents SNCB guidance on Displacement has been updated to reflect new evidence for Red Throated Diver. There is also upcoming revised joint SNCB guidance on collision risk modelling (CRM) including revised avoidance rates and other parameters. In the interim, NE has produced a summary of the key parameters and changes expected to be included in this guidance which we will provide to the Applicant through our Discretionary Advice Service.	The Applicant has made reference to the latest guidance in the PEIR as relevant and appropriate (Parker *et al.* 2022a,b,c).

Comment	Project Response
Existing Environment Natural England note that no information has been presented to characterise the existing environment.	The scoping report predated analysis of the survey data, hence it was not possible to present baseline array area site characterisation information at that time. This PEIR presents the results from the first 12 months of survey data. The ES will include all 24 months of survey data.
Species specific seasons NE note that the seasonal definitions provided in Table 2.19 are likely to be appropriate for species at a broad population scale such as at EIA (unless more up to date evidence becomes available, that suggests a change is required). However, NE recommend that colony and project specific data is used to inform colony specific seasons at an HRA level. As such, while the seasons presented in Table 2.19 are likely to be appropriate for the EIA, they are not necessarily appropriate for the HRA.	This PEIR only considers the wider (EIA) scale level of potential impacts, hence the seasonal definitions are considered appropriate, as noted by Natural England. Further consideration will be given in the Habitats Regulations Assessment (HRA) to the selection of appropriate seasonal definitions.
Approach to Data Collection Natural England are in agreement with two years' worth of data being collected via aerial digital surveys on the array area + 4km buffer. However, we urge the applicant to consider other key data gaps in regards quantification of ornithological receptors at the array area, in particular: • Flight height of species sensitive to collision risk (and potentially other parameters that inform collision risk such as nocturnal activity and flight speed) • Data contributing to increased understanding connectivity and apportioning	The Applicant will consider if any of these (and other) data gaps can be addressed within a reasonable time period.

Comment	Project Response
of key species (e.g. tracking work, age classes, observations of adults with attendant young).	
Potential Impacts Natural England is in agreement with the potential impacts identified.	The Applicant welcomes Natural England's agreement on this matter.
Impacts scoped in/out of assessment Natural England is broadly in agreement with the potential impacts identified.	The Applicant welcomes Natural England's agreement on this matter.
Approach to Impact Assessment Natural England are broadly in agreement with the proposed approach to assessment presented here but would expect a more thorough approach to assessment to be outlined within the PEIR/ES.	The Applicant welcomes Natural England's agreement on this matter and notes that further detail on all matters is presented through this PEIR.
Reference population sizes NE note that reference populations for specific SPAs should be informed by the most up to data at that colony rather than depending on Furness (2015).	The Applicant agrees with Natural England on this matter and has sought out more recent counts, where available for use in this PEIR.
Natural England comments on Ornithology Method Statement 9th December 2022	
NE request clarification of the survey schedule, the number of surveys per month, and the months in which surveys are/have been conducted. NE also request clarification that the intention is to present raw data, abundance estimates, and density estimates for all surveys conducted in the 24 month period to inform the final assessment.	Digital Aerial Surveys (DAS) began in March 2021 and were completed in Feb 2023 (i.e. 24 months), with one survey per month. Densities and abundances have been provided in the PEIR for Year 1 surveys and are presented by calendar month, as standard for a wind farm assessment.

Comment	Project Response
	The Applicant is unsure what the term 'raw data' means in the current context. For example, the most 'raw' data would include the complete tables of data supplied by the DAS contractor for observations and tracklines, which can run to thousands of rows of data per survey. It is assumed that this is not what Natural England are requesting, but clarity on this point has been requested.
NE cannot comment at this time on whether the proposed survey coverage will be sufficient for assessment purposes as this will depend on the data collected. NE recommend that Dogger Bank South consider the possible need to analyse additional data if, following the completion of 2 years baseline survey data collection, the survey coverage does not appear to be sufficient for assessment purposes.	The data presented in this PEIR were analysed at a minimum of 10% coverage across the array areas and 4 km buffers. Analysis of the full two year dataset is currently ongoing and will be discussed with NE during post-PEIR consultation.
NE request clarification that upper and lower (95%) confidence limits and precision or coefficient of variation (cv) values will be presented for each estimate.	All densities and abundances have been presented with measures of variation (standard deviation, 95% confidence intervals) and these have been used in the PEIR assessments as appropriate.
NE request clarification that internal QA and validation methods for processing of digital aerial survey data will be presented.	The DAS contractor (APEM) is carrying out internal QA on the data collected from each of the surveys. Images are assessed in batches with a different APEM staff member responsible for each batch. Each image

Comment	Project Response
	containing birds and/or marine megafauna is reviewed and checked by APEM's dedicated QA Manager, ensuring that 100% of birds and marine megafauna recorded are subject to internal QA to confirm that all species are correctly identified. Images containing no birds and/or marine megafauna are removed and stored separately for further internal QA. Of these 'blank' images, 10% are randomly selected for QA. If there is <90% agreement, the entire batch is re-analysed independently by a different member of staff.
NE note that no information has been presented on the proposed methodology for determining flight heights.	As agreed with Natural England, the Digital Aerial Survey supplier's flight height calculations will not be used for assessment purposes. DBS will use published flight height data from Johnston *et al* 2014a and 2014b.
NE note that there is now updated interim advice from NE on collision risk modelling (CRM) parameters – this was provided to the Applicant on the 7th November 2022 and is also provided alongside to this advice.	The updated collision avoidance rates (and other parameters) as supplied by NE have been used in the PEIR assessment (section 12.6.2.3). Based upon current NE advice the use of the updated parameter values has not been extended to projects within the cumulative assessment. We would welcome any revision of this advice to ensure that the

Comment	Project Response
	cumulative assessment is consistent with the project alone assessment and that effects are assessed proportionately.
NE request clarification on the populations being assessed and the baseline mortality parameters being used before we can agree to this methodology – NE looks forward to further engagement with the Applicant on these matters.	The reference populations assessed in the PEIR vary depending on the species and season. In the breeding season, for species within foraging range of breeding colonies, the population has been derived from the colony population, with allowance for sub-adult age birds to also be present. The reference population for species for which breeding season colony connectivity is not expected have been derived from the estimated sub-adult component of the spring BDMPS. In the nonbreeding seasons, the BDMPS and biogeographic populations have been used. Background mortality rates are appropriate to the age class being assessed. If it is just adults, then the adult mortality rate has been used. If it is all age classes, then a weighted average mortality across all age classes has been used.
NE would like to be clear that while predicted impacts lower than 1% of baseline mortality may not be significant at the project level, they will still need to be considered within the in-combination assessment.	This advice is noted and has been considered in this PEIR. However, it is also important to clarify that an increase in background mortality 'lower than 1%' can include extremely small increases, and in those cases,

Comment	Project Response
	there is likely to be little justification for a cumulative assessment.
NE advise that a site-specific bespoke approach to seasonality may be required for some species and look forward to further engagement with the Applicant on this.	The assessment in the PEIR has focussed on wider scale (EIA) effects and impacts, therefore this advice is more relevant to the colony specific assessment to be presented in the HRA.
NE note the lack of detail provided on apportioning methodology and look forward to further engagement with the Applicant on this.	In the HRA it is anticipated that breeding season apportioning has been undertaken using the NatureScot method, although it is worth noting that apart from the Flamborough and Filey Coast (FFC) SPA, the next nearest seabird SPAs (e.g. the Farne Islands) are over 200km from the array area, so connectivity with other SPAs during the breeding season are expected to be minimal at most.
NE note the lack of detail provided on cumulative and in-combination assessment methodology and look forward to further engagement with the Applicant on this.	Cumulative and in-combination assessment has been presented in this PEIR (section 12.7) following the approaches taken for the recent Vattenfall Norfolk Projects and the SPR East Anglia Projects, with the inclusion of data for more recent wind farms (e.g. Hornsea 4 and the Dudgeon and Sheringham Extensions). In the ES, agreed totals from the most recent examination available at the time of writing (which will be several months prior to submission of the DCO

Comment	Project Response
	Application) will be used as the starting point with Project alone numbers added for displacement and collision risk. The interim advice from NE on CRM parameters has not been incorporated into the cumulative assessments (although note the comment made above that this inconsistency in assessment methods is considered important to resolve).

12.3 Scope

7. The following potential sources of impact have been scoped into this assessment:

- Construction:
  - Impact 1: Direct disturbance and displacement; and
  - Impact 2: Indirect impacts through effects on habitats and prey species (including accidental pollution).
- Operation and maintenance:
  - Impact 3: Direct disturbance and displacement (including barrier effects, from offshore infrastructure and due to increased vessel and helicopter activity within the array areas);
  - Impact 4: Indirect impacts through effects on habitats and prey species;
  - Impact 5: Collision risk; and
  - Impact 6: Combined operational displacement risk and displacement.
- Decommissioning:
  - Impact 7: Direct disturbance and displacement; and
  - Impact 8: Indirect impacts through effects on habitats and prey species.

12.3.1 Study Area

8. The Offshore Ornithology study area has been defined on the basis of the potential connectivity between the Projects and seabird populations during the breeding, migration and wintering periods. This encompasses seabird colonies from northern Scotland (including Shetland) to south-east England (e.g. Suffolk).

9. The survey area includes the Project array areas and a 4km buffer (see Technical Appendix 12.7). Monthly aerial surveys across the survey area commenced in March 2021 and were completed in February 2023. This PEIR is based on data collected in the first 12 months, up to and including February 2022.

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

12.3.2 Realistic Worst Case Scenario

12.3.2.1 General Approach

11. The realistic worst case design parameters for likely significant effects scoped into the PEIR for the Offshore Ornithology assessment are summarised in **Table 12-2**. These are based on the project parameters described in **Chapter 5 Project Description**, which provides further details regarding specific activities and their durations.

12. In addition to the design parameters set out in **Table 12-2**, consideration is also given to the different development scenarios still under consideration and the possible phasing of the construction as set out in sections 12.3.2.2 to 12.3.2.5.

Table 12-2 Realistic Worst Case Design Parameters for Offshore Ornithology

	Parameter			
	DBS East or DBS West in isolation	**DBS West and DBS East concurrently**	**DBS West and DBS East sequentially**	**Notes and rationale**
Construction				
Array areas	Pin piling (4 pins per wind turbine) for largest number of wind turbines (up to 100 in either DBS East or DBS West) 3 piling vessels operating at same time	Pin piling (4 pins per wind turbine) for largest number of wind turbines (up to 200 across the two Projects) 3 piling vessels operating at same time	Pin piling (4 pins per wind turbine) for largest number of wind turbines (up to 200 across the two Projects) 3 piling vessels operating at same time	Assumed a 2km buffer around each construction location.
Offshore export cable corridor	Four cables (HVAC scenario) – assume each laid independently. Assessment will be based on a 2km buffer around each	Six cables– assume each laid independently. Assessment will be based on a 2km buffer around each independently operating cable laying vessel.	Six cables – assume each laid independently. Assessment will be based on a 2km buffer around each independently operating cable laying vessel.	

	Parameter			
	DBS East or DBS West in isolation	**DBS West and DBS East concurrently**	**DBS West and DBS East sequentially**	**Notes and rationale**
	independently operating cable laying vessel. Pin piling for one Reactive Compensation Platform (RCP) or one Electrical Switching Platform (ESP) along the offshore export cable corridor.	Pin piling for one Reactive Compensation Platform (RCP) andone Electrical Switching Platform (ESP) along the offshore export cable corridor.	Pin piling for one Reactive Compensation Platform (RCP) and one Electrical Switching Platform (ESP) along the offshore export cable corridor.	
Operation				
Array areas	100 smaller wind turbines in either DBS East or DBS West	200 smaller wind turbines (100 in DBS East and 100 in DBS West) for the same operational period i.e. 30 years.	200 smaller wind turbines (100 in DBS East and 100 in DBS West) for the overlapping operational period i.e. 32 years.	Larger number of smaller wind turbines gives highest collision risk

	Parameter			
	DBS East or DBS West in isolation	**DBS West and DBS East concurrently**	**DBS West and DBS East sequentially**	**Notes and rationale**
	Complete development of areas within array area boundaries	Complete development of areas within array area boundaries	Complete development of areas within array area boundaries	Greatest area from which birds could be displaced
Decommissioning				
No final decision regarding the final decommissioning policy for the offshore infrastructure has yet been made. It is also recognised that legislation and industry best practice change over time. However, it is likely that offshore project infrastructure will be removed above the seabed and reused or recycled where practicable. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and will be agreed with the regulator. It is anticipated that for the worst case scenario, the impacts will be no greater than those identified for the construction phase.				

12.3.2.2 Development Scenarios

13. There are currently two possible electrical solutions being considered for DBS West, HVAC or HVDC. Due to the distance of the array area offshore DBS East will be an HVDC project. Therefore, there are two possible electrical solutions for the Projects:

- One HVDC project and one HVAC project; or
- Two HVDC projects.

14. Offshore the most significant difference between an HVAC solution and an HVDC solution is that if an HVAC electrical solution is used an additional platform will be required along the offshore export cable. In addition, a HVAC solution will require two additional offshore cables , over and above the four export cables that would be required for two HVDC projects.

15. In order to ensure that a robust assessment has been undertaken, all development scenarios and options have been considered to ensure the realistic worst case scenario for each topic has been assessed. Further details are provided in **Chapter 5 Project Description**.

12.3.2.3 Construction Scenarios

16. The following principles set out the framework for how the Projects may be constructed (relating to both onshore and offshore works):

- DBS West and DBS East may be constructed at the same time, or at different times;
- If built concurrently, the Projects could be constructed in five years;
- If built non-concurrently, either Project could be built first;
- If built non-concurrently, each Project would require a five year period of construction;
- If built non-concurrently, it is anticipated that there would be up to a two year lag between the start of construction for the first project and the start of construction for the second project; and
- Assuming a maximum construction period per Project of five years, and taking the above into account, the maximum construction period over which the construction of the Projects could take place is seven years.

17. 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 each of the two Projects.

18. The three construction scenarios considered by the Offshore Ornithology assessment are therefore:

- Build DBS East or build DBS West in isolation (i.e. only one of the wind farms is constructed);
- Build DBS East and DBS West concurrently – reflecting the maximum peak effects (i.e. disturbance occurring on both sites over the same period); and
- Build the Projects sequentially with a lag of up to two years – reflecting the maximum duration of effects (i.e. disturbance occurring over a longer period of time due to the lag of two years between construction commencing at either site);.

19. The individual, concurrent and sequential construction scenarios all allow for flexibility to build out the Projects using a phased approach. This will allow the Projects to adapt to National Grid Electricity Transmission Operator's development plans for the onshore grid connection points. Under a phased approach the maximum timescales for individual elements of the construction have been assessed.

20. Any differences between the Projects, or differences that could result from the manner in which the first and the second Projects are built (concurrent or sequential and the length of any gap) are identified and discussed where relevant in section 59. 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 59.

12.3.2.4 Operation Scenarios

21. Operation scenarios are described in detail in **Chapter 5 Project Description**. The assessment considers the following scenarios:

- Only DBS East in operation;
- Only DBS West in operation; and
- The two projects operating concurrently, with a lag of two years between each Project commencing operation.

22. If the Projects are built out using a phased approach, there would also be a phased approach to starting the operational stage. The worst case scenario for the operational phases for the Projects have been assessed. See section 5.1.1 of **Chapter 5 Project Description** for further information on phasing scenarios for the Projects.

23. The operations lifetime of each Project is expected to be 30 years.

12.3.2.5 Decommissioning Scenarios

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

12.3.3 Mitigation Embedded in the Design

25. This section outlines the embedded mitigation relevant to the Offshore Ornithology assessment, which has been incorporated into the design of the Projects (**Table 12-3**). Where other mitigation measures are proposed, these are detailed in the impact assessment (section 12.4).

Table 12-3 Embedded Mitigation Measures

Parameter	Mitigation Measures Embedded into the Project Design
Site Selection	The Crown Estate conducted a detailed site selection exercise, considering a range of sensitivities which included ornithological impacts. The Projects' array area is located at least 100km from the nearest seabird breeding colony (FFC SPA) and as such connectivity for most species will be relatively low.
Wind turbine design	Design options are focussed on use of the smallest number of wind turbines to achieve the projected generating capacity, since experience has shown that while the per wind turbine collision risks may be slightly higher for larger wind turbines, this is more than offset by the reduction in the number of wind turbines required for a given capacity. Since most seabirds fly close to the sea, and the density of birds decreases with altitude, a key mitigation for reducing collision risk is raising the lower blade tip height as far from the sea surface (referred to as the draught height) as possible. In The Crown Estates' Plan level HRA the Applicant has committed to a minimum draught height of 34m from mean sea level, which is considerably higher than the minimum of 22m as required under Royal Yachting Association (RYA) guidance.

12.4 Assessment Methodology

12.4.1 Policy, Legislation and Guidance

12.4.1.1 National Policy Statements

26. The assessment of potential impacts upon Offshore Ornithology has been made with specific reference to the relevant National Policy Statements (NPS). The specific assessment requirements for Offshore Ornithology, as detailed in the NPS, are summarised in **Table 12-4** together with an indication of the section of this chapter where each is addressed. Consideration has also been given to the draft version of NPS (EN-3) in which relevant additional NPS requirements not presented within the current NPS (EN-3) have been included. The revised draft versions of NPS (EN-1) and NPS (EN-5) have also been reviewed but do not make any additional requirements relevant to this topic.

27. Following the consultation in 2021 on the draft energy NPS, a new consultation opened on the 30 March 2023 on revised drafts of the energy NPSs, including EN1, EN3 and EN5. Due to the timing of this consultation, and finalisation of this PEIR we have been unable to review and take these revised draft NPS into account within these documents. However, these will be reviewed and incorporated into the final ES where relevant.

Table 12-4 NPS Assessment Requirements

NPS Requirement	NPS Reference	PEIR Section Reference
EN-1 NPS for Energy		
The applicant should ensure that the ES clearly sets out any effects on internationally, nationally and locally designated sites of ecological or geological conservation importance, on protected species and on habitats and other species identified as being of principal importance for the conservation of biodiversity. Show how the proposed project has taken advantage of opportunities to conserve and	EN-1 Paragraphs 5.3.3, 5.3.4, 5.3.18	This approach has been taken through the assessment presented in this PEIR.

NPS Requirement	NPS Reference	PEIR Section Reference
enhance biodiversity conservation interests. Include appropriate mitigation measures as an integral part of the proposed development		
EN-3 NPS for Renewable Energy Infrastructure		
Assessment of offshore ecology and biodiversity should be undertaken by the applicant for all stages of the lifespan of the proposed offshore wind farm.	EN-3 Paragraph 2.6.64	This has been conducted in this PEIR: construction (section 12.6.1), operation (section 12.6.2) and decommissioning (section 12.6.3).
Consultation on the assessment methodologies should be undertaken at early stages with the statutory consultees as appropriate.	EN-3 Paragraph 2.6.65	As noted in **Table 12-1**, the Applicant has consulted with Natural England on these matters.
Any relevant data that has been collected as part of post-construction ecological monitoring from existing, operational offshore wind farms should be referred to where appropriate.	EN-3 Paragraph 2.6.66	Monitoring studies conducted at operational wind farms have been referred to as appropriate throughout the PEIR.
Offshore wind farms have the potential to impact on birds through: • collisions with rotating blades; • direct habitat loss; • disturbance from construction activities such as the movement	EN-3 Paragraph 2.6.101	These potential impacts have been assessed in section 59.

NPS Requirement	NPS Reference	PEIR Section Reference
of construction/decommissioning vessels and piling; • displacement during the operational phase, resulting in loss of foraging/roosting area; and • impacts on bird flight lines (i.e. barrier effect) and associated increased energy use by birds for commuting flights between roosting and foraging areas.”		
The scope, effort and methods required for ornithological surveys should have been discussed with the relevant statutory advisor.	EN-3 Paragraph 2.6.102	As noted in **Table 12-1**, the Applicant has consulted with Natural England on these matters.
Relevant data from operational offshore wind farms should be referred to in the applicant’s assessment.	EN-3 Paragraph 2.6.103	Monitoring studies conducted at operational wind farms have been referred to as appropriate throughout the PEIR.
Draft EN -3 NPS for Renewable Energy Infrastructure		
Currently, cumulative impact assessments for ornithology are based on the consented Rochdale Envelope parameters of projects, rather than the ‘as-built’ parameters, which may pose a lower risk to birds. The Secretary of State will therefore require any consents to include provisions to define the final 'as	Draft EN-3 Paragraph 2.29.2	Provisions to define and confirm the ‘as built’ parameters for DBS following completion of construction so that these can be used in Cumulative Impact Assessments (CIAs) for future

NPS Requirement	NPS Reference	PEIR Section Reference
built' parameters (which may not then be exceeded) so that these parameters can be used in future cumulative impact assessments. In parallel we will look to explore opportunities to reassess ornithological impact assessment of historic consents to reflect their 'as built' parameters. Any ornithological 'headroom' between the effects defined in the 'as built' parameters and Rochdale Envelope parameters can then be released. We will also consider the potential applicability of these principles to other consent parameters.		developments will be included in the Draft DCO.

12.4.1.2 Other

28. In addition to the NPS, there are a number of pieces of legislation, policy and guidance applicable to the assessment of Offshore Ornithology. These include:

- CIEEM (2018) presents the most relevant EIA guidance for offshore ornithology assessment. The EIA methodology described in Section 12.4.3 and applied in this chapter is based on this guidance;
- Guidance documents for the assessment of OWF impacts on offshore ornithology receptors produced by Natural England (Natural England 2021a, 2021b, 2021c);
- Interim advice on collision risk modelling parameters (Natural England 2022);
- Headroom in Cumulative Offshore Wind Farm Impacts for Seabirds: Legal Issues and Possible Solutions (The Crown Estate and Womble Bond Dickinson 2021); and

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

29. Further detail on overarching policy and guidance is provided in **Chapter 3 Policy and Legislative Context**.

12.4.2 Data and Information Sources

12.4.2.1 Site Specific Surveys

30. In order to provide site specific and up to date information on which to base the impact assessment, 24 months of digital aerial survey have been completed, of which the first 12 months were available for the assessment in this PEIR. The survey methodology was discussed and agreed with Natural England through the ETG process.

12.4.3 Impact Assessment Methodology

31. **Chapter 6 EIA Methodology** provides a summary of the general impact assessment methodology applied. The following sections describe the methods used to assess the likely significant effects on Offshore Ornithology.

12.4.3.1 Definitions

32. For each potential impact, the assessment identifies receptors sensitive to that impact and implements a systematic approach to understanding the impact pathways and the level of impacts (i.e. magnitude) on given receptors. The definitions of sensitivity and magnitude for the purpose of the Offshore Ornithology assessment are provided in **Table 12-5** and **Table 12-6.**

Table 12-5 Definition of Sensitivity for Ornithological Receptors

Sensitivity	Definition
High	Bird species has very limited tolerance of sources of impact.
Medium	Bird species has limited tolerance of sources of impact.
Low	Bird species has some tolerance of sources of impact.
Negligible	Bird species is generally tolerant of sources of impact.

33. It should be noted that although sensitivity is a core component of the assessment, conservation value (defined in section 12.5.2) is also taken into account in determining each potential impact's significance. Furthermore, high conservation value (defined below) and high sensitivity are not necessarily linked within a particular impact. A receptor could be categorised as being of high conservation value (e.g. an interest feature of a SPA) but have a low or negligible physical/ecological sensitivity to an effect and vice versa. Determination of potential impact significance takes both of these into consideration. The narrative behind the assessment is important here; the conservation value of an ornithological receptor can be used where relevant as a modifier for the sensitivity (to the effect) already assigned to the receptor.

34. The definitions of the magnitude levels for ornithology receptors are set out in **Table 12-6**. This set of definitions has been determined on the basis of changes to bird populations. Note that the effects assessment also applies to the approach advised by Natural England (Parker et al. 2022c), with effects which increase background mortality by less than 1% considered to be undetectable and therefore not significant. It is important to note that the corollary of this approach (i.e. effects that increase background mortality by more than 1%) does not automatically apply, but rather such effects warrant additional consideration, for example using population modelling or the basis for the assumptions applied in the assessment, to determine the likely significance.

Table 12-6 Definition of Magnitude of Impacts

Magnitude	Definition
High	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that is predicted to irreversibly alter the population in the short-to-long term and to alter the long-term viability of the population and / or the integrity of the protected site. Recovery from that change predicted to be achieved in the long-term (i.e. more than five years) following cessation of the project activity.
Medium	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that occurs in the short and long-term, but which is not predicted to alter the long-term viability of the population and / or the integrity of the protected site. Recovery from that change predicted to be achieved in the

Magnitude	Definition
	medium-term (i.e. no more than five years) following cessation of the project activity.
Low	A change in the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site that is sufficiently small-scale or of short duration to cause no long-term harm to the feature / population. Recovery from that change predicted to be achieved in the short-term (i.e. no more than one year) following cessation of the project activity.
Negligible	Very slight change from the size or extent of distribution of the relevant biogeographic population or the population that is the interest feature of a specific protected site. Recovery from that change predicted to be rapid (i.e. no more than circa six months) following cessation of the project related activity.
No change	No loss of, or gain in, size or extent of distribution of the relevant biogeographic population or the population that is the interest features of a specific protected site.

12.4.3.2 Significance of Effect

35. The assessment of significance of an effect is informed by the sensitivity of the receptor and the magnitude of the impact (see **Chapter 6 EIA Methodology** for further detail). The determination of significance is guided by the use of an Offshore Ornithology significance of effect matrix, as shown in **Table 12-7**. Definitions of each level of significance are provided in **Table 12-8.** For the purposes of this assessment, any effect that is of major or moderate significance is considered to be significant in EIA terms, whether this be adverse or beneficial. Any effect that has a significance of minor or negligible is not significant.

Table 12-7 Offshore Ornithology Significance of Effect Matrix

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

36. It is important that the matrix (and indeed the definitions of sensitivity and magnitude) is seen as a framework to aid understanding of how a judgement has been reached from the narrative of each impact assessment and it is not a prescriptive formulaic method. IEEM (2010) guidance and expert judgement has been applied to the assessment of likelihood and ecological significance of a predicted impact.

Table 12-8 Definition of Effect Significance

Significance	**Definition**
Major	Very large or large change in receptor condition, which is likely to be an important consideration at a regional or district level because it contributes to achieving national, regional or local objectives, or could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which is likely to be an important consideration at a local level.
Minor	Small change in receptor condition, which may be raised as a local issue but is 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.

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

12.4.4 Cumulative Effect Assessment Methodology

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

39. The methodology has also been aligned with the approach to the assessment of cumulative impacts that has been applied by Ministers when consenting offshore wind farms and confirmed in recent consent decisions. It also follows the approach set out in guidance from the Planning Inspectorate (Planning Inspectorate, 2015) and from the renewables industry (RenewableUK, 2013).

40. The final assessment of cumulative effects will be undertaken during the later stages of the EIA, once further information is available on a number of projects such as the Outer Dowsing Offshore Wind Farm, Hornsea Project Four decision and the Sheringham Shoal and Dudgeon Offshore Wind Farms examination. However, for the purposes of the PEIR, it is possible to identify a number of projects and plans which are likely to feature in that assessment and consider the extent to which cumulative effects might arise. Section 12.7 presents the following preliminary information regarding cumulative effects:

- Screening for cumulative effects; and
- A preliminary short list of plans and projects considered for CEA, including a brief description as to how projects have been screened in and the initial tier level they have been assigned.

12.4.5 Transboundary Effect Assessment Methodology

41. The transboundary assessment considers the potential for transboundary effects to occur on offshore ornithology receptors as a result of the Projects; either those that might arise within the Exclusive Economic Zone (EEZ) of European Economic Area (EEA) states or arising on the interests of EEA states e.g. a non UK fishing vessel. **Chapter 6 EIA Methodology** provides further details of the general framework and approach to the assessment of transboundary effects.

42. For Offshore Ornithology, the potential for transboundary effects has been identified in relation to potential linkages to non-UK protected sites and sites with large concentrations of breeding, migratory or wintering birds (including the use of available information on tagged birds).

12.4.6 Assumptions and Limitations

43. This preliminary assessment is considered to be an interim stage in the EIA process. The results presented in the following sections are based on early design assumptions and initial assessments which will be refined and presented in the final Environmental Statement (ES) to be submitted as part of the DCO application.

44. No further overarching assumptions or limitations have been identified that apply to the assessment for Offshore Ornithology. Where routine assumptions have been made in the course of undertaking the assessment, these are noted throughout.

12.5 Existing Environment

45. This section summarises the baseline ornithological information from the desk-based assessment and the aerial surveys, as detailed in **Appendices 12.1** to **12.7**.

12.5.1 Designated sites

46. The offshore ornithology section of the Habitats Regulations Assessment (HRA) will consider Special Protection Areas (SPAs) with the potential for connectivity to the array areas. The HRA Screening Report (shared with Natural England in December 2022) has considered 93 offshore and coastal designated sites within 700km of the Projects. These comprised SPAs and Ramsar sites designated for bird interests. Of these, the HRA screening identified ten sites for further consideration in relation to potential effects. All remaining sites were either considered to be beyond connectivity distance or to have no pathway for a potential effect in relation to the Projects.

47. Although the HRA is separate from the EIA, the screening carried out is also considered to be appropriate in terms of identifying potential connectivity for the ornithological impact assessment, so the same ten sites are identified here (**Table 12-9**).

Table 12-9 Designated Sites for Birds with Potential Connectivity to the Proposed Projects.

Site	Designation	Ornithological interest features with potential connectivity to the proposed Projects	Minimum distance to the array areas (km)
Flamborough and Filey Coast	SPA	Breeding seabirds	100 (SPA has small overlap with offshore export cable corridor)
Greater Wash	SPA	Non-breeding seabirds and breeding terns	130 (SPA has small overlap with offshore export cable corridor)
Northumbria Coast	SPA and Ramsar	Breeding seabirds, wintering and passage waterbirds	165
The Wash	SPA and Ramsar	Breeding seabirds, wintering and passage waterbirds	176
Northumberland Marine	SPA	Breeding seabirds	183
Coquet Island	SPA	Breeding seabirds	194
Farne Islands	SPA	Breeding seabirds	210
Outer Firth of Forth and St Andrews Bay Complex	SPA	Breeding seabirds	250
St Abbs Head to Fast Castle	SPA	Breeding seabirds	252
Forth Islands	SPA	Breeding seabirds	289

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

48. Bird abundances have been estimated from the DAS of the Projects' array areas and species specific buffers (Parker *et al*. 2022c). The bird abundance estimates and how they were derived are presented in detail in the Ornithology Technical Appendix (12.1). Detail from this report has not been repeated in this chapter to minimise unnecessary repetition.

49. Species assessed for impacts are those which were recorded during surveys and which are considered to be at potential risk either due to their abundance, potential sensitivity to wind farm impacts or due to biological characteristics which make them potentially susceptible (e.g. the species commonly flies at rotor heights). The conservation status of these species is provided in **Table 12-10**.

Table 12-10 Summary of Nature Conservation Value of Species Considered at Risk of Impacts.

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

50. Impacts have been assessed in relation to relevant biological seasons, as defined by Furness (2015). For the non-breeding period, the seasons and relevant population sizes for Biologically Defined Minimum Population Scales (BDMPS) were taken from Furness (2015;**Table 12-11**). For the breeding period, the potential for connectivity to known breeding populations has been considered in relation to species-specific foraging ranges (Woodward *et al*. 2019).

51. The seasonal definitions in Furness (2015) include overlapping months in some instances due to variation in the timing of migration for birds which breed at different latitudes (i.e. individuals from breeding sites in the north of the species' range may still be on spring migration when individuals farther south have already commenced breeding). However, as a precautionary assumption, the full breeding season has been applied, with the adjacent nonbreeding months reduced to remove overlaps (i.e. if March was identified as a spring migration month and also a breeding season month, it was assigned only to the latter).

Table 12-11 Species Specific Seasonal Definitions and Biologically Defined Minimum Population Sizes (In Brackets) Have Been Taken from Furness (2015). Shaded Cells Indicate the Appropriate Non-Breeding Season Periods Used in the Assessment for Each Species

Species	Breeding	Migration-free breeding	Migration - autumn	Winter	Migration - spring	Non-breeding
Fulmar	Jan-Aug	Apr-Aug	Sep-Oct (957,502)	Nov (568,736	Dec-Mar (957,502)	-
Gannet	Mar-Sep	Apr-Aug	Sep-Nov (456,298)	-	Dec-Mar (248,385)	Mar-Sep
Cormorant	Apr-Aug	May-Jul	-	-	-	Sep-Mar (10,460)
Shag	Feb-Aug	Mar-July	-	-	-	Sep-Jan (4,346)
Arctic skua	May-Jul	Jun-Jul	Aug-Oct (6,427)	-	Apr-May (1,227)	-
Great skua	May-Aug	May-Jul	Aug-Oct (19,556)	Nov-Feb (143)	Mar-Apr (8,485)	-
Puffin	Apr-Aug	May-Jun	Jul-Aug	Sep-Feb	Mar-Apr	Mid-Aug-Mar (231,957)
Razorbill	Apr-Jul	Apr-Jun	Aug-Oct (591,874)	Nov-Dec (218,622)	Jan-Mar (591,874)	-
Guillemot	Mar-Jul	Mar-Jun	Jul-Oct	Nov	Dec-Feb	Aug-Feb (1,617,306)
Sandwich tern	Apr-Aug	Jun	Jul-Sep (38,051)	Oct-Feb	Mar-May (38,051)	Sep-Mar
Commic tern*	May-Aug	Jun	Jul-Sep (308,841)	-	Apr-May (308,841)	-
Kittiwake	Mar-Aug	May-Jul	Aug-Dec (829,937)	-	Jan-Apr (627,816)	-
Little gull (Not included in Furness, 2015)	Apr-Jul	May-Jul	-	-	-	Aug-Apr
Lesser black-backed gull	Apr-Aug	May-Jul	Aug-Oct (209,007)	Nov-Feb (39,314)	Mar-Apr (197,483)	-
Herring gull	Mar-Aug	May-Jul	Aug-Nov	Dec	Jan-Apr	Sep-Feb (466,511)
Great black-backed gull	Mar-Aug	May-Jul	Aug-Nov	Dec	Jan-Apr	Sep-Mar (91,399)

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

52. In addition to BDMPS populations, the biogeographic populations have also been considered in the assessment where appropriate. These are provided in **Table 12-12**.

Table 12-12 Biogeographic Population Sizes Taken from Furness (2015).

Species	Biogeographic population with connectivity to UK waters (adults and immatures)
Fulmar	8,055,000
Gannet	1,180,000
Cormorant	324,000
Shag	106,000
Arctic skua	229,000
Great skua	73,000
Puffin	11,840,000
Razorbill	1,707,000
Guillemot	4,125,000
Commic tern*	628,000 (Arctic: 480,000; Common: 248,000)
Kittiwake	5,100,000
Great black-backed gull	235,000
Herring gull	1,098,000
Lesser black-backed gull	864,000
Little gull (not included in Furness, 2015)	75,000 #

 # Estimated passage population (Stienen et al., 2007)

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

53. The impact of additional mortality due to wind farm effects is assessed in terms of the change in the baseline mortality rate which could result. It has been assumed that all age classes are equally at risk of effects, with each age class affected in proportion to its presence in the population. Therefore, a weighted average baseline mortality rate has been calculated which is appropriate for all age classes for use in assessments, calculated for those species screened in for assessment. These were calculated using the different rates for each age class and their relative proportions in the population.

54. Demographic rates for each species screened into assessment were taken from Horswill and Robinson (2015) and entered into a matrix population model. This was used to calculate the expected stable proportions in each age class (note, to obtain robust stable age class distributions for less well studied species such as divers it was necessary to adjust the rates in order to obtain a stable population size). Each age class survival rate was multiplied by its stable age proportion and the total for all ages summed to give the weighted average survival rate for all ages. Taking this value from 1 gives the average mortality rate. The demographic rates and the age class proportions, and average mortality rates calculated from them are presented in **Table 13-13**.

Table 12-13 Average Mortality Across All Age Classes. Average Mortality Calculated Using Age Specific Demographic Rates and Age Class Proportions

Species	Parameter	Survival (age class)						Productivity	Average mortality
		0-10-1	1-2	2-3	3-4	4-5	Adult		
Gannet	Demographic rate	0.424	0.829	0.891	0.895	-	0.912	0.7	0.191
	Population age ratio	0.191	0.081	0.067	0.06	-	0.6	-	
Guillemot	Demographic rate	0.56	0.792	0.917	0.939	0.939	0.939	0.672	0.14
	Population age ratio	0.168	0.091	0.069	0.062	0.056	0.552	-	
Razorbill[1]	Demographic rate	0.63	0.63	0.895	0.895	-	0.895	0.57	0.174
	Population age ratio	0.159	0.102	0.065	0.059	-	0.613	-	
Puffin[2]	Demographic rate	0.709	0.709	0.76	0.805	-	0.906	0.617	0.167
	Population age ratio	0.162	0.115	0.082	0.063	-	0.577	-	
Common tern[3]	Demographic rate	0.441	0.441	0.85	-	-	0.883	0.764	0.263
	Population age ratio	0.223	0.103	0.048	-	-	0.626	-	
Kittiwake	Demographic rate	0.79	0.854	0.854	0.854		0.854	0.69	0.156
	Population age ratio	0.155	0.123	0.105	0.089		0.53	-	

Species	Parameter	Survival (age class)						Productivity	Average mortality
		0-10-1	1-2	2-3	3-4	4-5	Adult		
Lesser black-backed gull	Demographic rate	0.82	0.885	0.885	0.885		0.885	0.53	0.124
	Population age ratio	0.134	0.109	0.095	0.083		0.579	-	
Herring gull	Demographic rate	0.798	0.834	0.834	0.834		0.834	0.92	0.172
	Population age ratio	0.178	0.141	0.117	0.097		0.467		
Great black-backed gull	Demographic rate	0.815	0.815	0.815	0.815		0.885	0.53	0.144
	Population age ratio	0.137	0.112	0.093	0.076		0.581	-	

1 – Razorbill have a combined survival rate from 0 – 2 of 0.63, giving an annual rate of 0.79.

2 – Puffin have a combined survival rate from 0 – 3 of 0.709, giving an annual rate of 0.89.

3 – Common tern have a combined survival rate from 0 – 2 of 0.441, giving an annual rate of 0.66. Note that the rates for common tern have been used for the commic tern assessment where necessary.

55. The seasonal peak abundance within species specific seasons (as defined in **Table 12-11**) recorded individually within the array areas are provided in **Table 12-14** (note these abundances do not include birds observed in the 4km buffer around the array areas).

56. The method to calculate the seasonal peaks for DBS array areas were as follows:

- The population density and abundance for each survey was calculated using design-based estimation methods, with 95% confidence intervals calculated using non-parametric bootstrapping (see Technical Appendix 12.1 for further details).
- For this PEIR only 12 months of data were available, so these are presented as the monthly estimate (the final submission will present the abundance for each calendar month calculated as the mean of estimates for each month.

57. The seasonal peak was taken as the highest from the months falling within each season. Some months are included in both the full breeding season and the adjacent nonbreeding seasons. In these cases, the breeding season has taken precedence (i.e. if for a given species March falls in both the spring migration and full breeding season and a peak was recorded in this month it is only presented in the breeding season).

Table 12-14 Peak abundance estimates (and 95% Confidence Intervals) by Biological Season for Bird Species within the East and West Array Areas Recorded during Baseline Surveys.

	Biological Season									
Species	**Spring migration**		**Breeding (full)**		**Autumn migration**		**Winter**		**Non-breeding**	
	East	**West**	**East**	**West**	**East**	**West**	**East**	**West**	**East**	**West**
Red-throated diver	0 (0-0)	0 (0-0)	0 (0-0)	8.2 (0-24.5)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Fulmar	9.09 (0-27.28)	16.4 (0-49.2)	59.33 (16.95-101.71)	179.4 (106.0-261.0)	165.7 (95.93-244.19)	64.3 (24.1-112.5)	154.58 (94.46-223.28)	130.3 (65.2-203.6)	165.7 (95.93-244.19)	64.3 (24.1-112.5)
Gannet	9.09 (0-27.28)	0 (0-0)	710.91 (433.27-1023.02)	485.5 (323.5-671.6)	453.78 (325.35-599.33)	301.7 (195.7-407.8)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Arctic skua	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	8.54 (0-25.69)	0 (0-0)	0 (0-0)	0 (0-0)	8.54 (0-25.69)	0 (0-0)
Great skua	0 (0-0)	0 (0-0)	8.55 (0-25.64)	0 (0-0)	0 (0-0)	8.15 (0-24.5)	0 (0-0)	16.3 (0-40.7)	0 (0-0)	16.3 (0-40.7)
Puffin[1]	95.4 (28.6-171.7)	82.8 (27.6-129.0)	61.1 (10.2-112.4)	194.2 (138.7-249.7)	0 (0-0)	0 (0-0)	385.3 (221.8-583.8)	228.3 (119.1-327.6)	385.3 (221.8-583.8)	228.3 (119.1-327.6)

	Biological Season									
Species	**Spring migration**		**Breeding (full)**		**Autumn migration**		**Winter**		**Non-breeding**	
	East	**West**	**East**	**West**	**East**	**West**	**East**	**West**	**East**	**West**
Razorbill[1]	6103.5 (4257.0-7830.2)	1393.8 (826.8-1937.7)	559.1 (279.5-855.0)	3155.8 (2115.0-4144.1)	383.7 (204.3-575.6)	375.1 (195.7-554.5)	3048.6 (2491.6-3591.2)	1550.3 (787.1-2337.9)	6103.5 (4257.0-7830.2)	1550.3 (787.1-2337.9)
Guillemot[1]	5766.8 (4237.3-7647.3)	3223.3 (3015.7-4298.4)	11504.7 (8596.5-14413.8)	11329.8 (7080.7-15595.6)	3102.7 (1822.8-4430.1)	2928.3 (2173.2-3670.2)	12872.7 (10490.6-15192.1)	5986.8 (4957.3-7127.6)	12872.73 (10490.64-15192.11)	5986.8 (4957.3-7127.6)
Arctic tern	0 (0-0)	0 (0-0)	17.5 (0-52.5)	9.5 (0-28.6)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Common tern	0 (0-0)	0 (0-0)	0 (0-0)	8.2 (0-24.5)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Kittiwake	991.7 (627.2-1347.9)	855.8 (570.6-1133.0)	11851.5 (8912.2-14938.1)	2929.7 (1919.8-4014.1)	815.8 (592.5-1064.9)	538.2 (293.6-799.2)	0 (0-0)	0 (0-0)	991.7 (627.2-1347.9)	855.8 (570.6-1133.0)
Little gull	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Common gull	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	17.2 (0-51.5)	0 (0-0)
Lesser black-backed gull	8.67 (0-26.01)	0 (0-0)	86.4 (0-259.21)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	8.67 (0-26.01)	0 (0-0)
Herring gull	0 (0-0)	8.1 (0-24.4)	138.2 (0-414.7)	8.2 (0-24.6)	8.6 (0-25.8)	0 (0-0)	0 (0-0)	0 (0-0)	8.6 (0-25.8)	8.1 (0-24.4)

	Biological Season									
Species	**Spring migration**		**Breeding (full)**		**Autumn migration**		**Winter**		**Non-breeding**	
	East	**West**	**East**	**West**	**East**	**West**	**East**	**West**	**East**	**West**
Great black-backed gull	93.2 (33.9-161.0)	40.7 (8.2-81.7)	51.8 (0-155.5)	16.4 (0-49.3)	17.2 (0-42.9)	24.4 (0-57.0)	9.1 (0-27.3)	32.8 (0-131.2)	51.8 (0-155.5)	40.7 (8.2-81.7)
1. Including unidentified auks apportioned using identified auk ratios and accounting for availability bias										

12.5.3 Future Trends

58. In the event that the Projects are not developed, an assessment of future conditions for Offshore Ornithology has been carried out and is described within this section.

59. Key drivers of seabird population size in western Europe are climate change (Sandvik *et al*. 2012; Frederiksen *et al*. 2004, 2013; Burthe *et al*. 2014; Macdonald *et al*. 2015; Furness 2016; JNCC 2016; Pearce-Higgins 2021), and fisheries (Tasker *et al*. 2000; Frederiksen *et al*. 2004; Ratcliffe 2004; Carroll *et al*. 2017; Sydeman *et al*. 2017). Pollutants (including oil, persistent organic pollutants, plastics), alien mammal predators at colonies, disease, and loss of nesting habitat also impact on seabird populations but are generally much less important and often more local factors (Ratcliffe 2004; Votier *et al*. 2005, 2008; JNCC 2016). In 2022 Highly Pathogenic Avian Influenza (HPAI) adversely affected survival and productivity within seabird colonies across the UK, and investigations are underway to determine the long-term effects on species' populations.

60. Trends in seabird numbers in breeding populations are better known, and better understood than trends in numbers at sea within particular areas. Breeding numbers are regularly monitored at many colonies (JNCC 2016), and in the British Isles there have been three comprehensive censuses of breeding seabirds in 1969-70, 1985-88 and 1998-2002 (Mitchell *et al*. 2004) as well as single-species surveys (such as the decadal counts of breeding gannet numbers, Murray *et al*. 2015). In contrast, the European Seabirds at Sea (ESAS) database is incomplete, and few data have been added since 2000, so that current trends in numbers at sea in areas of the North Sea are not so easy to assess.

61. Breeding numbers of many seabird species in the British Isles are declining, especially in the northern North Sea (Foster and Marrs 2012; Macdonald *et al*. 2015; JNCC 2016). The most striking exception is gannet, which continues to increase (Murray *et al*. 2015), although the rate of increase has been slowing (Murray *et al*. 2015). These trends in British seabird populations seem likely to continue in the short to medium term future, although for gannet, which has notably been susceptible to the effects of HPAI, the long-term impact on the population trend is unclear.

62. Climate change has been identified as one of three key threats to UK seabirds and a key cause of recent declines, along with invasive alien species and by-catch in fisheries (Burthe *et al*. 2014; Macdonald *et al*. 2015; Capuzzo *et al*. 2018; Dias *et al*. 2019, Mitchell *et al*. 2020. Pearce-Higgins 2021). Pearce-Higgins (2021) assessed the impact that climate change has already had on UK bird populations by relating their long-term trends to separately published species' responses to climate change, temperature and rainfall. It was found that of the 20 seabird species found in the UK, 14 are regarded as being at high or medium risk of negative climate change impacts. Documented declines in sandeel populations have led to reduced breeding success in seabirds, and at least partially underpin long-term population declines (Johnston *et al*. 2021).

63. Whilst the results of the current seabird census (Seabirds Count) will provide important information, there is already good evidence that kittiwake, Arctic skua, puffin and fulmar are being affected by climate processes (Frederiksen *et al*. 2004, Burthe *et al*. 2014, Cook *et al*. 2014, Perkins *et al*. 2018). It is therefore highly likely that breeding numbers of most of our seabird species will continue to decline under a scenario with continuing climate change due to increasing levels of greenhouse gases.

64. Fisheries management is also likely to influence future numbers in seabird populations. The Common Fisheries Policy (CFP) Landings Obligation ('discard ban') will further reduce food supply for scavenging seabirds such as great black-backed gulls, lesser black-backed gulls, herring gulls, fulmars, kittiwakes and gannets (Votier *et al*. 2004; Bicknell *et al*. 2013; Votier *et al*. 2013; Foster *et al*. 2017). Recent changes in fisheries management that aid recovery of predatory fish stock biomass are likely to further reduce food supply for seabirds that feed primarily on small fish such as sandeels, as those small fish are major prey of large predatory fish. Therefore, anticipated future increases in predatory fish abundance resulting from improved management to constrain fishing mortality on those commercially important species at more sustainable levels than in the past are likely to cause further declines in stocks of small pelagic seabird 'food-fish' such as sandeels (Frederiksen *et al*. 2007; Macdonald *et al*. 2015). Lindegren *et al*. (2018) concluded that sandeel stocks in the North Sea, the most important prey fish stock for North Sea seabirds during the breeding season (Furness and Tasker 2000), have been depleted by high levels of fishing effort. These stocks are unlikely to recover fully even if fishing effort was reduced, because climate change has altered the North Sea food web to the detriment of productivity of fish populations. As a result, seabird populations are likely to continue to experience food shortages in the North Sea, especially for those species most dependent on sandeels as food.

65. Future decreases in kittiwake breeding numbers are likely to be particularly pronounced, as kittiwakes are very sensitive to climate change (Frederiksen *et al*. 2013; Carroll *et al*. 2015) and to fishery impacts on sandeel stocks near breeding colonies (Frederiksen *et al*. 2004; Carroll *et al*. 2017), and the species will lose the opportunity to feed on fishery discards as the Landings Obligation comes into effect. Gannet numbers may continue to increase for some years, but evidence suggests that this increase is already slowing (Murray *et al*. 2015), and numbers may peak not too far into the future. While the Landings Obligation will reduce discard availability to gannets in European waters, in recent years increasing proportions of adult gannets have wintered in west African waters rather than in UK waters (Kubetzki *et al*. 2009), probably because there are large amounts of fish discarded by west African trawl fisheries and decreasing amounts available in the North Sea (Kubetzki *et al*. 2009; Garthe *et al*. 2012). The flexible behaviour and diet of gannets probably reduces their vulnerability to changes in fishery practices or to climate change impacts on fish communities (Garthe *et al*. 2012).

66. Fulmars, terns, common guillemot, razorbill and puffin appear to be highly vulnerable to climate change, so numbers may decline over the next few decades (Burthe *et al*. 2014). Strong declines in shag numbers are likely to continue as they are adversely affected by climate change, by low abundance of sandeels and especially by stormy and wet weather conditions in winter (Burthe *et al*. 2014; Frederiksen *et al*. 2008). Most of the red-throated divers and common scoters wintering in the southern North Sea originate from breeding areas at high latitudes in Scandinavia and Russia. Numbers of red-throated divers and common scoters wintering in the southern North Sea may possibly decrease in future if warming conditions make the Baltic Sea more favourable as a wintering area for those species so that they do not need to migrate as far as UK waters. There has been a trend of increasing numbers of sea ducks remaining in the Baltic Sea overwinter (Mendel *et al*. 2008; Fox *et al*. 2016; Ost *et al*. 2016) and decreasing numbers coming to the UK (Austin and Rehfisch 2005; Pearce-Higgins and Holt 2013), and that trend is likely to continue, although to an uncertain extent.

67. ESAS data indicate that there has already been a long-term decrease in numbers of great black-backed gulls wintering in the southern North Sea (S. Garthe *et al*. in prep.), and the Landings Obligation will probably result in further decreases in numbers of north Norwegian great black-backed gulls and herring gulls coming to the southern North Sea in winter. It is likely that further redistribution of breeding herring gulls and lesser black-backed gulls will occur into urban environments (Rock and Vaughan 2013), although it is unclear how the balance between terrestrial and marine feeding by these gulls may alter over coming years; that may depend greatly on the consequences of Brexit for UK fisheries and farming. Some of the human impacts on seabirds are amenable to effective mitigation (Ratcliffe *et al*. 2009; Brooke *et al*. 2018), but the scale of efforts to reduce these impacts on seabird populations has been small by comparison with the major influences of climate change and fisheries. This is likely to continue to be the case in future, and the conclusion must be that with the probable exception of gannet, numbers of almost all other seabird species in the UK North Sea region will most likely be on a downward trend over the next few decades, due to population declines, redistributions or a combination of both.

68. For offshore ornithology, the ecological impact assessment is therefore carried out in a context of declining baseline populations of a number of species. Where a species is declining, the assessment takes into account whether a given impact is likely to exacerbate a decline in the relevant reference population and prevent a species from recovery should environmental conditions become more favourable.

69. Climate change has been identified as the strongest influence on future seabird population trends. In this context it is noted that a key component of global strategies to reduce climate change is the development of low-carbon renewable energy developments such as offshore wind.

12.6 Assessment of Significance

12.6.1 Potential Effects During Construction

12.6.1.1 Impact 1 Direct Disturbance and Displacement from Increased Vessel Activity

70. The Projects have the potential to affect bird populations in the marine environment through disturbance due to activity leading to displacement of birds from construction areas.

71. There is a degree of uncertainty about which construction scenario would be most disturbing overall, however it has been assumed that the worst case construction impact would comprise five years of concurrent construction (i.e. DBS East and DBS West being constructed at the same time).

72. The construction phase would require the mobilisation of vessels, helicopters and equipment and the installation of foundations, export cables and other infrastructure. These activities have the potential to disturb and displace birds from within and around the array areas and offshore export cable corridor. Causes of potential disturbance would comprise the presence of construction vessels and associated human activity, noise and vibration from construction activities and lighting associated with construction sites. The level of disturbance at each work location would differ dependent on the activities taking place, but there could be vessel movements at any time of day or night over the construction period.

73. Any impacts resulting from disturbance and displacement from construction activities would be short-term, temporary and reversible in nature, lasting only for the duration of construction activity, with birds expected to return to the area once construction activities have ceased. Construction related disturbance and displacement is most likely to affect foraging birds. Furthermore, modelling of the consequences of displacement for fitness of displaced birds suggests that even in the case of breeding seabirds that are displaced on a daily basis, there is likely to be little or no impact on survival unless the offshore windfarm is close to the breeding colony (Searle *et al*. 2014, 2017).

74. Bird species differ in their susceptibility to anthropogenic disturbance and in their responses to noise and visual disturbance stimuli. The principal source of noise during construction would be subsea noise from piling works associated with the installation of foundations for wind turbines and associated offshore substation platforms. While assessed for marine mammals and fish, subsea noise is not considered a risk factor for diving birds. Seabirds and other diving bird species will spend most of their time above or on the water surface, where hearing will detect sound propagated through the air.

75. It has been speculated, based on what is known about the physiology of hearing in birds, and comparison to the underwater hearing ability of humans, that birds do not hear well underwater (Dooling and Therrien, 2012). Anatomical studies of ear structure in diving birds suggest that there are adaptations for protection against the large pressure changes that may occur while diving, which may reduce hearing ability underwater but also protect the ear from damage due to acoustic over-exposure (Dooling and Therrien, 2012). Above water noise disturbance from construction activities is not considered in isolation as a risk factor for birds; but rather, combined with the presence of vessels, man-made structures, and human activity, part of the overall disturbance stimulus that causes birds to avoid boats and other structures – as discussed below.

76. 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 night at a given time.

77. Phototaxis can be a serious hazard for fledglings of some seabird species (notably petrels and shearwaters) but occurs over short distances (hundreds of metres) in response to bright white light close to breeding colonies of these species. It is not seen over large distances or in older (adult and immature) seabirds (**Appendix 12.8)** (Furness, 2018). Construction sites associated with the offshore development area would be far enough removed from any seabird breeding colonies as to render this risk negligible. Phototaxis of nocturnal migrating birds can be a problem, especially in autumn during conditions of poor visibility, but is generally seen where birds are exposed to intense white lighting such as from lighthouses; light from construction sites is likely to be one or two orders of magnitude less powerful than that from lighthouses (**Appendix 12.8)** (Furness, 2018).

78. Construction will not occur across the whole of the proposed array areas simultaneously or every day but will be phased and assumed to occur at three discrete locations for the purposes of this assessment. Consequently, the effects will occur only in the areas where vessels are operating at any given point and not the entire array areas. Until wind turbines (and other structures) are placed on foundations, the impacts will occur only in the areas where vessels are operating at any given point and not the entire array areas. At such time as wind turbines (and other infrastructure) are installed onto foundations the impact of displacement would increase incrementally to the same levels as operational impacts (section 1.6.2, below).

79. Considering variation between species in response to disturbance, gulls are not considered susceptible to disturbance, as they are often associated with fishing boats (e.g. Camphuysen, 1995; Hüppop and Wurm, 2000) and have been noted in association with construction vessels at the Greater Gabbard offshore windfarm (GGOWL 2011) and close to active foundation piling activity at the Egmond aan Zee (OWEZ) windfarm, where they showed no noticeable reactions to the works (Leopold and Camphuysen, 2007); and Irwin *et al*. (2019) found that great black-backed gull distribution within the Outer Thames Estuary SPA showed a slight skew towards shipping lanes in the southern sector. However, species such as divers and scoters have been observed to avoid shipping by several kilometres (Mitschke *et al*., 2001 from Exo *et al*. 2003; Garthe and Hüppop, 2004; Schwemmer *et al*., 2011), and Irwin *et al*. (2019) found that red-throated divers clearly showed displacement from shipping lanes within the Outer Thames SPA.

80. There are a number of different measures used to assess bird disturbance and displacement from areas of sea in response to activities associated with an offshore windfarm. Garthe and Hüppop (2004) developed a scoring system for such disturbance factors which they applied to seabird species in German sectors of the North Sea. This was refined by Furness and Wade (2012) and Furness *et al*. (2013) with a focus on seabirds using Scottish offshore waters. The approach uses information in the scientific and 'grey' literature, as well as expert opinion to identify disturbance ratings for individual species, alongside scores for habitat flexibility and conservation importance. These factors were used to define an index value that highlights the sensitivity of a species to disturbance and displacement. As many of these references relate to disturbance from helicopter and vessel activities, these are considered relevant to this assessment.

81. In order to focus the assessment of disturbance and displacement, a screening exercise was undertaken to identify those species most likely to be at risk (**Table 12-15**). Any species recorded only in very small numbers within the study area or with a low sensitivity to displacement was screened out of further assessment.

82. The species screened in for assessment were: gannet, guillemot, razorbill and puffin. These were assessed for impacts during the construction period and spatial locations where effects were likely.

83. The increase in mortality rate has been calculated for each array area separately (DBS East and DBS West) to estimate effects for each array area, with the results summed to obtain the combined impact.

84. Since the preliminary results presented below are based on the first year of survey data only, the abundance of each species will change when the second year is included, and the assessment will therefore change when the second year of data is included in the analysis. Thus, while estimates of effect significance have been provided within this PEIR, these will be subject to change once the full dataset has been used and should therefore not be considered as final.

Table 12-15 Construction Disturbance and Displacement Screening

Species	**Sensitivity to Disturbance and Displacement[1]**	**Screening Result (IN or OUT)**	**Rationale**
Red-throated diver	Very high	OUT	Single individual recorded in one baseline survey during passage migration period. Site is unsuitable habitat as too far from shore.
Fulmar	Low	OUT	Recorded at low densities during baseline surveys and not considered at risk of disturbance
Gannet	Low	IN	Recorded at moderate densities during baseline surveys and considered to be at risk of disturbance
Arctic skua	Low	OUT	Recorded in very low numbers on baseline surveys and only during passage migration periods
Great skua	Low	OUT	Recorded in very low numbers on baseline surveys and only during passage migration periods

Species	Sensitivity to Disturbance and Displacement[1]	Screening Result (IN or OUT)	Rationale
Puffin	Medium	IN	Recorded at moderate densities during baseline surveys and considered to be at risk of disturbance
Razorbill	Medium	IN	Recorded at high densities during baseline surveys and considered to be at risk of disturbance
Guillemot	Medium	IN	Recorded at high densities during baseline surveys and considered to be at risk of disturbance
Arctic tern	Low	OUT	Recorded in very low numbers on baseline surveys and only during passage migration periods
Common tern	Low	OUT	Recorded in very low numbers on baseline surveys and only during passage migration periods
Sandwich tern	Low	OUT	Not recorded during baseline surveys
Kittiwake	Low	OUT	Recorded at moderate densities during baseline surveys but not considered at risk of disturbance
Little gull	Low	OUT	Recorded at very low densities during baseline surveys and not considered at risk of disturbance
Common gull	Low	OUT	Recorded at very low densities during baseline surveys and not considered at risk of disturbance
Lesser black-backed gull	Low	OUT	Recorded at very low densities during baseline surveys and not considered at risk of disturbance
Herring gull	Low	OUT	Recorded at low densities during baseline surveys and not considered at risk of disturbance
Great black-backed gull	Low	OUT	Recorded at low densities during baseline surveys and not considered at risk of disturbance
[1] With reference to Garthe and Hüppop, 2004; Furness and Wade, 2012; Furness *et al*., 2013; Wade *et al*., 2016; Goodship and Furness, 2022.			

12.6.1.1.1 Gannet

85. The nearest gannet breeding colony to the array areas is the Flamborough and Filey Coast SPA. The SPA is a minimum of 100km from the Projects' array areas, and therefore they are within the mean maximum foraging range of gannets, estimated as 315km (Woodward et al. 2019). Consequently, breeding season connectivity to this SPA has been assumed. Although the gannets which breed at the Bass Rock, part of the Forth Islands SPA, are also within this distance (c. minimum of 290km to the Projects), Wakefield et al. (2013) found very little overlap in colony foraging areas, so connectivity is considered very unlikely during the breeding season.

86. Gannets were recorded in the array areas year round, with peak estimated densities within the DBS East array area plus 2km buffer in March (1.23/km^2) and in the DBS West array area plus 2km buffer in April (0.94/km^2).

87. Additional mortality of gannet during the breeding season has been assessed in relation to the Flamborough and Filey Coast SPA population. The SPA population at designation was 11,061 pairs, increasing to 13,392 pairs in 2017 (Aitken *et al*., 2017) with 13,125 pairs recorded in 2022 (Clarkson *et al*., 2022). The Clarkson *et al*. (2022) estimate), adjusted to include nonbreeding and immature birds that associate with the colony, has been used as a reference population, being closer in time to baseline surveys. This equates to a total population size during the breeding season of approximately 47,727 (derived as individual adults divided by the adult proportion of 0.55 from Furness, 2015, to provide an all-age class total).

88. The number of individuals from this population expected to die at the baseline mortality rate in the breeding season is 9,116 (47,727 x 0.191, **Table 12-13**).

89. During the nonbreeding seasons the gannet BDMPS populations for the North Sea have been used as the reference populations (in the autumn: 456,298 and in the spring: 248,385). For the annual assessment. impacts have been considered in relation to the largest of the BDMPS populations (autumn) and also to the biogeographic population (1,180,000; Furness, 2015). The number of individuals from these populations expected to die in the autumn is 87,153 (456,298 x 0.191), in the spring is 47,442 (248,385 x 0.191), and annually from the biogeographic population is 225,380 (1,180,000 x 0.191).

90. For this precautionary assessment it has been assumed that 1% of displaced individuals could be at risk of mortality as a result of displacement by construction vessels.

12.6.1.1.1.1 Significance of Effect – DBS East in Isolation

12.6.1.1.1.1.1 Breeding Season

91. During the breeding season, the maximum mean peak density in the DBS East array area was 1.23/km^2. With a 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), up to 46 individuals (1.23 x 12.56 x 3) could be at risk of displacement, of which 0.46 would be expected to be at risk of mortality.

92. Based on the average mortality for the species of 0.191 a total of 9,116 birds would be expected to die each year (see paragraph 88). The addition of a maximum of 0.46 birds predicted to be at risk of mortality from construction disturbance and displacement would increase the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.1.1.2 Autumn Migration

93. During the autumn migration season the maximum mean peak density in the DBS East array area was 1.08 /km^2. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure) up to 41 individual birds (1.08 x 12.56 x 3) could be at risk of displacement, of which 0.41 birds would be predicted to be at risk of mortality.

94. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die in autumn (see paragraph 89). The addition of 0.41 to this would increase the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.1.1.3 Spring Migration

95. During the spring migration season, the maximum mean peak density in the DBS East array area was 0.02/km^2. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), up to 0.75 individual birds (0.02 x 12.56 x 3) could be at risk of displacement, of which 0.007 a would be expected to be at risk of mortality.

96. Based on the average mortality for the species of 0.191, a total of 47,442 birds would be expected to die in spring (see paragraph 89). The addition of a maximum of 0.007 to this would increase the mortality rate by <0.001%, which is below the 1% threshold for detectability.

12.6.1.1.1.1.4 Annual

97. The estimated number of gannets subject to construction disturbance/displacement mortality at DBS East throughout the year is 0.88 individuals.

98. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 89). The addition of a maximum of 0.88 to this increases the mortality rate by 0.001%, which is below the 1% threshold for detectability.

99. The number of individuals from the biogeographic population expected to die across all seasons is 225,380 (see paragraph 89). The addition of a maximum of 0.88 to this increases the mortality rate by 0.01%, which is below the 1% threshold for detectability.

100. The sensitivity of gannet to construction displacement is considered to be low and the magnitude of annual impact at DBS East is negligible, therefore the annual effect on gannet due to construction displacement at DBS East is assessed as negligible.

12.6.1.1.1.2 Significance of Effect – DBS West in Isolation

12.6.1.1.1.2.1 Breeding Season

101. During the breeding season, the maximum mean peak density in the DBS West array area was 0.94/km^2. With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), up to 35 individuals (0.94 x 12.56 x 3) could be at risk of displacement, of which 0.35 would be expected to be at risk of mortality.

102. Based on the average mortality for the species of 0.191 a total of 9,116 birds would be expected to die in the breeding season (see paragraph 88). The addition of a maximum of 0.35 birds predicted to be at risk of mortality from construction disturbance and displacement to these would increase the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.1.2.2 Autumn Migration

103. During the autumn migration season the maximum mean peak density in the DBS West array area was 0.57 /km$^{2.}$. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure) up to 21 individual birds (0.57 x 12.56 x 3) could be at risk of displacement, of which 0.21 birds would be predicted to be at risk of mortality.

104. At the average baseline mortality rate for gannet of 0.191 a total of 87,153 birds would be expected to die in autumn (see paragraph 89). The addition of a maximum of 0.21 to this would increase the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.1.2.3 Spring Migration

105. During the spring migration season, the maximum mean peak density in the DBS West array was 0.02/km^2. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), up to 0.75 individual birds (0.02 x 12.56 x 3) could be at risk of displacement, of which 0.007 would be expected to be at risk of mortality.

106. Based on the average mortality for the species of 0.191, a total of 47,442 birds would be expected to die in spring (see paragraph 89). The addition of a maximum of 0.007 to this would increase the mortality rate by <0.001%, which is below the 1% threshold for detectability.

12.6.1.1.1.2.4 Annual

107. The estimated number of gannets subject to construction disturbance/displacement mortality at DBS West throughout the year is 0.58 individuals.

108. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 89). The addition of a maximum of 0.58 to this would increase the mortality rate by 0.001%, which is below the 1% threshold for detectability.

109. The number of individuals from the biogeographic population expected to die across all seasons is 225,380 (see paragraph 89). The addition of a maximum of 0.58 to this increases the mortality rate by <0.01%, which is below the 1% threshold for detectability.

110. The sensitivity of gannet to construction displacement is considered to be low and the magnitude of annual impact at DBS West is negligible, therefore the annual effect on gannet due to construction displacement at DBS West is assessed as negligible.

12.6.1.1.1.3 Significance of Effect – DBS East and DBS West Together

12.6.1.1.1.3.1 Breeding Season

111. During the breeding season the number of gannets at risk of mortality due to displacement from construction activity across the array areas was 0.81 birds.

112. Based on the average mortality for the species of 0.191, a total of 9,116 birds would be expected to die in the breeding season (see paragraph 88). The addition of 0.81 individuals to this would increase the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.1.3.2 Autumn Migration

113. During the autumn the number of gannets at risk of mortality due to displacement from construction activity across the array areas was 0.62 birds.

114. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die in autumn (see paragraph 89). The addition of a maximum of 0.62 to this increases the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.1.3.3 Spring Migration

115. During the spring season the number of gannets at risk of mortality due to displacement from construction activity across the array areas was 0.15 birds.

116. Based on the average mortality for the species of 0.191, a total of 47,442 birds would be expected to die in spring (see paragraph 89). The addition of a maximum of 0.15 to this increases the mortality rate by 0.001%, which is below the 1% threshold for detectability.

12.6.1.1.1.3.4 Annual

117. Throughout the year the number of gannets at risk of mortality due to displacement from construction activity across the array areas was up to 1.46 individuals.

118. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 89). The addition of a maximum of 1.46 to this increases the mortality rate by 0.002%, which is below the 1% threshold for detectability.

119. The number of individuals from the biogeographic population expected to die across all seasons is 225,380 (see paragraph 89). The addition of a maximum of 1.46 to this increases the mortality rate by 0.001%, which is below the 1% threshold for detectability.

120. The sensitivity of gannet to construction displacement is considered to be low and the magnitude of annual impact at the array areas is negligible, therefore the annual effect on gannet due to construction displacement at the array areas is assessed as negligible.

121. A table summarising the gannet construction displacement assessment is provided below (**Table 12-16**).

12.6.1.1.1.4 Summary of Construction Displacement Assessment - Gannet

Table 12-16 Summary of Gannet Displacement During Construction Assessment for DBS East, DBS West and Combined (Projects). Note that the Project Total is Less Than the Sum of East and West due to Overlap of the Individual 2km Buffers.

Gannet		DBS East	DBS West	Projects
Baseline average annual mortality				0.191
Breeding season	Reference population (subadult component of nonbreeding BDMPS)			47,727
	Density (birds/km^2)	1.23	0.94	N/A
	Individuals at risk of displacement	46	35	81
	Displacement mortality (@1%)	0.46	0.35	0.81
	Increase in background mortality (%)	<0.001	<0.001	<0.001
Autumn	Reference population (nonbreeding season BDMPS)			456,298
	Density (birds/km^2)	1.08	0.57	N/A
	Individuals at risk of displacement	41	21	62
	Displacement mortality (@1%)	0.41	0.21	0.62
	Increase in background mortality (%)	<0.001	<0.001	<0.001
Spring	Reference population			248,835
	Density (birds/km^2)	0.02	0.02	N/A
	Individuals at risk of displacement	0.75	0.75	1.5
	Displacement mortality (@1%)	0.007	0.075	0.015
	Increase in background mortality (%)	<0.001	<0.001	<0.001
Annual (BDMPS)	Reference population			456,298
	Density (birds/km^2)	2.33	1.53	N/A
	Individuals at risk of displacement	88	58	146
	Displacement mortality (@1%)	0.88	0.58	1.46
	Increase in background mortality (%)	<0.001	<0.001	0.002
	Significance	Negligible	Negligible	Negligible
Annual (biogeographic)	Biogeographical population			1,180,000
	Individuals at risk of displacement	0.88	0.58	1.46
	Increase in background mortality (%)	<0.001	<0.001	0.001
	Significance	Negligible	Negligible	Negligible

12.6.1.1.2 Auks (Guillemot and Razorbill and Puffin)

122. A review of available evidence for displacement of auks concluded that precautionary rates of displacement and mortality from operational wind farms would be 50% and 1% respectively (MacArthur Green 2021, submitted for the Norfolk Vanguard assessment). These figures are also considered suitably precautionary for the potential displacement around

construction vessels. Thus, the assessment presents estimates using a range from 1% mortality to 10% mortality.

12.6.1.1.3 Guillemot

123. Guillemots were recorded in the array areas year-round, with estimated peak densities within the DBS East array plus 2km buffer in November (26.12/km^2) and in the DBS West array and 2km buffer in March (26.67/km^2). Guillemots are considered to have a medium sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004), Furness and Wade (2012), Furness et al. (2013) and Bradbury et al. (2014).

124. The mean maximum foraging range for breeding guillemot is 73km (Woodward et al, 2019) which places the array areas beyond the range of the nearest breeding colony at Flamborough Head which is 100km from the array areas (**Table 12-9**).

125. It is therefore appropriate to assume that individuals seen during the breeding season are nonbreeding and that they are predominantly sub-adult birds. Indeed, the lowest densities in the array areas were recorded during the peak breeding months of May and June (<1bird/km^2). Since sub-adult guillemots are known to remain in wintering areas, the number of sub-adult birds in the relevant population during the breeding season may be estimated as 43% of the preceding BDMPS population (the proportion of the wintering BDMPS population that is immature, Furness, 2015). This gives a breeding season reference population of 695,441 (BDMPS for the UK North Sea and English Channel, 1,617,306 x 43%).

126. The number of individuals from this population expected to die in the breeding season is 97,362 (695,441 x 0.14, **Table 12-13**).

127. During the nonbreeding season the guillemot BDMPS population for the North Sea has been used as the reference population (1,617,306). For the annual assessment impacts have been considered in relation to both the largest of the BDMPS populations and also to the biogeographic population (4,125,000; Furness, 2015). The number of individuals from these populations expected to die in the nonbreeding season are 226,423 (1,617,306 x 0.14) and 577,500 (4,125,000 x 0.14) respectively.

12.6.1.1.3.1 Significance of Effect – DBS East in Isolation

12.6.1.1.3.1.1 Breeding Season

128. During the breeding season, the maximum mean peak density in the DBS East array area was $22.11/km^2$. With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure) up to 833 individuals (22.11 x 12.56 x 3) could be at risk of displacement, of which up to 83.3 would be expected to be at risk of mortality.

129. Based on the average mortality for guillemot of 0.14 (**Table 12-13**), a total of 97,362 birds would be expected to die each year from the breeding season reference population (see paragraph 126125). The addition of a maximum of 83.3 birds would increase the mortality rate by 0.09%. which is below the 1% threshold for detectability.

12.6.1.1.3.1.2 Nonbreeding

130. During the nonbreeding season the maximum mean peak density in the DBS East array area was $26.12/km^2$. With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), up to 984 individual birds (26.12 x 12.56 x 3) could be at risk of displacement, of which up to 98.4 would be expected to be at risk of mortality.

131. Based on the average mortality rate for guillemot of 0.14, a total 226,423 birds would be expected to die each year from the nonbreeding season BDMPS population (see paragraph 127). The addition of a maximum of 98.4 birds to this would increase the mortality rate by 0.04%, which is below the 1% threshold for detectability.

12.6.1.1.3.1.3 Annual

132. The estimated number of guillemots subject to construction disturbance and displacement mortality at DBS East throughout the year is up to 181.7 individuals.

133. The number of individuals expected to die from the largest BDMPS population throughout the year is 226,423. The addition of a maximum of 181.7 individuals to this increases the mortality rate by 0.08%, which is below the 1% threshold for detectability.

134. The number of individuals from the biogeographic population expected to die across all seasons is 577,500 (see paragraph 127). The addition of a maximum of 181.7 to this increases the mortality rate by 0.03%, which is below the 1% threshold for detectability.

135. The sensitivity of guillemot to construction displacement is considered to be medium and the magnitude of annual impact at DBS East is negligible, therefore the annual effect on guillemot due to construction displacement at DBS East is assessed as minor.

12.6.1.1.3.2 Significance of Effect – DBS West in Isolation

12.6.1.1.3.2.1 Breeding Season

136. During the breeding season, the maximum mean peak density in the DBS West array area was 26.67/km^2. With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure) up to 1,005 individuals (26.67 x 12.56 x 3) could be at risk of displacement, of which up to 100.5 would be expected to be at risk of mortality.

137. Based on the average mortality for the species of 0.14, a total of 97,362 birds would be expected to die each year from the breeding season reference population (see paragraph 126). The addition of a maximum of 100.5 birds would increase the mortality rate by 0.1%, which is below the 1% threshold for detectability.

12.6.1.1.3.2.2 Nonbreeding

138. During the nonbreeding season, the maximum mean peak density in the DBS West array area was 12.6/km^2. With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), up to 475 individual birds (12.6 x 12.56 x 3) could be at risk of displacement, of which up to 47.5 would be expected to be at risk of mortality.

139. Based on the average mortality rate for guillemot, of 0.14, 226,423 birds would be expected to die each year from the nonbreeding season BDMPS population (see paragraph 127). The addition of 47.5 birds to this would increase the mortality rate by up to 0.02%, which is below the 1% threshold for detectability.

12.6.1.1.3.2.3 Annual

140. The estimated number of guillemots subject to construction disturbance and displacement mortality at DBS West throughout the year is up to 148.

141. The number of individuals expected to die from the largest BDMPS population throughout the year is 226,423. The addition of a maximum of 148 individuals to this increases the mortality rate by 0.07%, which is below the 1% threshold for detectability.

142. The number of individuals from the biogeographic population expected to die across all seasons is 577,500 (see paragraph 127). The addition of a maximum of 148 to this increases the mortality rate by 0.03%, which is below the 1% threshold for detectability.

143. The sensitivity of guillemot to construction displacement is considered to be medium and the magnitude of annual impact at DBS West is negligible, therefore the annual effect on guillemot due to construction displacement at DBS West is assessed as minor.

12.6.1.1.3.3 Significance of Effect – DBS East and DBS West Together

12.6.1.1.3.3.1 Breeding Season

144. During the breeding season the number of guillemots at risk of mortality due to displacement from construction vessels across the array areas was up to 183.8.

145. Based on the average mortality for the species of 0.14 (**Table 12-13**), a total of 97,362 birds would be expected to die each year from the breeding season reference population (see paragraph 126). The addition of a maximum of 183.8 birds predicted to be at risk of mortality from construction disturbance and displacement would increase the mortality rate by 0.2%, which is below the 1% threshold for detectability.

12.6.1.1.3.3.2 Nonbreeding

146. During the nonbreeding season the number of guillemots at risk of mortality due to displacement from construction vessels across the array areas was up to 145.9.

147. Based on the average mortality rate for guillemot, of 0.14, 226,423 birds would be expected to die each year from the nonbreeding season BDMPS population (see paragraph 127). The addition of 145.9 birds to this would increase the mortality rate by up to 0.06%, which is below the 1% threshold for detectability.

12.6.1.1.3.3.3 Annual

148. Throughout the year the number of guillemots at risk of mortality due to displacement from construction activity across the array areas was up to 329.7.

149. The number of individuals expected to die from the largest BDMPS population throughout the year is 226,423. The addition of a maximum of 329.7 individuals to this increases the mortality rate by 0.15%, which is below the 1% threshold for detectability.

150. The number of individuals from the biogeographic population expected to die across all seasons is 577,500 (see paragraph 127). The addition of a maximum of 329.7 to this increases the mortality rate by 0.06%, which is below the 1% threshold for detectability. The sensitivity of guillemot to construction displacement is considered to be medium and the magnitude of annual impact at the array areas is negligible, therefore the annual effect on guillemot due to construction displacement at the array areas is assessed as minor. A table summarising the guillemot construction displacement assessment is provided below (**Table 12-17**).

12.6.1.1.3.4 Summary of Construction Displacement Assessment - Guillemot

Table 12-17 Summary of Guillemot Displacement During Construction Assessment For DBS East, DBS West and Combined (Projects). Note that the Project Total is Less Than the Sum of East and West Due to Overlap of the Individual 2km Buffers.

Guillemot		DBS East	DBS West	Projects
Baseline average annual mortality				0.14
Breeding season	Reference population (subadult component of nonbreeding BDMPS)			695,441
	Density (birds/km^2)	22.11	26.67	N/A
	Individuals at risk of displacement	833	1005	1838
	Displacement mortality (@10%)	83.3	100.5	183.8
	Increase in background mortality (%)	0.09	0.1	0.2
Non breeding season	Reference population			1,617,306
	Density (birds/km^2)	26.12	12.6	N/A
	Individuals at risk of displacement	984	475	1459
	Displacement mortality (@10%)	98.4	47.5	145.9
	Increase in background mortality (%)	0.04	0.02	0.06
Annual (BDMPS)	Reference population			1,617,306
	Density (birds/km^2)	48.23	38.72	N/A
	Individuals at risk of displacement	1817	1480	3297
	Displacement mortality (@1%)	181.7	148	329.7
	Increase in background mortality (%)	0.08	0.07	0.15
	Significance	Minor	Minor	Minor
Annual (biogeographic)	Biogeographical population			4,125,000
	Individuals at risk of displacement	181.7	148	329.7
	Increase in background mortality (%)	0.03	0.03	0.06
	Significance	Minor	Minor	Minor

12.6.1.1.4 Razorbill

151. Razorbills were recorded in the array areas year-round, with estimated peak densities within the DBS East array plus 2km buffer in March (11.64/km²) and in the DBS West array plus 2km buffer in April (5.79/km²). Razorbills are considered to have a medium sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004), Furness and Wade (2012), Furness *et al*. (2013) and Bradbury *et al*. (2014).

152. The mean maximum foraging range for breeding razorbill is 88.7km (Woodward et al. 2019) which places the array areas beyond the range of the nearest breeding colony at Flamborough Head which is 100km from the array areas (**Table 12-9**).

153. It is therefore appropriate to assume that individuals seen during the breeding season are nonbreeding and that they are predominantly sub-adult birds. Since sub-adult seabirds are known to remain in wintering areas, the number of sub-adult birds in the relevant population during the breeding season may be estimated as 43% of the preceding BDMPS population (the proportion of the wintering BDMPS population that is immature, Furness, 2015). This gives a breeding season population of 94,007 (BDMPS for the UK North Sea and Channel, 218,622 x 43%).

154. The number of individuals from this population expected to die in the breeding season is 16,357 (94,007 x 0.174, **Table 12-13**).

155. During the nonbreeding seasons the razorbill BDMPS populations for the North Sea have been used as the reference populations (in the autumn and spring: 591,874 and in the winter: 218,622). For the annual assessment impacts have been considered in relation to the largest of the BDMPS populations (autumn/spring) and also to the biogeographic population (1,707,000; Furness, 2015). The number of individuals from these populations expected to die in the nonbreeding season are for spring and autumn 102,986 (591,874 x 0.174), for winter 38,040 (218,622 x 0.174) and from the biogeographic population 297,018 (1,707,000 x 0.174) respectively.

12.6.1.1.4.1 Significance of Effect – DBS East in Isolation

12.6.1.1.4.1.1 Breeding Season

156. During the breeding season, the maximum peak density in the DBS East array area was 2.11/km². With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), up to 80 individuals (2.11 x 12.56 x 3) could be at risk of displacement, of which up to 8 would be expected to be at risk of mortality.

157. Based on the average mortality for the species of 0.174, a total of 16,357 birds would be expected to die each year from the breeding season reference population (see paragraph 154). The addition of a maximum of 8 birds would increase the mortality rate by 0.05%, which is below the 1% threshold for detectability.

12.6.1.1.4.1.2 Autumn Migration

158. During the autumn migration season the maximum mean peak density in the DBS East array area was 0.94/km^2. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure) up to 35 individual birds (0.94 x 12.56 x 3) that could be at risk of displacement, of which up to 3.5 birds would be predicted to be at risk of mortality.

159. Based on the average mortality for the species of 0.174, a total of 102,986 birds would be expected to die in autumn (see paragraph 155). The addition of 3.5 birds to this would increase the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.4.1.3 Winter

160. During the winter, the maximum mean peak density in the DBS East array areas was 5.59/km^2. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), up to 211 individual birds (5.59 x 12.56 x 3) could be at risk of displacement, of which up to 21.1 would be expected to be at risk of mortality.

161. Based on the average mortality for the species of 0.174, a total of 38,040 birds would be expected to die from the winter population (see paragraph 155). The addition of a maximum of 21.1 birds would increase the mortality rate by 0.05%, which is below the 1% threshold for detectability.

12.6.1.1.4.1.4 Spring Migration

162. During the spring migration, the maximum mean peak density in the DBS East array was 11.64/km^2. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), up to 439 individual birds (11.64 x 12.56 x 3) could be at risk of displacement, of which up to 43.9 would be expected to be at risk of mortality.

163. Based on the average mortality for the species of 0.174, a total of 102,986 birds would be expected to die during the spring migration period (see paragraph 155). The addition of a maximum of 43.9 birds would increase the mortality rate by 0.04%, which is below the 1% threshold for detectability.

12.6.1.1.4.1.5 Annual

164. The estimated number of razorbills subject to construction disturbance and displacement mortality at DBS East throughout the year was up to 76.4 individuals.

165. At the average baseline mortality rate for razorbill of 0.174, a total of 102,986 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 155). The addition of a maximum of 76.4 individuals to this increases the mortality rate by 0.07%, which is below the 1% threshold for detectability.

166. The number of individuals from the biogeographic population expected to die across all seasons is 297,018 (see paragraph 155). The addition of a maximum of 76.4 to this increases the mortality rate by 0.03%, which is below the 1% threshold for detectability.

167. The sensitivity of razorbill to displacement is considered to be medium and the magnitude of annual impact at DBS East is negligible, therefore the annual effect on razorbill due to construction displacement at DBS East is assessed as minor.

12.6.1.1.4.2 Significance of Effect – DBS West in Isolation

12.6.1.1.4.2.1 Breeding Season

168. During the breeding season, the maximum mean peak density in the DBS West array areas was 5.79/km^2. With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), up to 218 individuals (5.79 x 12.56 x 3) could be at risk of displacement, of which up to 21.8 birds would be expected to be at risk of mortality.

169. Based on the average mortality for the species of 0.174, a total of 16,357 birds would be expected to die each year from the breeding season reference population (see paragraph 154).The addition of a maximum of 21.8 birds predicted to be at risk of mortality from construction disturbance and displacement would increase the mortality rate by 0.13%, which is below the 1% threshold for detectability.

12.6.1.1.4.2.2 Autumn Migration

170. During the autumn migration season the maximum mean peak density in the DBS West array area was 1.06 /km2 DBS West. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure) up to 40 individual birds (1.06 x 12.56 x 3) could be at risk of displacement, of which up to 4 birds would be predicted to be at risk of mortality.

171. Based on the average mortality for the species of 0.174, a total of 102,986 birds would be expected to die in autumn (see paragraph 155). The addition of 4 birds to this would increase the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.4.2.3 Winter

172. During the winter, the maximum mean peak density in the DBS West array area was 2.65/km^2. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), up to 100 individual birds (2.65 x 12.56 x 3) could be at risk of displacement, of which up to 10 would be expected to be at risk of mortality.

173. Based on the average mortality for the species of 0.174, a total of 38,040 birds would be expected to die in winter (see paragraph 155). The addition of a maximum of 10 birds would increase the mortality rate by 0.03%, which is below the 1% threshold for detectability.

12.6.1.1.4.2.4 Spring Migration

174. During the spring migration, the maximum mean peak density in the DBS West array area was 3.36/km^2. With a precautionary 2km radius of disturbance around each of three construction areas (wind turbines or other infrastructure), up to 127 individual birds (3.36 x 12.56 x 3) could be at risk of displacement, of which up to 12.7 would be expected to be at risk of mortality.

175. Based on the average mortality for the species of 0.174, a total of 102,986 birds would be expected to die each year from the spring migration (see paragraph 155). The addition of a maximum of 12.7 birds would increase the mortality rate by 0.01%, which is below the 1% threshold for detectability.

12.6.1.1.4.2.5 Annual

176. The estimated number of razorbills subject to construction disturbance/displacement mortality at DBS West throughout the year was up to 48.5 individuals.

177. At the average baseline mortality rate for razorbill of 0.174, a total of 102,986 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 155). The addition of a maximum of 48.5 individuals to this increases the mortality rate by 0.05%, which is below the 1% threshold for detectability.

178. The number of individuals from the biogeographic population expected to die across all seasons is 297,018 (see paragraph 154). The addition of a maximum of 48.5 to this increases the mortality rate by 0.16%, which is below the 1% threshold for detectability.

179. The sensitivity of razorbill to displacement is considered to be medium and the magnitude of annual impact at DBS West is negligible, therefore the annual effect on razorbill due to construction displacement at DBS West is assessed as minor.

12.6.1.1.4.3 Significance of Effect – DBS East and DBS West Together

12.6.1.1.4.3.1 Breeding Season

180. During the breeding season the number of razorbills at risk of mortality due to displacement from construction vessels across the array areas was up to 29.8.

181. Based on the average mortality for the species of 0.174, a total of 16,357 birds would be expected to die each year from the breeding season reference population (see paragraph 154). The addition of a maximum of 29.8 birds predicted to be at risk of mortality from construction disturbance and displacement would increase the mortality rate by 0.18%, which is below the 1% threshold for detectability.

12.6.1.1.4.3.2 Autumn Migration

182. During the autumn migration the number of razorbills at risk of mortality due to displacement from construction vessels across the array areas was up to 7.5 birds.

183. Based on the average mortality for the species of 0.174, a total of 102,986 birds would be expected to die in autumn (see paragraph 155). The addition of 7.5 birds to this would increase the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.4.3.3 Winter

184. During the winter the number of razorbills at risk of mortality due to displacement from construction vessels across the array areas was up to 31.1.

185. Based on the average mortality for the species of 0.174, a total of 38,040 birds would be expected to die in winter (see paragraph 155). The addition of a maximum of 31.1 birds would increase the mortality rate by 0.08%, which is below the 1% threshold for detectability.

12.6.1.1.4.3.4 Spring Migration

186. During the spring migration the number of razorbills at risk of mortality due to displacement from construction vessels across the array areas was up to 56.6.

187. Based on the average mortality for the species of 0.174, a total of 102,986 birds would be expected to die each year from the spring migration (see paragraph 155). The addition of a maximum of 56.6 birds would increase the mortality rate by 0.05%, which is below the 1% threshold for detectability.

12.6.1.1.4.3.5 Annual

188. Throughout the year the number of razorbills at risk of mortality due to displacement from construction vessels across the array areas was up to 125 individuals.

189. At the average baseline mortality rate for razorbill of 0.174, a total of 102,986 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 155). The addition of a maximum of 125 individuals to this increases the mortality rate by 0.1%, which is below the 1% threshold for detectability.

190. The number of individuals from the biogeographic population expected to die across all seasons is 297,018 (see paragraph 154). The addition of a maximum of 125 to this increases the mortality rate by 0.07%, which is below the 1% threshold for detectability.

191. The sensitivity of razorbill to displacement is considered to be medium and the magnitude of annual impact at the array areas is negligible, therefore the annual effect on razorbill due to construction displacement at the array areas is assessed as minor.

192. A table summarising the razorbill construction displacement assessment is provided below (**Table 12-18**).

12.6.1.1.4.4 Summary of Construction Displacement Assessment - Razorbill

Table 12-18 Summary of Razorbill Displacement During Construction Assessment for DBS East, DBS West and Combined (Projects). Note that the Project Total is Less Than the Sum of East and West Due to Overlap of the Individual 2km Buffers.

Razorbill		DBS East	DBS West	Projects
Baseline Average Annual Mortality				0.174
Breeding season	Reference population (subadult component of nonbreeding BDMPS)			94,007
	Density (birds/km^2)	2.11	5.79	N/A
	Individuals at risk of displacement	80	218	298
	Displacement mortality (@80% x 1%)	8	21.8	29.8
	Increase in background mortality (%)	0.05	0.13	0.18
Autumn	Reference population (Nonbreeding season BDMPS)			591,874
	Density (birds/km^2)	0.94	1.06	N/A
	Individuals at risk of displacement	35	40	75
	Displacement mortality (@10%)	3.5	4	7.5
	Increase in background mortality (%)	<0.01	<0.01	<0.01
Winter	Reference population (nonbreeding season BDMPS)			218,622
	Density (birds/km^2)	5.59	2.65	N/A
	Individuals at risk of displacement	211	100	311
	Displacement mortality (@10%)	21.1	10	31.1
	Increase in background mortality (%)	0.05	0.03	0.08
Spring	Reference population			591,874
	Density (birds/km^2)	11.64	3.36	N/A
	Individuals at risk of displacement	439	127	565
	Displacement mortality (@10%)	43.9	12.7	56.5
	Increase in background mortality (%)	0.04	0.01	0.05
Annual (BDMPS)	Reference population			591,874
	Density (birds/km^2)	20.28	12.86	N/A
	Individuals at risk of displacement	764	485	1249
	Displacement mortality (@10%)	76.4	48.5	124.9
	Increase in background mortality (%)	0.07	0.05	0.1
	Significance	Minor	Minor	Minor
Annual (biogeographic)	biogeographical population			1,707,000
	Displacement mortality (@10%)	76.4	48.5	124.9
	Increase in background mortality (%)	0.03	0.16	0.07
	Significance	Minor	Minor	Minor

12.6.1.1.5 Puffin

193. Puffins were recorded in the array areas with a spring and autumn focus (March, April and July to October). Estimated densities peaked within the DBS East array plus 2km buffer in October (0.66/km^2) and in the DBS West array plus 2km buffer in October (0.51/km^2). Puffins are considered to have a medium sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004), Furness and Wade (2012), Furness *et al*. (2013) and Bradbury *et al*. (2014).

194. The array areas are within the mean maximum foraging range of puffins (137km) from the breeding colony at the FFC SPA, therefore indicating some degree of connectivity is possible. However, as the array areas are at the upper end of the foraging range, and the numbers seen in breeding season months were generally low (or the birds were absent altogether, e.g. May and June), two reference populations have been considered for the breeding season assessment. The first is derived from the latest FFC SPA breeding adult population estimate of 3,080 individuals (Clarkson *et al*., 2022). If it is assumed these are adult breeding birds, the inclusion of sub-adults associated with the colony based on the adult proportion of 55%, Furness, 2015), the total population associated with the FFC would be 5,600 individuals.

195. However, since the array areas are within foraging range from the FFC SPA, assessment against the sub-adult component of the nonbreeding BDMPS population is also appropriate (on the basis that these sub-adult birds remain in the wintering areas over the summer). The puffin nonbreeding season BDMPS population is 231,957, of which the subadult population is estimated as 104,381 (45%), which has been used as an alternative breeding season reference population.

196. In the breeding season, the number of individuals expected to die from the population associated with the FFC SPA is 935 (5,600 x 0.167, **Table 12-13**Error! Reference source not found.), while the number of birds expected to die from the subadult breeding season population is 17,432 (104,381 x 0.167).

197. During the nonbreeding seasons the puffin BDMPS population for the North Sea, 231,957, is used as the reference population for assessment. For the assessment of annual impacts, two reference populations have been considered; the BDMPS (231,957) and the biogeographic population (11,840,000; Furness, 2015). The number of individuals from these populations expected to die in the nonbreeding season are 38,737 (231,957 x 0.167) and 1,977,280 (11,840,000 x 0. 167) respectively.

12.6.1.1.5.1 Significance of Effect – DBS East in Isolation

12.6.1.1.5.1.1 Breeding Season

198. During the breeding season, the maximum mean peak density in the DBS East array area was 0.11/km². With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure) up to 4 individuals (0.11 x 12.56 x 3) could be at risk of displacement, of which 0.4 would be expected to be at risk of mortality.

199. Based on the average mortality for adult puffin of 0.167, a total of 935 birds from the FFC SPA population would be expected to die in the breeding season (see paragraph 196). The addition of a maximum of 0.4 to this increases the mortality rate by 0.04% which is below the 1% threshold for detectability.

200. Alternatively, a total of 17,432 birds from the breeding season reference population (derived from the spring BDMPS, see paragraph 196). would be expected to die in the breeding season. The addition of a maximum of 0.4 to this increases the mortality rate by <0.01% which is below the 1% threshold for detectability.

12.6.1.1.5.1.2 Nonbreeding

201. During the nonbreeding season the maximum mean peak density in DBS East array area was 0.66/km². With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), up to 25 individual birds (0.66 x 12.56 x 3) could be at risk of displacement, of which up to 2.5 birds would be expected to be at risk of mortality.

202. Based on the average mortality rate for adult puffin of 0.167, a total of 38,737 birds would be expected to die each year from the non-breeding season BDMPS population (see paragraph 197). The addition of 2.5 birds to this would increase the mortality rate by up to <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.5.1.3 Annual

203. The estimated number of puffins subject to construction disturbance and displacement mortality at DBS East throughout the year is up to 2.9 individuals.

204. At the average baseline mortality rate for puffin of 0.167, a total of 38,737 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 197). The addition of a maximum of 2.9 individuals to this increases the mortality rate by 0.01%, which is below the 1% threshold for detectability.

205. The number of individuals from the biogeographic population expected to die across all seasons is 1,977,280 (see paragraph 197). The addition of a maximum of 2.9 to this increases the mortality rate by <0.001%, which is below the 1% threshold for detectability.

206. The sensitivity of puffin to construction displacement is considered to be medium and the magnitude of annual impact at DBS East is negligible, therefore the annual effect on puffin due to construction displacement at DBS East is assessed as minor.

12.6.1.1.5.2 Significance of Effect – DBS West in Isolation

12.6.1.1.5.2.1 Breeding Season

207. During the breeding season, the maximum mean peak density in the DBS West array area was 0.38/km². With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure) up to 14 individuals (0.38 x 12.56 x 3) could be at risk of displacement, of which 1.4 would be expected to be at risk of mortality.

208. Based on the average mortality for adult puffin of 0.167, a total of 935 birds individuals from the FFC SPA population expected to die in the breeding season (see paragraph 196). The addition of a maximum of 1.4 to this increases the mortality rate by 0.15%, which is below the 1% threshold for detectability.

209. Alternatively, a total of 17,432 birds from the breeding season reference population (derived from the spring BDMPS, see paragraph 196). would be expected to die in the breeding season. The addition of a maximum of 1.4 to this increases the mortality rate by <0.01% which is below the 1% threshold for detectability.

12.6.1.1.5.2.2 Nonbreeding

210. During the nonbreeding season the maximum mean peak density in DBS West array area was 0.51/km². With a precautionary 2km radius of disturbance around each of three active construction areas (wind turbines or other infrastructure), up to 19 individual birds (0.51 x 12.56 x 3) could be at risk of displacement, of which up to 1.9 birds would be expected to be at risk of mortality.

211. Based on the average mortality rate for adult puffin of 0.167, a total of 38,737 birds would be expected to die each year from the non-breeding season BDMPS population (see paragraph 197). The addition of 1.9 birds to this would increase the mortality rate by up to <0.01%, which is below the 1% threshold for detectability.

12.6.1.1.5.2.3 Annual

212. The estimated number of puffins subject to construction disturbance and displacement mortality at DBS West throughout the year is up to 3.4 individuals.

213. At the average baseline mortality rate for puffin of 0.167, a total of 38,737 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 197). The addition of a maximum of 3.4 individuals to this increases the mortality rate by 0.01%, which is below the 1% threshold for detectability.

214. The number of individuals from the biogeographic population expected to die across all seasons is 1,977,280 (see paragraph 197). The addition of a maximum of 3.4 to this increases the mortality rate by <0.001%, which is below the 1% threshold for detectability.

215. The sensitivity of puffin to displacement is considered to be medium and the magnitude of annual impact at DBS West is negligible, therefore the annual effect on puffin due to construction displacement at DBS West is assessed as minor.

12.6.1.1.5.3 Significance of Effect – DBS East and DBS West Together

12.6.1.1.5.3.1 Breeding Season

216. During the breeding season the number of puffins at risk of mortality due to displacement from construction vessels across the array areas plus 2km buffer was up to 1.8 birds.

217. Based on the average mortality for adult puffin of 0.167, a total of 935 birds individuals from the FFC SPA population expected to die in the breeding season (see paragraph 196). The addition of a maximum of 1.8 birds to this increases the mortality rate by 0.19%, which is below the 1% threshold for detectability.

218. Alternatively, a total of 17,432 birds from the breeding season reference population (derived from the spring BDMPS, see paragraph 196). would be expected to die in the breeding season. The addition of a maximum of 1.8 to this increases the mortality rate by 0.01% which is below the 1% threshold for detectability.

12.6.1.1.5.3.2 Nonbreeding

219. During the breeding season the number of guillemots at risk of mortality due to displacement from construction vessels across the array areas was up to 4.4 birds.

220. Based on the average mortality rate for adult puffin of 0.167, a total of 38,737 birds would be expected to die each year from the non-breeding season BDMPS population (see paragraph 197). The addition of 4.4 birds to this would increase the mortality rate by up to 0.01%, which is below the 1% threshold for detectability.

12.6.1.1.5.3.3 Annual

221. Throughout the year the number of puffins at risk of mortality due to displacement from construction vessels across the array areas was up to 6.3 birds.

222. At the average baseline mortality rate for puffin of 0.167, a total of 38,737 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 197). The addition of a maximum of 6.3 individuals to this increases the mortality rate by 0.02%, which is below the 1% threshold for detectability.

223. The number of individuals from the biogeographic population expected to die across all seasons is 1,977,280 (see paragraph 197). The addition of a maximum of 6.3 to this increases the mortality rate by <0.001%, which is below the 1% threshold for detectability.

224. The sensitivity of puffin to construction displacement is considered to be medium and the magnitude of annual impact at the array areas is negligible, therefore the annual effect on puffin due to construction displacement at the array areas is assessed as minor.

225. A table summarising the puffin construction displacement assessment is provided below (**Table 12-19**).

12.6.1.1.5.4 Summary of Construction Displacement Assessment - Puffin

Table 12-19 Summary of Puffin Displacement During Construction Assessment for DBS East, DBS West and Combined (Projects). Note that the Project Total is Less Than the Sum of East and West Due to Overlap of the Individual 2km Buffers

Puffin		DBS East	DBS West	Projects
Baseline average annual mortality				0.167
Breeding season	Reference population (FFC SPA only)			5,600
	Density (birds/km^2)	0.11	0.38	N/A
	Individuals at risk of displacement	4	14	18
	Displacement mortality (@10%)	0.4	1.4	1.8
	Increase in background mortality (%)	0.04	0.15	0.19
	Reference population (subadult component of nonbreeding BDMPS)			104,381
	Increase in background mortality (%)	<0.01	<0.01	0.01
Non breeding season	Reference population			231,957
	Density (birds/km^2)	0.66	0.51	N/A
	Individuals at risk of displacement	25	19	44
	Displacement mortality (@10%)	2.5	1.9	4.4
	Increase in background mortality (%)	<0.01	<0.01	0.01
Annual (BDMPS)	Reference population			231,957
	Density (birds/km^2)	0.77	0.89	N/A
	Individuals at risk of displacement	29	33.5	62.5
	Displacement mortality (@10%)	2.9	3.4	6.3
	Increase in background mortality (%)	0.01	0.01	0.02
	Significance	Minor	Minor	Minor
Annual (biogeographic)	Biogeographical population			11,840,000
	Displacement mortality (@10%)	2.9	3.4	6.3
	Increase in background mortality (%)	<0.001	<0.001	<0.001
	Significance	Minor	Minor	Minor

12.6.1.2 Impact 2 Indirect Impacts Through Effects on Habitats and Prey Species During Construction

226. Indirect disturbance and displacement of birds may occur during the construction phase if there are impacts on prey species and the habitats of prey species. These indirect effects include those resulting from the production of underwater noise (e.g. during piling) and the generation of suspended sediments (e.g. during preparation of the seabed for foundations) that may alter the behaviour or availability of bird prey species. Underwater noise may cause fish and mobile invertebrates to avoid the construction area and also affect their physiology and behaviour. Suspended sediments may cause fish and mobile invertebrates to avoid the construction area and may smother and hide immobile benthic prey. These mechanisms may result in less prey being available within the construction area to foraging seabirds. Such potential effects on benthic invertebrates and fish have been assessed in **Chapter 9 Benthic and Intertidal Ecology** and **Chapter 10 Fish and Shellfish Ecology** and the conclusions of those assessments inform this assessment of indirect effects on birds.

227. With regard to noise impacts on fish, **Chapter 10 Fish and Shellfish Ecology** discusses the potential impacts upon fish relevant to ornithology as prey species. For species such as herring, sprat and sandeel, which are the main prey items of seabirds such as gannet and auks, unmitigated underwater noise effects (physical injury or behavioural changes) during construction are considered to be moderate adverse for herring (group 3, most sensitive species) and minor adverse for sandeel and sprat (group 1, least sensitive species). With a minor effect on fish that are bird prey species, it is concluded that the magnitude of effect on seabirds, for which the DBS array areas represent only a small part of their possible foraging range, will be negligible. Therefore, the indirect significance, even for high sensitivity seabirds, of impacts on fish during the construction phase is, at most, minor adverse. This conclusion applies irrespective of the alternative construction scenarios (one or two projects, constructed concurrently or sequentially).

228. With regard to changes to the seabed and to suspended sediment levels, **Chapter 8 Marine Physical Environment** and **Chapter 9 Benthic and Intertidal Ecology** discusses the nature of any likely significant effects on the seabed and benthic habitats. The impact on benthic habitats is predicted to be of local spatial extent (i.e. restricted to discrete areas within the array areas in the vicinity of the construction location, short-term duration (as it is limited to the duration of construction activities), intermittent and with high reversibility. The consequent indirect effect on benthic habitats is considered to be minor. With a minor effect on benthic habitats which support fish that are bird prey species, it is concluded that

the magnitude of effect on seabirds, for which the DBS array areas represent only a small part of their possible foraging range, will be negligible. Therefore, the indirect significance, even for high sensitivity seabirds, of impacts on benthic habitats during the construction phase is, at most, minor adverse. This conclusion applies irrespective of the alternative construction scenarios (one or two Projects, constructed concurrently or sequentially).

12.6.2 Potential Effects During Operation

12.6.2.1 Impact 3 Disturbance and Displacement from Offshore Infrastructure

229. The presence of wind turbines has the potential to directly disturb and displace birds from within and around the array area. This is assessed as effective habitat loss, as it has the potential to reduce the area available to birds for feeding, loafing and moulting. Vessel activity and the lighting of wind turbines and associated ancillary structures could also attract (or repel) certain species of birds and affect migratory behaviour on a local scale.

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

231. Post-construction monitoring over two breeding seasons of the Beatrice wind farm in Scotland has found little indication that guillemots and razorbills avoid wind turbines, with spatial distributions within the wind farm no different from those that might be expected by chance (MacArthur Green, 2021).

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

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

234. Both the presence of the infrastructure and the operational activities associated with the Projects have the potential to directly disturb birds. These activities could potentially displace birds from important areas for feeding, moulting and loafing. Reduced access to some areas could result, at the extreme, in changes to feeding and other behavioural activities resulting in a loss of fitness and a reduction in survival chances. This would be unlikely for seabirds that have large areas of alternative habitat available but would be more likely to affect seabirds with highly specialised habitat requirements that are limited in availability (Furness *et al*., 2013; Bradbury *et al*., 2014).

235. The methodology presented in JNCC (2017) recommends a matrix is presented for each key species showing bird losses at differing rates of displacement and mortality. This assessment uses the range of predicted losses, in association with the scientific evidence available from post-construction monitoring studies, to quantify the level of displacement and the potential losses as a consequence of the proposed project. These losses are then placed in the context of the relevant population (e.g. SPA, BDMPS or biogeographic) to determine the magnitude of impact.

236. The population estimate used for each species to assess the displacement effects was the relevant seasonal peak (i.e. the highest value for the months within each season). The seasonal peaks were calculated as follows; first the density for each calendar month was calculated, then the highest value from the months within each season extracted. As per JNCC (2017), for divers, the assessment used all data recorded within the 4km buffer, for all other species the assessment used all data recorded within the 2km buffer (although it should be noted that the evidence reviews in MacArthur Green

2021 indicate that these buffer distances are highly precautionary for both divers and auks).

237. Birds are considered to be most at risk from operational disturbance and displacement effects when they are resident (e.g. during the breeding season or wintering season). The small risk of impact to migrating birds is better considered in terms of barrier effects. However, JNCC (2017) suggests that migration periods should also be assessed using the matrix approach and this has been undertaken where appropriate.

238. Following installation of the offshore cable, the required operational and maintenance activities (in relation to the cable) may have short-term and localised disturbance and displacement impacts on birds. However, disturbance from operational cable activities (e.g. maintenance) would be temporary and localised, and is unlikely to result in detectable effects at either the local or regional population level. Therefore, no impact due to cable operation and maintenance is predicted. The focus of this section is therefore on the disturbance and displacement of birds due to the presence and operation of wind turbines, other offshore infrastructure and any maintenance operations associated with these structures.

239. In order to focus the assessment of disturbance and displacement, a screening exercise was undertaken to identify those species most likely to be at risk (**Table 12-20**), focussing on the main species described in the Ornithology Technical Report (Technical Appendix 12.1). The species identified as at risk were then assessed within the biological seasons within which effects were potentially likely to occur. Any species with a low sensitivity to displacement or recorded only in very small numbers within the DBS offshore wind farms during the breeding and wintering seasons, were screened out of further assessment.

240. This process screened out great northern diver as only a single individual of this species was recorded in one survey.

241. Operational disturbance and displacement screening (**Table 12-20**) presents the general sensitivity to disturbance and displacement for each species.

Table 12-20 Operational Disturbance and Displacement Screening.

Receptor	Sensitivity to Disturbance and Displacement[1]	Biological Season(s) with peak numbers	Screening Result (IN or OUT)
Red-throated diver	Very High	Breeding (although considered to be a record of a late migrant)	Screened OUT due to very low numbers recorded (1 individual) and sub-optimal location.
Great northern diver	Very High	Breeding (although considered to be a record of a late migrant)	Screened OUT due to very low numbers recorded (1 individual) and sub-optimal location.
Fulmar	Considered Low in some studies, but possibly high according to Dierschke *et al.* (2016)	Moderate numbers throughout the year	Screened OUT as the species has a maximum habitat flexibility score of 1 in Furness & Wade (2012), suggesting species utilises a wide range of habitats over a large area.
Gannet	Considered Low in some studies, but possibly high according to Dierschke *et al.* (2016)	Spring and autumn migration	Screened IN for breeding, autumn and spring migration seasons, as has a high macro avoidance rate.
Guillemot	Medium	Non-breeding	Screened IN as present in moderate to high numbers all year round and due to medium sensitivity to disturbance and displacement.
Razorbill	Medium	Breeding, migration, and nonbreeding season	Screened IN as present in moderate to high numbers all year round and due to medium sensitivity to disturbance and displacement.

Receptor	Sensitivity to Disturbance and Displacement[1]	Biological Season(s) with peak numbers	Screening Result (IN or OUT)
Puffin	Low	Winter	Screened IN as present in moderate numbers, particularly in migration periods and due to medium sensitivity to disturbance and displacement.
Kittiwake	Low	Breeding	Screened OUT as migration numbers low relative to BDMPS and not known to avoid wind turbines (low macro avoidance rate)
Lesser black-backed gull	Low	Breeding	Screened OUT as present in low numbers in all seasons and not known to avoid wind turbines (low macro avoidance rate)
Herring gull	Low	Breeding	Screened OUT as present in low numbers in all seasons and not known to avoid wind turbines (low macro avoidance rate)
Great black-backed gull	Low	Non-breeding	Screened OUT as present in relatively low numbers in all seasons and not known to avoid wind turbines (low macro avoidance rate)
[1] Garthe and Hüppop, 2004; Furness and Wade, 2012, Wade *et al*., 2016, Dierschke *et al*., 2016			

242. The impact of mortality caused by displacement on a population has been assessed in terms of the change in the baseline mortality rate which could result. It has been assumed that all age classes are equally at risk of displacement (i.e. in proportion to their presence in the population), therefore the average mortality rates calculated above (**Table 12-13**) have been used.

243. For assessment a worst case assumption has been made that birds will be at risk of displacement from the complete extent of the array areas plus species specific buffers. This will over-estimate impacts since it is highly unlikely that the entire area within the array areas will contain wind turbines, and even if it did then the inter-wind turbine separation distance would be such that birds would be very likely to use areas between wind turbines. Therefore, the estimated number of birds at risk of an effect is precautionary, since it corresponds to a larger area than will ultimately be developed. There is evidence to suggest that the density of wind turbines influences the magnitude of displacement (Leopold *et al*., 2011). Indeed, since the cause of operational displacement is bird responses to the wind turbines, it is logical to infer that a wind farm with a lower wind turbine density will cause lower displacement levels than one with a higher density of wind turbines.

244. In addition, because the two array areas (East and West) share a border the buffer areas from the two array areas overlap. Therefore, the sum of the number at risk from each array area (when the buffers are included) is greater than the total from analysis of the array areas combined (i.e. as a result of double counting of birds recorded in the overlap zone; this double counting will be addressed in the ES).

245. Natural England guidance (Parker et al. 2022c) is that displacement effects estimated in different seasons should be combined to provide an annual effect for assessment which should then be assessed in relation to the largest of the component BDMPS populations, and also the biogeographic population. Natural England have acknowledged that summing impacts in this manner almost certainly over-estimates the number of individuals at risk through double counting (i.e. some individuals may potentially be present in more than one season) and assessing against the BDMPS almost certainly under-estimates the population from which they are drawn (which must be at least this size and is likely to be considerably larger as a consequence of turnover of individuals). However, at the present time there is no agreed alternative method for undertaking assessment of annual displacement and therefore the above approach is presented, albeit with the caveat that the results are anticipated to be highly precautionary.

12.6.2.1.1 Gannet

246. Gannets show a low level of sensitivity to ship and helicopter traffic (Garthe and Hüppop, 2004; Furness and Wade, 2012) however, a detailed study (Krijgsveld *et al*., 2011) using radar and visual observations to monitor the post-construction effects of the Windpark Egmond aan Zee OWEZ established that 64% of gannets avoided entering the wind farm (macro-avoidance) and a similar result (80% macro avoidance) was also observed during a study at the Thanet wind farm (Skov *et al*., 2018). Leopold *et al*. (2013) reported that most gannets avoided Dutch offshore wind farms and did not forage within these. Dierschke *et al*. (2016) concluded that gannets show high avoidance of offshore wind farms despite showing little avoidance of ships.

247. The displacement matrices have been populated with data for gannets recorded during the autumn and spring migration periods within the DBS East and DBS West array areas and the two combined including a 2km buffer, in line with guidance (JNCC, 2017). It should be noted that the inclusion of birds within the 2km buffer to determine the total number of birds subject to displacement is precautionary since in reality the avoidance rate is likely to fall with distance from the array area, as demonstrated in a study of gannet distribution in relation to the Greater Gabbard wind farm (APEM, 2014).

248. For the purpose of this assessment, percentage displacement rates between 10 and 100% at 10% increments have been combined with mortality between 1 and 100% at varying increments. The highlighted cells in the matrices indicate displacement rates of 60% to 80% (as the OWEZ and Thanet data suggest the actual rate lies between these two figures based on macro-avoidance; Leopold *et al*., 2013; Skov *et al*., 2018) and the most likely mortality rate, which is assumed to be no more than 1% (as they score highly for habitat flexibility; Furness and Wade, 2012). A high score in habitat flexibility is given to species that use a wide range of habitats over a large area, and usually with a relatively wide range of foods (Furness and Wade, 2012).

249. The nearest gannet breeding colony to the proposed development is the Flamborough and Filey Coast SPA. The SPA is a minimum of 100km from the Projects' array areas, and therefore they are within the mean maximum foraging range of gannets, estimated as 315km (Woodward *et al*. 2019). Consequently, breeding season connectivity to this SPA has been assumed.

250. Additional mortality of gannet during the breeding season has been assessed in relation to the Flamborough and Filey Coast SPA population. The SPA population at designation was 11,061 pairs, increasing to 13,392 pairs in 2017 (Aitken *et al*. 2017) with 13,125 pairs recorded in 2022 (Clarkson *et al*., 2022). The Clarkson *et al*. (2022) estimate), adjusted to include nonbreeding and immature birds that associate with the colony, has been used as a reference population, being closer in time to baseline surveys. This equates to a total population size during the breeding season of approximately 47,727 (derived as individual adults divided by the adult proportion of 0.55 from Furness, 2015, to provide an all-age class total).

251. The number of individuals from this population expected to die at the baseline mortality rate in the breeding season is 9,116 (47,727 x 0.191, **Table 12-13**).

252. During the nonbreeding seasons the gannet BDMPS populations for the North Sea have been used as the reference populations (in the autumn: 456,298 and in the spring: 248,385). For the annual assessment. impacts have been considered in relation to the largest of the BDMPS populations (autumn) and also to the biogeographic population (1,180,000; Furness, 2015). The number of individuals from these populations expected to die in the autumn is 87,153 (456,298 x 0.191), in the spring is 47,442 (248,385 x 0.191), and annually from the biogeographic population is 225,380 (1,180,000 x 0.191).

12.6.2.1.1.1 Significance of Effect – DBS East in Isolation

12.6.2.1.1.1.1 Breeding Season

253. During the breeding season, the maximum mean peak abundance in the DBS East array area and 2km buffer was 853 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the DBS East array area (and 2km buffer) during the breeding season has been estimated as 7 individuals (**Table 12-21**).

Table 12-21 Displacement Matrix Presenting the Number of Gannets in the DBS East Array Area (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	2	3	3	4	5	6	7	8	9
2	2	3	5	7	9	10	12	14	15	17
3	3	5	8	10	13	15	18	20	23	26
4	3	7	10	14	17	20	24	27	31	34
5	4	9	13	17	21	26	30	34	38	43
6	5	10	15	20	26	31	36	41	46	51
7	6	12	18	24	30	36	42	48	54	60
8	7	14	20	27	34	41	48	55	61	68
9	8	15	23	31	38	46	54	61	69	77
10	9	17	26	34	43	51	60	68	77	85
20	17	34	51	68	85	102	119	136	154	171
30	26	51	77	102	128	154	179	205	230	256
50	43	85	128	171	213	256	299	341	384	427
75	64	128	192	256	320	384	448	512	576	640
100	85	171	256	341	427	512	597	682	768	853

254. Based on the average mortality for the species of 0.191 a total of 9,116 birds would be expected to die each year (see paragraph 251). The addition of 7 individuals to these would increase the mortality rate by 0.08%, which is below the 1% threshold for detectability.

12.6.2.1.1.1.2 Autumn Migration

255. During the autumn migration period, the maximum mean peak abundance in the DBS East array area and 2km buffer was 753 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the DBS East array area (and 2km buffer) during the autumn migration period has been estimated as 6 individuals (**Table 12-22**).

Table 12-22 Displacement Matrix Presenting the Number of Gannets in the DBS East Array Area (and 2km Buffer) During the Autumn Migration Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	**Displacement (%)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	1	2	2	3	4	5	5	6	7	8
2	2	3	5	6	8	9	11	12	14	15
3	2	5	7	9	11	14	16	18	20	23
4	3	6	9	12	15	18	21	24	27	30
5	4	8	11	15	19	23	26	30	34	38
6	5	9	14	18	23	27	32	36	41	45
7	5	11	16	21	26	32	37	42	47	53
8	6	12	18	24	30	36	42	48	54	60
9	7	14	20	27	34	41	47	54	61	68
10	8	15	23	30	38	45	53	60	68	75
20	15	30	45	60	75	90	105	120	136	151
30	23	45	68	90	113	136	158	181	203	226
50	38	75	113	151	188	226	264	301	339	377
75	56	113	169	226	282	339	395	452	508	565
100	75	151	226	301	377	452	527	602	678	753

256. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die in autumn (see paragraph 252). The addition of a maximum of 6 to this increases the mortality rate by 0.01%, which is below the 1% threshold for detectability.

12.6.2.1.1.1.3 Spring Migration

257. During the spring migration period, the maximum mean peak abundance in the DBS East array area and 2km buffer was 17 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the DBS East array area (and 2km buffer) during the spring migration period has been estimated as <0.1 individuals (**Table 12-23)**.

Table 12-23 Displacement Matrix Presenting the Number of Gannets in the DBS East Array Area (and 2km Buffer) During the Spring Migration Season That May Be Subject to Mortality (Highlighted)

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	1
4	0	0	0	0	0	0	0	1	1	1
5	0	0	0	0	0	1	1	1	1	1
6	0	0	0	0	1	1	1	1	1	1
7	0	0	0	0	1	1	1	1	1	1
8	0	0	0	1	1	1	1	1	1	1
9	0	0	0	1	1	1	1	1	1	2
10	0	0	1	1	1	1	1	1	2	2
20	0	1	1	1	2	2	2	3	3	3
30	1	1	2	2	3	3	4	4	5	5
50	1	2	3	3	4	5	6	7	8	9
75	1	3	4	5	6	8	9	10	11	13
100	2	3	5	7	9	10	12	14	15	17

258. Based on the average mortality for the species of 0.191, a total of 47,442 birds would be expected to die in spring (see paragraph 252). The addition of a maximum of <0.1 to this increases the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.2.1.1.1.4 Annual

259. Summed across the year the maximum mean peak abundance in the DBS East array area and 2km buffer was 1,623 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the DBS East array area (and 2km buffer) during the breeding, autumn migration and spring migration periods combined (i.e. annually) has been estimated as 13 individuals (**Table 12-24**).

Table 12-24 Displacement Matrix Presenting the Number of Gannets in the DBS East Array Area (and 2km Buffer) Combined Across the Breeding and Nonbreeding Seasons That May Be Subject to Mortality (Highlighted).

Mortality (%)	**Displacement (%)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	2	3	5	6	8	10	11	13	15	16
2	3	6	10	13	16	19	23	26	29	32
3	5	10	15	19	24	29	34	39	44	49
4	6	13	19	26	32	39	45	52	58	65
5	8	16	24	32	41	49	57	65	73	81
6	10	19	29	39	49	58	68	78	88	97
7	11	23	34	45	57	68	80	91	102	114
8	13	26	39	52	65	78	91	104	117	130
9	15	29	44	58	73	88	102	117	131	146
10	16	32	49	65	81	97	114	130	146	162
20	32	65	97	130	162	195	227	260	292	325
30	49	97	146	195	243	292	341	390	438	487
50	81	162	243	325	406	487	568	649	730	812
75	122	243	365	487	609	730	852	974	1096	1217
100	162	325	487	649	812	974	1136	1298	1461	1623

260. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 252). The addition of a maximum of 13 to this increases the mortality rate by 0.01%, which is below the 1% threshold for detectability.

261. The number of individuals from the biogeographic population expected to die across all seasons is 225,380 (see paragraph 252). The addition of a maximum of 13 to this increases the mortality rate by 0.01%, which is below the 1% threshold for detectability.

262. The sensitivity of gannet to operational displacement is considered to be low and the magnitude of annual impact at DBS East is negligible, therefore the annual effect on gannet due to operational displacement at DBS East is assessed as negligible.

12.6.2.1.1.2 Significance of Effect – DBS West in Isolation

12.6.2.1.1.2.1 Breeding Season

263. During the breeding season, the maximum mean peak abundance in the DBS West array area and 2km buffer was 654 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the DBS West array area (and 2km buffer) during the breeding season has been estimated as 5 individuals (**Table 12-25**).

Table 12-25 Displacement Matrix Presenting the Number of Gannets in the DBS West Array Area (And 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	1	2	3	3	4	5	5	6	7
2	1	3	4	5	7	8	9	10	12	13
3	2	4	6	8	10	12	14	16	18	20
4	3	5	8	10	13	16	18	21	24	26
5	3	7	10	13	16	20	23	26	29	33
6	4	8	12	16	20	24	27	31	35	39
7	5	9	14	18	23	27	32	37	41	46
8	5	10	16	21	26	31	37	42	47	52
9	6	12	18	24	29	35	41	47	53	59
10	7	13	20	26	33	39	46	52	59	65
20	13	26	39	52	65	78	92	105	118	131
30	20	39	59	78	98	118	137	157	177	196
50	33	65	98	131	164	196	229	262	294	327
75	49	98	147	196	245	294	343	392	441	491
100	65	131	196	262	327	392	458	523	589	654

264. Based on the average mortality for the species of 0.191 a total of 9,116 birds would be expected to die each year (see paragraph 251). The addition of 5 individuals to these would increase the mortality rate by 0.05%, which is below the 1% threshold for detectability.

12.6.2.1.1.2.2 Autumn Migration

265. During the autumn migration period, the maximum mean peak abundance in the DBS West array area and 2km buffer was 394 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the DBS West array area ~~site~~ (and 2km buffer) during the autumn migration period has been estimated as 3 individuals (**Table 12-26**).

Table 12-26 Displacement Matrix Presenting the Number Of Gannets in the DBS West Array Area (and 2km Buffer) During the Autumn Migration Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	2	2	2	3	3	4	4
2	1	2	2	3	4	5	6	6	7	8
3	1	2	4	5	6	7	8	9	11	12
4	2	3	5	6	8	9	11	13	14	16
5	2	4	6	8	10	12	14	16	18	20
6	2	5	7	9	12	14	17	19	21	24
7	3	6	8	11	14	17	19	22	25	28
8	3	6	9	13	16	19	22	25	28	32
9	4	7	11	14	18	21	25	28	32	35
10	4	8	12	16	20	24	28	32	35	39
20	8	16	24	32	39	47	55	63	71	79
30	12	24	35	47	59	71	83	95	106	118
50	20	39	59	79	99	118	138	158	177	197
75	30	59	89	118	148	177	207	236	266	296
100	39	79	118	158	197	236	276	315	355	394

266. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die in autumn (see paragraph 252). The addition of a maximum of 3 to this increases the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.2.1.1.2.3 Spring Migration

267. During the spring migration period, the maximum mean peak abundance in the DBS West array area and 2km buffer was 17 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the DBS West array area (and 2km buffer) during the spring migration period has been estimated as <0.1 individuals (**Table 12-27**).

Table 12-27 Displacement Matrix Presenting the Number of Gannets in the DBS West Array Area (and 2km Buffer) During the Spring Migration Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	**Displacement (%)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	1
4	0	0	0	0	0	0	0	1	1	1
5	0	0	0	0	0	1	1	1	1	1
6	0	0	0	0	1	1	1	1	1	1
7	0	0	0	0	1	1	1	1	1	1
8	0	0	0	1	1	1	1	1	1	1
9	0	0	0	1	1	1	1	1	1	2
10	0	0	1	1	1	1	1	1	2	2
20	0	1	1	1	2	2	2	3	3	3
30	1	1	2	2	3	3	4	4	5	5
50	1	2	3	3	4	5	6	7	8	9
75	1	3	4	5	6	8	9	10	11	13
100	2	3	5	7	9	10	12	14	15	17

268. Based on the average mortality for the species of 0.191, a total of 47,442 birds would be expected to die in spring (see paragraph 252). The addition of a maximum of <0.1 to this increases the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.2.1.1.2.4 Annual

269. Summed across the year the maximum mean peak abundance in the DBS West array area and 2km buffer was 1,065 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the DBS West array area (and 2km buffer) during the breeding, autumn migration and spring migration periods combined has been estimated as 9 individuals (**Table 12-28**).

Table 12-28 Displacement Matrix Presenting the Number of Gannets in the DBS West Array Area (and 2km Buffer) Combined Across the Breeding and Nonbreeding Seasons That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	2	3	4	5	6	7	9	10	11
2	2	4	6	9	11	13	15	17	19	21
3	3	6	10	13	16	19	22	26	29	32
4	4	9	13	17	21	26	30	34	38	43
5	5	11	16	21	27	32	37	43	48	53
6	6	13	19	26	32	38	45	51	58	64
7	7	15	22	30	37	45	52	60	67	75
8	9	17	26	34	43	51	60	68	77	85
9	10	19	29	38	48	58	67	77	86	96
10	11	21	32	43	53	64	75	85	96	107
20	21	43	64	85	107	128	149	170	192	213
30	32	64	96	128	160	192	224	256	288	320
50	53	107	160	213	266	320	373	426	479	533
75	80	160	240	320	399	479	559	639	719	799
100	107	213	320	426	533	639	746	852	959	1065

270. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 252). The addition of a maximum of 9 to this increases the mortality rate by 0.01%, which is below the 1% threshold for detectability.

271. The number of individuals from the biogeographic population expected to die across all seasons is 225,380 (see paragraph 252). The addition of a maximum of 9 to this increases the mortality rate by <0.01%, which is below the 1% threshold for detectability.

272. The sensitivity of gannet to operational displacement is considered to be low and the magnitude of annual impact at DBS West is negligible, therefore the annual effect on gannet due to operational displacement at DBS West is assessed as negligible.

12.6.2.1.1.3 Significance of Effect – DBS East and DBS West Together

12.6.2.1.1.3.1 Breeding Season

273. During the breeding season, the maximum mean peak abundance in the array areas and 2km buffer was 1,038 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the array areas (and 2km buffer) during the breeding season has been estimated as 8 individuals (**Table 12-29**).

Table 12-29 Displacement Matrix Presenting the Number of Gannets in the Array Areas (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	**Displacement (%)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	1	2	3	4	5	6	7	8	9	10
2	2	4	6	8	10	12	15	17	19	21
3	3	6	9	12	16	19	22	25	28	31
4	4	8	12	17	21	25	29	33	37	42
5	5	10	16	21	26	31	36	42	47	52
6	6	12	19	25	31	37	44	50	56	62
7	7	15	22	29	36	44	51	58	65	73
8	8	17	25	33	42	50	58	66	75	83
9	9	19	28	37	47	56	65	75	84	93
10	10	21	31	42	52	62	73	83	93	104
20	21	42	62	83	104	125	145	166	187	208
30	31	62	93	125	156	187	218	249	280	311
50	52	104	156	208	260	311	363	415	467	519
75	78	156	234	311	389	467	545	623	701	779
100	104	208	311	415	519	623	727	830	934	1038

274. Based on the average mortality for the species of 0.191 a total of 9,116 birds would be expected to die each year (see paragraph 251). The addition of 8 individuals to these would increase the mortality rate by 0.09%, which is below the 1% threshold for detectability.

12.6.2.1.1.3.2 Autumn Migration

275. During the autumn migration period, the maximum mean peak abundance in the array areas and 2km buffer was 1,020 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the array areas (and 2km buffer) during the autumn migration period has been estimated as 8 individuals (**Table 12-30**).

Table 12-30 Displacement Matrix Presenting the Number of Gannets in the Array Areas (and 2km Buffer) During the Autumn Migration Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	2	3	4	5	6	7	8	9	10
2	2	4	6	8	10	12	14	16	18	20
3	3	6	9	12	15	18	21	24	28	31
4	4	8	12	16	20	24	29	33	37	41
5	5	10	15	20	26	31	36	41	46	51
6	6	12	18	24	31	37	43	49	55	61
7	7	14	21	29	36	43	50	57	64	71
8	8	16	24	33	41	49	57	65	73	82
9	9	18	28	37	46	55	64	73	83	92
10	10	20	31	41	51	61	71	82	92	102
20	20	41	61	82	102	122	143	163	184	204
30	31	61	92	122	153	184	214	245	275	306
50	51	102	153	204	255	306	357	408	459	510
75	77	153	230	306	383	459	536	612	689	765
100	102	204	306	408	510	612	714	816	918	1020

276. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die in autumn (see paragraph 252). The addition of a maximum of 8 to this increases the mortality rate by 0.01%, which is below the 1% threshold for detectability.

12.6.2.1.1.3.3 Spring Migration

277. During the spring migration period, the maximum mean peak abundance in the array areas and 2km buffer was 17 individuals. Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the array areas (and 2km buffer) during the spring migration period has been estimated as <0.1 individuals (**Table 12-31**).

Table 12-31 Displacement Matrix Presenting the Number of Gannets in the Array Areas (and 2km Buffer) During the Spring Migration Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	1
4	0	0	0	0	0	0	0	1	1	1
5	0	0	0	0	0	1	1	1	1	1
6	0	0	0	0	1	1	1	1	1	1
7	0	0	0	0	1	1	1	1	1	1
8	0	0	0	1	1	1	1	1	1	1
9	0	0	0	1	1	1	1	1	1	2
10	0	0	1	1	1	1	1	1	2	2
20	0	1	1	1	2	2	2	3	3	3
30	1	1	2	2	3	3	4	4	5	5
50	1	2	3	3	4	5	6	7	8	9
75	1	3	4	5	6	8	9	10	11	13
100	2	3	5	7	9	10	12	14	15	17

278. Based on the average mortality for the species of 0.191, a total of 47,442 birds would be expected to die in spring (see paragraph 252). The addition of a maximum of <0.1 to this increases the mortality rate by <0.01%, which is below the 1% threshold for detectability.

12.6.2.1.1.3.4 Annual

279. Summed across the year the maximum mean peak abundance in the array areas and 2km buffer was 2,075 individuals Within the range of 60-80% displacement and 1% mortality, the maximum number of individual gannets which could potentially suffer mortality as a consequence of displacement from the array areas (and 2km buffer) during the breeding, autumn migration and spring migration periods combined has been estimated as 17 individuals (**Table 12-32**).

Table 12-32 Displacement Matrix Presenting the Number of Gannets in the Array Areas (and 2km Buffer) Combined Across the Breeding and Nonbreeding Seasons That May Be Subject to Mortality (Highlighted).

Mortality (%)	**Displacement (%)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	2	4	6	8	10	12	15	17	19	21
2	4	8	12	17	21	25	29	33	37	42
3	6	12	19	25	31	37	44	50	56	62
4	8	17	25	33	42	50	58	66	75	83
5	10	21	31	42	52	62	73	83	93	104
6	12	25	37	50	62	75	87	100	112	125
7	15	29	44	58	73	87	102	116	131	145
8	17	33	50	66	83	100	116	133	149	166
9	19	37	56	75	93	112	131	149	168	187
10	21	42	62	83	104	125	145	166	187	208
20	42	83	125	166	208	249	291	332	374	415
30	62	125	187	249	311	374	436	498	560	623
50	104	208	311	415	519	623	726	830	934	1038
75	156	311	467	623	778	934	1089	1245	1401	1556
100	208	415	623	830	1038	1245	1453	1660	1868	2075

280. At the average baseline mortality rate for gannet of 0.191, a total of 87,153 birds would be expected to die from the largest BDMPS population throughout the year (see paragraph 252). The addition of a maximum of 17 to this increases the mortality rate by 0.02%, which is below the 1% threshold for detectability.

281. The number of individuals from the biogeographic population expected to die across all seasons is 225,380 (see paragraph 252). The addition of a maximum of 17 to this increases the mortality rate by 0.01%, which is below the 1% threshold for detectability.

282. The sensitivity of gannet to operational displacement is considered to be low and the magnitude of annual impact at the array areas is negligible, therefore the annual effect on gannet due to operational displacement at the array areas is assessed as negligible.

283. A table summarising the gannet operational displacement assessment is provided below (**Table 12-33**).

12.6.2.1.1.4 Summary of Operational Displacement Assessment - Gannet

Table 12-33 Summary of Gannet Operational Displacement Assessment for DBS East, DBS West and Combined (Projects). Note that the Project Total is Less Than the Sum of East and West Due to Overlap of the Individual 2km Buffers.

<table>
<tr><th colspan="2">Gannets</th><th>DBS East</th><th>DBS West</th><th>Projects</th></tr>
<tr><td colspan="2">Baseline average annual mortality</td><td colspan="3">0.191</td></tr>
<tr><td rowspan="3">Breeding season</td><td>Reference population</td><td colspan="3">47,727</td></tr>
<tr><td>Displacement mortality (@80% x 1%)</td><td>7</td><td>5</td><td>8</td></tr>
<tr><td>Increase in background mortality (%)</td><td>0.08</td><td>0.05</td><td>0.09</td></tr>
<tr><td rowspan="3">Autumn</td><td>Reference population</td><td colspan="3">456,298</td></tr>
<tr><td>Displacement mortality (@80% x 1%)</td><td>6</td><td>3</td><td>8</td></tr>
<tr><td>Increase in background mortality (%)</td><td><0.01</td><td><0.01</td><td>0.01</td></tr>
<tr><td rowspan="3">Spring</td><td>Reference population</td><td colspan="3">248,835</td></tr>
<tr><td>Displacement mortality (@80% x 1%)</td><td><0.1</td><td><0.1</td><td><0.1</td></tr>
<tr><td>Increase in background mortality (%)</td><td><0.001</td><td><0.001</td><td><0.001</td></tr>
<tr><td rowspan="4">Annual (BDMPS)</td><td>Reference population</td><td colspan="3">456,298</td></tr>
<tr><td>Displacement mortality (@80% x 1%)</td><td>13</td><td>9</td><td>17</td></tr>
<tr><td>Increase in background mortality (%)</td><td>0.01</td><td>0.01</td><td>0.02</td></tr>
<tr><td>Significance</td><td>Negligible</td><td>Negligible</td><td>Negligible</td></tr>
<tr><td rowspan="4">Annual (biogeographic)</td><td>Biogeographical population</td><td colspan="3">1,180,000</td></tr>
<tr><td>Displacement mortality (@80% x 1%)</td><td>13</td><td>9</td><td>17</td></tr>
<tr><td>Increase in background mortality (%)</td><td><0.01</td><td><0.01</td><td>0.01</td></tr>
<tr><td>Significance</td><td>Negligible</td><td>Negligible</td><td>Negligible</td></tr>
</table>

12.6.2.1.2 Auks (Guillemot, Razorbill and Puffin)

284. Razorbill, guillemot and puffin are considered to have a medium sensitivity to disturbance and displacement, based on their sensitivity to ship and helicopter traffic in Garthe and Hüppop (2004), Langston (2010), an interpretation of the Furness and Wade (2012) species concern index value in the context of disturbance and/or displacement from a habitat, and the

meta-analysis of avoidance and attraction responses of seabirds to offshore wind farms by Dierschke *et al*. (2016).

285. Available pre- and post-construction monitoring data have yielded variable results but indicate that auks may be displaced to some extent by some wind farms, but this is partial, and apparently negligible in some array areas (Dierschke *et al*., 2016).

286. Common guillemots were displaced at Blighbank (Vanermen *et al*., 2012), were displaced only in a minority of surveys at two Dutch wind farms (OWEZ and PAWP; Leopold *et al*., 2011; Krijgsveld *et al*., 2011), but were not significantly displaced at Horns Rev (although the data suggest that slight displacement was probably occurring; Petersen *et al*., 2006) or Thornton Bank (Vanermen *et al*., 2012). Razorbills were displaced in one out of six surveys at two Dutch wind farms (OWEZ and PAWP; Leopold *et al*., 2011, Krijgsveld *et al*., 2011), but not at Horns Rev (Petersen *et al*., 2006), Thornton Bank or Blighbank (Vanermen *et al*., 2012). There is less direct evidence for puffin as this species has not typically been recorded in the monitoring of earlier installed wind farms in the southern North Sea. However, given the similarities of these auk species it is considered reasonable to apply a similar approach as that used for guillemot and razorbill.

287. For recent wind farm assessments Natural England has advised that a 10% mortality rate should be used for auks displaced from wind farms. This magnitude of impact is not supported in the literature. For, example this would equate to a doubling of natural adult annual mortality for razorbill (10.5%; Horswill and Robinson, 2015) and puffin (9.4% Horswill and Robinson, 2015) and more than double that for guillemot (6%; Horswill and Robinson, 2015). Therefore, it is considered that this mortality rate is highly conservative and improbable in reality.

288. A review of available evidence for auk displacement was submitted for the Norfolk Vanguard assessment (MacArthur Green, 2021) and this concluded that precautionary rates of displacement and mortality from operational wind farms would be 50% and 1% respectively. These figures are also considered suitably precautionary for the potential displacement around construction vessels. Thus, the assessment presents estimates using 1% mortality and 10%.

289. Following statutory guidance (Joint SNCB Note, 2017), the abundance estimates for the most relevant biological periods have each been placed into individual displacement matrices. Each displacement matrix contains the abundance of each auk species within the DBS offshore wind farms and the 2km buffer.

290. Each matrix displays displacement rates and mortality rates for each species, with the species-specific recommended rates highlighted in each case. At the upper end these extend to 70% displaced and to 10% mortality, representing a highly precautionary worst case scenario as advised by Natural England. Mortality due to displacement might arise if displacement increased competition for resources in the remaining areas of auk habitat outside the wind farm. However, it should be recognised that the mortality rate due to displacement may well be 0% since the increase in density of birds outside the wind farm area will be negligible (because the rest of the available habitat is vast in comparison) and is very unlikely to be as high as these precautionary values.

291. There are no breeding colonies for guillemot and razorbill within foraging range of the DBS offshore wind farms (guillemot mean maximum range: 73km; razorbill mean maximum foraging range 88km). Puffins have a slightly larger foraging range (mean maximum 137km) which just extends into the DBS array area from the nearest colony. Therefore, for guillemot and razorbill it is reasonable to assume that individuals seen during the breeding season are nonbreeding individuals (e.g. immature birds). For puffin, assessment considers both the breeding population within foraging range and also the nonbreeding birds which may be present. Since immature seabirds are known to remain in wintering areas, the number of immature birds in the relevant populations during the breeding season may be estimated as 43% of the total wintering BDMPS population for guillemot and razorbill and 45% for puffins (Furness, 2015). These give breeding season populations of nonbreeding individuals of 695,441 guillemots (BDMPS for the UK North Sea and Channel, 1,617,306 x 43%), 94,007 razorbills (BDMPS for the UK North Sea and Channel, 218622 x 43%) and 104,381 puffins (BDMPS for the UK North Sea and Channel, 231,957 x 45%). Puffin observed during the breeding season have also been assessed in relation to the Flamborough and Filey Coast SPA colony since the array areas are partially located within this species' foraging range (130km), although the numbers seen in breeding season months were generally low (or zero, e.g. May and July) suggesting that connectivity is at the low end of the scale. The latest population estimate is 3,080 individuals (Clarkson *et al.*, 2022). If it is assumed these are adult breeding birds with associated sub-adults, the total population would be 5,600 individuals (3,080 / 55%). This population size has been used in the assessment.

292. There is only one defined nonbreeding season for guillemot and puffin (for both: August - February) while for razorbill there are three (August - October, November - December and January - March; **Table 12-13**). The number of birds which could potentially be displaced has been estimated for each species using their species-specific relevant seasons.

293. For each auk species the abundance estimates used in the assessment include unidentified auks assigned to each species using the identified proportions and adjustment for availability bias.

12.6.2.1.3 Guillemot

12.6.2.1.3.1 Significance of Effect – DBS East in Isolation

12.6.2.1.3.1.1 Breeding Season

294. During the breeding season, the maximum mean peak abundance in the DBS East array area and 2km buffer was 15,369 individuals. The estimated number of guillemots subject to mortality during the breeding period due to displacement from the DBS East (and 2km buffer; **Table 12-34**) is between 46 and 1,076 individuals.

Table 12-34 Displacement Matrix Presenting the Number of Guillemots in the DBS East Array Area (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	15	31	46	61	77	92	108	123	138	154
2	31	61	92	123	154	184	215	246	277	307
3	46	92	138	184	231	277	323	369	415	461
4	61	123	184	246	307	369	430	492	553	615
5	77	154	231	307	384	461	538	615	692	768
6	92	184	277	369	461	553	645	738	830	922
7	108	215	323	430	538	645	753	861	968	1076
8	123	246	369	492	615	738	861	984	1107	1230
9	138	277	415	553	692	830	968	1107	1245	1383
10	154	307	461	615	768	922	1076	1230	1383	1537
20	307	615	922	1230	1537	1844	2152	2459	2766	3074
30	461	922	1383	1844	2305	2766	3227	3689	4150	4611
50	768	1537	2305	3074	3842	4611	5379	6148	6916	7685
75	1153	2305	3458	4611	5763	6916	8069	9221	10374	11527
100	1537	3074	4611	6148	7685	9221	10758	12295	13832	15369

295. At the average baseline mortality rate for guillemot of 0.14 (**Table 12-13**Error! Reference source not found.) the number of individuals expected to die in the breeding season is 97,362 (695,441 x 0.14). The addition of a maximum of 1,076 to this increases the background mortality rate by 1.11%, which is slightly above the 1% threshold for detectability.

12.6.2.1.3.1.2 Nonbreeding Season

296. During the nonbreeding season, the maximum mean peak abundance in the DBS East array area and 2km buffer was 18,156 individuals. The estimated number of guillemots subject to mortality during the nonbreeding period due to displacement from the DBS East (and 2km buffer; **Table 12-35**) is between 54 and 1,271 individuals.

Table 12-35 Displacement Matrix Presenting the Number of Guillemots in the DBS East Array Area (and 2km Buffer) During the Nonbreeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	18	36	54	73	91	109	127	145	163	182
2	36	73	109	145	182	218	254	290	327	363
3	54	109	163	218	272	327	381	436	490	545
4	73	145	218	290	363	436	508	581	654	726
5	91	182	272	363	454	545	635	726	817	908
6	109	218	327	436	545	654	763	871	980	1089
7	127	254	381	508	635	763	890	1017	1144	1271
8	145	290	436	581	726	871	1017	1162	1307	1452
9	163	327	490	654	817	980	1144	1307	1471	1634
10	182	363	545	726	908	1089	1271	1452	1634	1816
20	363	726	1089	1452	1816	2179	2542	2905	3268	3631
30	545	1089	1634	2179	2723	3268	3813	4357	4902	5447
50	908	1816	2723	3631	4539	5447	6355	7262	8170	9078
75	1362	2723	4085	5447	6809	8170	9532	10894	12255	13617
100	1816	3631	5447	7262	9078	10894	12709	14525	16340	18156

297. At the average baseline mortality rate for guillemot of 0.14 (**Table 12-13**) the number of individuals expected to die in the nonbreeding period is 226,423 (1,617,306 x 0.14). The addition of a maximum of 1,271 to this increases the background mortality rate by 0.56%, which is below the 1% threshold for detectability.

12.6.2.1.3.1.3 Annual

298. Summed across the year the maximum mean peak abundance in the DBS East array area and 2km buffer was 33,525 individuals. The estimated number of guillemots subject to mortality combined across all seasons due to displacement from DBS East array area (and 2km buffer; **Table 12-36**) is between 101 and 2,347 individuals.

Table 12-36 Displacement Matrix Presenting the Number of Guillemots in the DBS East Array Area (and 2km Buffer) Combined Across the Breeding and Nonbreeding Seasons That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	34	67	101	134	168	201	235	268	302	335
2	67	134	201	268	335	402	469	536	603	671
3	101	201	302	402	503	603	704	805	905	1006
4	134	268	402	536	671	805	939	1073	1207	1341
5	168	335	503	671	838	1006	1173	1341	1509	1676
6	201	402	603	805	1006	1207	1408	1609	1810	2012
7	235	469	704	939	1173	1408	1643	1877	2112	2347
8	268	536	805	1073	1341	1609	1877	2146	2414	2682
9	302	603	905	1207	1509	1810	2112	2414	2716	3017
10	335	671	1006	1341	1676	2012	2347	2682	3017	3353
20	671	1341	2012	2682	3353	4023	4694	5364	6035	6705
30	1006	2012	3017	4023	5029	6035	7040	8046	9052	10058
50	1676	3353	5029	6705	8381	10058	11734	13410	15086	16763
75	2514	5029	7543	10058	12572	15086	17601	20115	22629	25144
100	3353	6705	10058	13410	16763	20115	23468	26820	30173	33525

299. At the average baseline mortality rate for guillemot of 0.14 (**Table 12-13**) the number of individuals expected to die from the BDMPS population across all seasons is 226,423 (1,617,306 x 0. 140). The addition of a maximum of 2,347 to this increases the background mortality rate by 1.04%, which is just above the 1% threshold for detectability.

300. The number of individuals from the biogeographic population expected to die across all seasons is 577,500 (4,125,000 x 0.14). The addition of a maximum of 2,347 to this increases the mortality rate by 0.41%. Thus, the increase in background mortality is between 0.41% and 1.04%.

301. While the upper end of this range is above the 1% threshold, this is only achieved through a combination of worst case assumptions (the smaller reference population estimate, the worst case displacement and mortality rates). Even small reductions in the precaution would reduce this effect to 1% (e.g. 67% displaced instead of 70% or 9.6% mortality instead of 10%). Therefore the magnitude of impact for guillemot assessed against the BDMPS population is considered to be low.

302. The sensitivity of guillemot to operational displacement is considered to be medium and the magnitude of annual impact at DBS East is low when assessed against the BDMPS population and negligible when assessed against the biogeographic population. Therefore, the significance of the annual effect on guillemot due to operational displacement at DBS East is assessed as minor.

12.6.2.1.3.2 Significance of Effect – DBS West in Isolation

12.6.2.1.3.2.1 Breeding Season

303. During the breeding season, the maximum mean peak abundance in the DBS West array area and 2km buffer was 18,491 individuals. The estimated number of guillemots subject to mortality during the breeding period due to displacement from the DBS West (and 2km buffer; **Table 12-37**) is between 55 and 1,294 individuals.

Table 12-37 Displacement Matrix Presenting the Number of Guillemots in the DBS West Array Area (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	18	37	55	74	92	111	129	148	166	185
2	37	74	111	148	185	222	259	296	333	370
3	55	111	166	222	277	333	388	444	499	555
4	74	148	222	296	370	444	518	592	666	740
5	92	185	277	370	462	555	647	740	832	925
6	111	222	333	444	555	666	777	888	999	1109
7	129	259	388	518	647	777	906	1035	1165	1294
8	148	296	444	592	740	888	1035	1183	1331	1479
9	166	333	499	666	832	999	1165	1331	1498	1664
10	185	370	555	740	925	1109	1294	1479	1664	1849
20	370	740	1109	1479	1849	2219	2589	2959	3328	3698
30	555	1109	1664	2219	2774	3328	3883	4438	4993	5547
50	925	1849	2774	3698	4623	5547	6472	7396	8321	9246
75	1387	2774	4160	5547	6934	8321	9708	11095	12481	13868
100	1849	3698	5547	7396	9246	11095	12944	14793	16642	18491

304. At the average baseline mortality rate for guillemot of 0.14 (**Table 12-13**) the number of individuals expected to die in the breeding season is 97,362 (695,441 x 0.14). The addition of a maximum of 1,294 to this increases the background mortality rate by 1.33%, which is above the 1% threshold for detectability.

12.6.2.1.3.2.2 Nonbreeding Season

305. During the nonbreeding season, the maximum mean peak abundance in the DBS West array area and 2km buffer was 8,725 individuals. The estimated number of guillemots subject to mortality during the nonbreeding period due to displacement from the DBS West (and 2km buffer; **Table 12-38**) is between 26 and 611 individuals.

Table 12-38 Displacement Matrix Presenting the Number of Guillemots in the DBS West Array Area (and 2km Buffer) During the Nonbreeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	9	17	26	35	44	52	61	70	79	87
2	17	35	52	70	87	105	122	140	157	175
3	26	52	79	105	131	157	183	209	236	262
4	35	70	105	140	175	209	244	279	314	349
5	44	87	131	175	218	262	305	349	393	436
6	52	105	157	209	262	314	366	419	471	524
7	61	122	183	244	305	366	428	489	550	611
8	70	140	209	279	349	419	489	558	628	698
9	79	157	236	314	393	471	550	628	707	785
10	87	175	262	349	436	524	611	698	785	873
20	175	349	524	698	873	1047	1222	1396	1571	1745
30	262	524	785	1047	1309	1571	1832	2094	2356	2618
50	436	873	1309	1745	2181	2618	3054	3490	3926	4363
75	654	1309	1963	2618	3272	3926	4581	5235	5889	6544
100	873	1745	2618	3490	4363	5235	6108	6980	7853	8725

306. At the average baseline mortality rate for guillemot of 0.14 (**Table 12-13**) the number of individuals expected to die in the nonbreeding period is 226,423 (1,617,306 x 0.14). The addition of a maximum of 611 to this increases the background mortality rate by 0.27%, which is below the 1% threshold for detectability.

12.6.2.1.3.2.3 Annual

307. Summed across the year the maximum mean peak abundance in the DBS West array area and 2km buffer was 27,216 individuals. The estimated number of guillemots subject to mortality combined across all seasons due to displacement from the DBS West (and 2km buffer; **Table 12-39**) is between 82 and 1,905 individuals.

Table 12-39 Displacement Matrix Presenting the Number of Guillemots in the DBS West Array Area (and 2km Buffer) During the Nonbreeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	27	54	82	109	136	163	191	218	245	272
2	54	109	163	218	272	327	381	435	490	544
3	82	163	245	327	408	490	572	653	735	816
4	109	218	327	435	544	653	762	871	980	1089
5	136	272	408	544	680	816	953	1089	1225	1361
6	163	327	490	653	816	980	1143	1306	1470	1633
7	191	381	572	762	953	1143	1334	1524	1715	1905
8	218	435	653	871	1089	1306	1524	1742	1960	2177
9	245	490	735	980	1225	1470	1715	1960	2204	2449
10	272	544	816	1089	1361	1633	1905	2177	2449	2722
20	544	1089	1633	2177	2722	3266	3810	4355	4899	5443
30	816	1633	2449	3266	4082	4899	5715	6532	7348	8165
50	1361	2722	4082	5443	6804	8165	9526	10886	12247	13608
75	2041	4082	6124	8165	10206	12247	14288	16330	18371	20412
100	2722	5443	8165	10886	13608	16330	19051	21773	24494	27216

308. At the average baseline mortality rate for guillemot of 0.14 (**Table 12-13**) the number of individuals expected to die from the BDMPS population across all seasons is 226,423 (1,617,306 x 0.14). The addition of a maximum of 1,905 to this increases the background mortality rate by 0.84%, which is below the 1% threshold for detectability.

309. The number of individuals from the biogeographic population expected to die across all seasons is 577,500 (4,125,000 x 0. 140). The addition of a maximum of 1,905 to this increases the mortality rate by 0.33%. Thus, the increase in background mortality is between 0.33% and 0.84%.

310. The sensitivity of guillemot to operational displacement is considered to be medium and the magnitude of annual impact at DBS West is negligible, therefore the annual effect on guillemot due to operational displacement at DBS West is assessed as minor.

12.6.2.1.3.3 Significance of Effect – DBS East and DBS West Together

12.6.2.1.3.3.1 Breeding Season

311. During the breeding season, the maximum mean peak abundance in the array areas and 2km buffer was 31,587 individuals. The estimated number of guillemots subject to mortality during the breeding period due to displacement from the array areas (and 2km buffer; **Table 12-40**) is between 95 and 2,211 individuals.

Table 12-40 Displacement Matrix Presenting the Number of Guillemots in the Array Areas (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	32	63	95	126	158	190	221	253	284	316
2	63	126	190	253	316	379	442	505	569	632
3	95	190	284	379	474	569	663	758	853	948
4	126	253	379	505	632	758	884	1011	1137	1263
5	158	316	474	632	790	948	1106	1263	1421	1579
6	190	379	569	758	948	1137	1327	1516	1706	1895
7	221	442	663	884	1106	1327	1548	1769	1990	2211
8	253	505	758	1011	1263	1516	1769	2022	2274	2527
9	284	569	853	1137	1421	1706	1990	2274	2559	2843
10	316	632	948	1263	1579	1895	2211	2527	2843	3159
20	632	1263	1895	2527	3159	3790	4422	5054	5686	6317
30	948	1895	2843	3790	4738	5686	6633	7581	8528	9476
50	1579	3159	4738	6317	7897	9476	11055	12635	14214	15794
75	2369	4738	7107	9476	11845	14214	16583	18952	21321	23690
100	3159	6317	9476	12635	15794	18952	22111	25270	28428	31587

312. At the average baseline mortality rate for guillemot of 0.14 (**Table 12-13**) the number of individuals expected to die in the breeding season is 97,362 (695,441x 0.14). The addition of a maximum of 2,211 to this increases the background mortality rate by 2.27%, which is above the 1% threshold for detectability.

12.6.2.1.3.3.2 Nonbreeding Season

313. During the breeding season, the maximum mean peak abundance in the array areas and 2km buffer was 25,342 individuals. The estimated number of guillemots subject to mortality during the nonbreeding period due to displacement from the array areas (and 2k buffer; **Table 12-41**) is between 76 and 1,774 individuals.

Table 12-41 Displacement Matrix Presenting the Number of Guillemots in the Array Areas (and 2km Buffer) During the Nonbreeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	25	51	76	101	127	152	177	203	228	253
2	51	101	152	203	253	304	355	405	456	507
3	76	152	228	304	380	456	532	608	684	760
4	101	203	304	405	507	608	710	811	912	1014
5	127	253	380	507	634	760	887	1014	1140	1267
6	152	304	456	608	760	912	1064	1216	1368	1521
7	177	355	532	710	887	1064	1242	1419	1597	1774
8	203	405	608	811	1014	1216	1419	1622	1825	2027
9	228	456	684	912	1140	1368	1597	1825	2053	2281
10	253	507	760	1014	1267	1521	1774	2027	2281	2534
20	507	1014	1521	2027	2534	3041	3548	4055	4562	5068
30	760	1521	2281	3041	3801	4562	5322	6082	6842	7603
50	1267	2534	3801	5068	6336	7603	8870	10137	11404	12671
75	1901	3801	5702	7603	9503	11404	13305	15205	17106	19007
100	2534	5068	7603	10137	12671	15205	17739	20274	22808	25342

314. At the average baseline mortality rate for guillemot of 0.14 (**Table 12-13**) the number of individuals expected to die in the nonbreeding period is 226,423 (1,617,306 x 0.14). The addition of a maximum of 1,774 to this increases the background mortality rate by 0.78%, which is below the 1% threshold for detectability.

12.6.2.1.3.3.3 Annual

315. Summed across the year the maximum mean peak abundance in the array areas and 2km buffer was 56,929 individuals. The estimated number of guillemots subject to mortality combined across all seasons due to displacement from the array areas (and 2km buffer; **Table 12-42**) is between 171 and 3,985 individuals.

Table 12-42 Displacement Matrix Presenting the Number of Guillemot in the Array Areas (and 2km Buffer) Combined Across the Breeding and Nonbreeding Seasons That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	57	114	171	228	285	342	399	455	512	569
2	114	228	342	455	569	683	797	911	1025	1139
3	171	342	512	683	854	1025	1196	1366	1537	1708
4	228	455	683	911	1139	1366	1594	1822	2049	2277
5	285	569	854	1139	1423	1708	1993	2277	2562	2846
6	342	683	1025	1366	1708	2049	2391	2733	3074	3416
7	399	797	1196	1594	1993	2391	2790	3188	3587	3985
8	455	911	1366	1822	2277	2733	3188	3643	4099	4554
9	512	1025	1537	2049	2562	3074	3587	4099	4611	5124
10	569	1139	1708	2277	2846	3416	3985	4554	5124	5693
20	1139	2277	3416	4554	5693	6831	7970	9109	10247	11386
30	1708	3416	5124	6831	8539	10247	11955	13663	15371	17079
50	2846	5693	8539	11386	14232	17079	19925	22772	25618	28465
75	4270	8539	12809	17079	21348	25618	29888	34157	38427	42697
100	5693	11386	17079	22772	28465	34157	39850	45543	51236	56929

316. At the average baseline mortality rate for guillemot of 0.14 (**Table 12-13**) the number of individuals expected to die from the BDMPS population across all seasons is 226,423 (1,617,306 x 0.14). The addition of a maximum of 3,985 to this increases the background mortality rate by 1.76%, which is above the 1% threshold for detectability.

317. The number of individuals from the biogeographic population expected to die across all seasons is 577,500 (4,125,000 x 0. 140). The addition of a maximum of 3,985 to this increases the mortality rate by 0.69%. Thus, the increase in background mortality is between 0.69% and 1.76%.

318. The sensitivity of guillemot to operational displacement is considered to be medium and the magnitude of annual impact at the array areas, when the most precautionary combination of assumptions is applied, is medium when assessed against the BDMPS population and negligible when assessed against the biogeographic population. Therefore, the significance of the annual effect on guillemot due to operational displacement at the array areas is assessed as minor to moderate.

319. A table summarising the guillemot operational displacement assessment is provided below (**Table 12-43**).

12.6.2.1.3.4 Summary of Operational Displacement Assessment - Guillemot

Table 12-43 Summary of Guillemot Operational Displacement Assessment for DBS East, DBS West and Combined (Projects). Note that the Projects Total is Less Than the Sum of East and West Due to Overlap of the Individual 2km Buffers.

Guillemot		**DBS East**	**DBS West**	**Projects**
Baseline average annual mortality		0.14		
Breeding season	Reference population (subadult component of nonbreeding BDMPS)	695,441		
	Displacement mortality (@70% x 10%)	1,076	1,294	2,211
	Increase in background mortality (%)	1.1	1.3	2.27
Non breeding season	Reference population	1,617,306		
	Displacement mortality (@70% x 10%)	1,271	611	1,774
	Increase in background mortality (%)	0.56	0.27	0.78
	Significance			
Annual (BDMPS)	Reference population	1,617,306		
	Displacement mortality (@70% x 10%)	2,374	1,905	3,985
	Increase in background mortality (%)	1.04	0.84	1.76
	Significance	Minor	Minor	Moderate
Annual (biogeographic)	Biogeographical population	4,125,000		
	Displacement mortality (@70% x 10%)	2,374	1,905	3,985
	Increase in background mortality (%)	0.4	0.33	0.69
	Significance	Minor	Minor	Minor

12.6.2.1.4 Razorbill

12.6.2.1.4.1 Significance of Effect – DBS East in Isolation

12.6.2.1.4.1.1 Breeding Season

320. During the breeding season, the maximum mean peak abundance in the DBS East array area and 2km buffer was 1,465 individuals. The estimated number of razorbills subject to mortality during the breeding period due to displacement from the DBS East (and 2k buffer; **Table 12-44**) is between four and 103 individuals.

Table 12-44 Displacement Matrix Presenting the Number of Razorbills in the DBS East Array Area (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	3	4	6	7	9	10	12	13	15
2	3	6	9	12	15	18	21	23	26	29
3	4	9	13	18	22	26	31	35	40	44
4	6	12	18	23	29	35	41	47	53	59
5	7	15	22	29	37	44	51	59	66	73
6	9	18	26	35	44	53	62	70	79	88
7	10	21	31	41	51	62	72	82	92	103
8	12	23	35	47	59	70	82	94	105	117
9	13	26	40	53	66	79	92	105	119	132
10	15	29	44	59	73	88	103	117	132	147
20	29	59	88	117	147	176	205	234	264	293
30	44	88	132	176	220	264	308	352	396	440
50	73	147	220	293	366	440	513	586	659	733
75	110	220	330	440	549	659	769	879	989	1099
100	147	293	440	586	733	879	1026	1172	1319	1465

321. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the breeding season is 16,357 (94,007 x 0.174). The addition of a maximum of 103 to this increases the background mortality rate by 0.63%, which is below the 1% threshold for detectability.

12.6.2.1.4.1.2 Autumn Migration

322. During the autumn migration period, the maximum mean peak abundance in the DBS East array area and 2km buffer was 650 individuals. The estimated number of razorbills subject to mortality during the autumn migration period due to displacement from the DBS East (and 2km buffer; **Table 12-45**) is between 2 and 46 individuals.

Table 12-45 Displacement Matrix Presenting the Number of Razorbills in the DBS East Array Area (and 2km buffer) During Autumn Migration That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	1	2	3	3	4	5	5	6	7
2	1	3	4	5	7	8	9	10	12	13
3	2	4	6	8	10	12	14	16	18	20
4	3	5	8	10	13	16	18	21	23	26
5	3	7	10	13	16	20	23	26	29	33
6	4	8	12	16	20	23	27	31	35	39
7	5	9	14	18	23	27	32	36	41	46
8	5	10	16	21	26	31	36	42	47	52
9	6	12	18	23	29	35	41	47	53	59
10	7	13	20	26	33	39	46	52	59	65
20	13	26	39	52	65	78	91	104	117	130
30	20	39	59	78	98	117	137	156	176	195
50	33	65	98	130	163	195	228	260	293	325
75	49	98	146	195	244	293	341	390	439	488
100	65	130	195	260	325	390	455	520	585	650

323. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the autumn migration period is 102,986 (591,874 x 0.174). The addition of a maximum of 46 to this increases the background mortality rate by 0.04%, which is below the 1% threshold for detectability.

12.6.2.1.4.1.3 Winter

324. During the winter period, the maximum mean peak abundance in the DBS East array area and 2km buffer was 3,883 individuals. The estimated number of razorbills subject to mortality during the winter period due to displacement from the DBS East (and 2km buffer; **Table 12-46**) is between 12 and 272 individuals.

Table 12-46 Displacement Matrix Presenting the Number of Razorbills in the DBS East Array Area (and 2km Buffer) During the Winter Period That May Be Subject to Mortality (Highlighted).

Mortality (%)	**Displacement (%)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	4	8	12	16	19	23	27	31	35	39
2	8	16	23	31	39	47	54	62	70	78
3	12	23	35	47	58	70	82	93	105	116
4	16	31	47	62	78	93	109	124	140	155
5	19	39	58	78	97	116	136	155	175	194
6	23	47	70	93	116	140	163	186	210	233
7	27	54	82	109	136	163	190	217	245	272
8	31	62	93	124	155	186	217	249	280	311
9	35	70	105	140	175	210	245	280	315	349
10	39	78	116	155	194	233	272	311	349	388
20	78	155	233	311	388	466	544	621	699	777
30	116	233	349	466	582	699	815	932	1048	1165
50	194	388	582	777	971	1165	1359	1553	1747	1942
75	291	582	874	1165	1456	1747	2039	2330	2621	2912
100	388	777	1165	1553	1942	2330	2718	3106	3495	3883

325. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the winter is 38,040 (218,622 x 0.174). The addition of a maximum of 272 to this increases the background mortality rate by 0.72%, which is below the 1% threshold for detectability.

12.6.2.1.4.1.4 Spring Migration

326. During spring migration period, the maximum mean peak abundance in the DBS East array area and 2km buffer was 8,090 individuals. The estimated number of razorbills subject to mortality during the spring migration period due to displacement from the DBS East (and 2km buffer; **Table 12-47**) is between 24 and 566 individuals.

Table 12-47 Displacement Matrix Presenting the Number of Razorbills in the DBS East Array Area (and 2km Buffer) During Spring Migration That May Be Subject to Mortality (Highlighted).

Mortality (%)	**Displacement (%)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	8	16	24	32	40	49	57	65	73	81
2	16	32	49	65	81	97	113	129	146	162
3	24	49	73	97	121	146	170	194	218	243
4	32	65	97	129	162	194	227	259	291	324
5	40	81	121	162	202	243	283	324	364	405
6	49	97	146	194	243	291	340	388	437	485
7	57	113	170	227	283	340	396	453	510	566
8	65	129	194	259	324	388	453	518	582	647
9	73	146	218	291	364	437	510	582	655	728
10	81	162	243	324	405	485	566	647	728	809
20	162	324	485	647	809	971	1133	1294	1456	1618
30	243	485	728	971	1214	1456	1699	1942	2184	2427
50	405	809	1214	1618	2023	2427	2832	3236	3641	4045
75	607	1214	1820	2427	3034	3641	4247	4854	5461	6068
100	809	1618	2427	3236	4045	4854	5663	6472	7281	8090

327. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the spring migration season is 102,986 (591,874 x 0.174). The addition of a maximum of 566 to this increases the background mortality rate by 0.55%, which is below the 1% threshold for detectability.

12.6.2.1.4.1.5 Annual

328. Summed across the year the maximum mean peak abundance in the DBS East array area and 2km buffer was 14,088 individuals. The estimated number of razorbills subject to mortality combined across all seasons due to displacement from the DBS East (and 2km buffer; **Table 12-48**) is between 42 and 986 individuals.

Table 12-48 Displacement Matrix Presenting the Number of Razorbills in the DBS East Array Area (and 2km Buffer) Combined Across the Breeding, Autumn Migration, Winter and Spring Migration Periods That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	14	28	42	56	70	85	99	113	127	141
2	28	56	85	113	141	169	197	225	254	282
3	42	85	127	169	211	254	296	338	380	423
4	56	113	169	225	282	338	394	451	507	564
5	70	141	211	282	352	423	493	564	634	704
6	85	169	254	338	423	507	592	676	761	845
7	99	197	296	394	493	592	690	789	888	986
8	113	225	338	451	564	676	789	902	1014	1127
9	127	254	380	507	634	761	888	1014	1141	1268
10	141	282	423	564	704	845	986	1127	1268	1409
20	282	564	845	1127	1409	1691	1972	2254	2536	2818
30	423	845	1268	1691	2113	2536	2958	3381	3804	4226
50	704	1409	2113	2818	3522	4226	4931	5635	6340	7044
75	1057	2113	3170	4226	5283	6340	7396	8453	9509	10566
100	1409	2818	4226	5635	7044	8453	9862	11270	12679	14088

329. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals from the largest BDMPS population expected to die across all seasons is 102,986 (591,874 x 0.174). The addition of a maximum of 986 to this increases the background mortality rate by 0.96%, which is just below the 1% threshold for detectability.

330. The number of individuals from the biogeographic population expected to die across all seasons is 297,018 (1,707,000 x 0.174). The addition of a maximum of 986 to this increases the mortality rate by 0.33%. Thus, the increase in background mortality is between 0.33% and 0.96%.

331. The sensitivity of razorbill to operational displacement is considered to be medium and the magnitude of annual impact at DBS East is negligible, therefore the annual effect on razorbill due to operational displacement at DBS East is assessed as minor.

12.6.2.1.4.2 Significance of Effect – DBS West in Isolation

12.6.2.1.4.2.1 Breeding Season

332. During the breeding season, the maximum mean peak abundance in the DBS West array area and 2km buffer was 4,015 individuals. The estimated number of razorbills subject to mortality during the breeding period due to displacement from DBS West array area (and 2k buffer; **Table 12-49**) is between 12 and 281 individuals.

Table 12-49 Displacement Matrix Presenting the Number of Razorbills in the DBS West Array Area (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	4	8	12	16	20	24	28	32	36	40
2	8	16	24	32	40	48	56	64	72	80
3	12	24	36	48	60	72	84	96	108	120
4	16	32	48	64	80	96	112	128	145	161
5	20	40	60	80	100	120	141	161	181	201
6	24	48	72	96	120	145	169	193	217	241
7	28	56	84	112	141	169	197	225	253	281
8	32	64	96	128	161	193	225	257	289	321
9	36	72	108	145	181	217	253	289	325	361
10	40	80	120	161	201	241	281	321	361	402
20	80	161	241	321	402	482	562	642	723	803
30	120	241	361	482	602	723	843	964	1084	1205
50	201	402	602	803	1004	1205	1405	1606	1807	2008
75	301	602	903	1205	1506	1807	2108	2409	2710	3011
100	402	803	1205	1606	2008	2409	2811	3212	3614	4015

333. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the breeding season is 16,357 (94,007 x 0.174). The addition of a maximum of 281 to this increases the background mortality rate by 1.72%, which is above the 1% threshold for detectability.

12.6.2.1.4.2.2 Autumn Migration

334. During the autumn migration period, the maximum mean peak abundance in the DBS West array area and 2km buffer was 737 individuals. The estimated number of razorbills subject to mortality during the autumn migration period due to displacement from the DBS West (and 2km buffer; **Table 12-50**) is between two and 52 individuals.

Table 12-50 Displacement Matrix Presenting the Number of Razorbills in the DBS West Array Area (and 2km Buffer) During Autumn Migration That May Be Subject to Mortality (Highlighted).

Mortality (%)	**Displacement (%)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	1	1	2	3	4	4	5	6	7	7
2	1	3	4	6	7	9	10	12	13	15
3	2	4	7	9	11	13	15	18	20	22
4	3	6	9	12	15	18	21	24	27	29
5	4	7	11	15	18	22	26	29	33	37
6	4	9	13	18	22	27	31	35	40	44
7	5	10	15	21	26	31	36	41	46	52
8	6	12	18	24	29	35	41	47	53	59
9	7	13	20	27	33	40	46	53	60	66
10	7	15	22	29	37	44	52	59	66	74
20	15	29	44	59	74	88	103	118	133	147
30	22	44	66	88	111	133	155	177	199	221
50	37	74	111	147	184	221	258	295	332	369
75	55	111	166	221	276	332	387	442	497	553
100	74	147	221	295	369	442	516	590	663	737

335. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the autumn migration period is 102,986 (591,874 x 0.174). The addition of a maximum of 52 to this increases the background mortality rate by 0.05%, which is below the 1% threshold for detectability.

12.6.2.1.4.2.3 Winter

336. During the winter period, the maximum mean peak abundance in the DBS West array area and 2km buffer was 1,837 individuals. The estimated number of razorbills subject to mortality during the winter period due to displacement from the DBS West (and 2km buffer; **Table 12-51**) is between six and 129 individuals.

Table 12-51 Displacement Matrix Presenting the Number of Razorbills in the DBS West Array area (and 2km Buffer) During the Winter Period That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	2	4	6	7	9	11	13	15	17	18
2	4	7	11	15	18	22	26	29	33	37
3	6	11	17	22	28	33	39	44	50	55
4	7	15	22	29	37	44	51	59	66	73
5	9	18	28	37	46	55	64	73	83	92
6	11	22	33	44	55	66	77	88	99	110
7	13	26	39	51	64	77	90	103	116	129
8	15	29	44	59	73	88	103	118	132	147
9	17	33	50	66	83	99	116	132	149	165
10	18	37	55	73	92	110	129	147	165	184
20	37	73	110	147	184	220	257	294	331	367
30	55	110	165	220	276	331	386	441	496	551
50	92	184	276	367	459	551	643	735	827	919
75	138	276	413	551	689	827	964	1102	1240	1378
100	184	367	551	735	919	1102	1286	1470	1653	1837

337. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the winter is 38,040 (218,622 x 0.174). The addition of a maximum of 129 to this increases the background mortality rate by 0.34%, which is below the 1% threshold for detectability.

12.6.2.1.4.2.4 Spring Migration

338. During the spring migration period, the maximum mean peak abundance in the DBS West array area and 2km buffer was 2,333 individuals. The estimated number of razorbills subject to mortality during the spring migration period due to displacement from the DBS West (and 2km buffer; **Table 12-52**) is between seven and 163 individuals.

Table 12-52 Displacement Matrix Presenting the Number of Razorbill in the DBS West Array Area (and 2km Buffer) During Spring Migration That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	2	5	7	9	12	14	16	19	21	23
2	5	9	14	19	23	28	33	37	42	47
3	7	14	21	28	35	42	49	56	63	70
4	9	19	28	37	47	56	65	75	84	93
5	12	23	35	47	58	70	82	93	105	117
6	14	28	42	56	70	84	98	112	126	140
7	16	33	49	65	82	98	114	131	147	163
8	19	37	56	75	93	112	131	149	168	187
9	21	42	63	84	105	126	147	168	189	210
10	23	47	70	93	117	140	163	187	210	233
20	47	93	140	187	233	280	327	373	420	467
30	70	140	210	280	350	420	490	560	630	700
50	117	233	350	467	583	700	817	933	1050	1167
75	175	350	525	700	875	1050	1225	1400	1575	1750
100	233	467	700	933	1167	1400	1633	1866	2100	2333

339. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the spring migration season is 102,986 (591,874 x 0.174). The addition of a maximum of 163 to this increases the background mortality rate by 0.16%, which is below the 1% threshold for detectability.

12.6.2.1.4.2.5 Annual

340. Summed across the year the maximum mean peak abundance in the DBS West array area and 2km buffer was 8,922 individuals. The estimated number of razorbills subject to mortality combined across all seasons due to displacement from the DBS West (and 2km buffer; **Table 12-53**) is between 27 and 625 individuals.

Table 12-53 Displacement Matrix Presenting the Number of Razorbill in the DBS West Array Area (and 2km Buffer) Combined Across the Breeding, Autumn Migration, Winter and Spring Migration Periods That May Be Subject to Mortality (highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	9	18	27	36	45	54	62	71	80	89
2	18	36	54	71	89	107	125	143	161	178
3	27	54	80	107	134	161	187	214	241	268
4	36	71	107	143	178	214	250	286	321	357
5	45	89	134	178	223	268	312	357	401	446
6	54	107	161	214	268	321	375	428	482	535
7	62	125	187	250	312	375	437	500	562	625
8	71	143	214	286	357	428	500	571	642	714
9	80	161	241	321	401	482	562	642	723	803
10	89	178	268	357	446	535	625	714	803	892
20	178	357	535	714	892	1071	1249	1428	1606	1784
30	268	535	803	1071	1338	1606	1874	2141	2409	2677
50	446	892	1338	1784	2231	2677	3123	3569	4015	4461
75	669	1338	2007	2677	3346	4015	4684	5353	6022	6692
100	892	1784	2677	3569	4461	5353	6245	7138	8030	8922

341. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals from the largest BDMPS population expected to die across all seasons is 102,986 (591,874 x 0.174). The addition of a maximum of 625 to this increases the background mortality rate by 0.61%, which is below the 1% threshold for detectability.

342. The number of individuals from the biogeographic population expected to die across all seasons is 297,018 (1,707,000 x 0.174). The addition of a maximum of 625 to this increases the mortality rate by 0.22%. Thus, the increase in background mortality is between 0.21% and 0.61%.

343. The sensitivity of razorbill to operational displacement is considered to be medium and the magnitude of annual impact at DBS West is negligible, therefore the annual effect on razorbill due to operational displacement at DBS West is assessed as minor.

12.6.2.1.4.3 Significance of Effect – DBS East and DBS West Together

12.6.2.1.4.3.1 Breeding Season

344. During the breeding season, the maximum mean peak abundance in the array areas and 2km buffer was 5,313 individuals. The estimated number of razorbills subject to mortality during the breeding period due to displacement from the array areas (and 2km buffer; **Table 12-54**) is between 16 and 372 individuals.

Table 12-54 Displacement Matrix Presenting the Number of Razorbills in the Array Areas (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	5	11	16	21	27	32	37	43	48	53
2	11	21	32	43	53	64	74	85	96	106
3	16	32	48	64	80	96	112	128	143	159
4	21	43	64	85	106	128	149	170	191	213
5	27	53	80	106	133	159	186	213	239	266
6	32	64	96	128	159	191	223	255	287	319
7	37	74	112	149	186	223	260	298	335	372
8	43	85	128	170	213	255	298	340	383	425
9	48	96	143	191	239	287	335	383	430	478
10	53	106	159	213	266	319	372	425	478	531
20	106	213	319	425	531	638	744	850	956	1063
30	159	319	478	638	797	956	1116	1275	1435	1594
50	266	531	797	1063	1328	1594	1860	2125	2391	2657
75	398	797	1195	1594	1992	2391	2789	3188	3586	3985
100	531	1063	1594	2125	2657	3188	3719	4250	4782	5313

345. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the breeding season is 16,357 (94,007 x 0.174). The addition of a maximum of 372 to this increases the background mortality rate by 2.27%, which is above the 1% threshold for detectability.

12.6.2.1.4.3.2 Autumn Migration

346. During the autumn migration period, the maximum mean peak abundance in the array areas and 2km buffer was 1,238 individuals. The estimated number of razorbills subject to mortality during the autumn migration period due to displacement from the array areas (and 2km buffer; **Table 12-55** is between four and 87 individuals.

Table 12-55 Displacement Matrix Presenting the Number of Razorbill in the Array Areas (and 2km Buffer) During Autumn Migration That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	2	4	5	6	7	9	10	11	12
2	2	5	7	10	12	15	17	20	22	25
3	4	7	11	15	19	22	26	30	33	37
4	5	10	15	20	25	30	35	40	45	50
5	6	12	19	25	31	37	43	50	56	62
6	7	15	22	30	37	45	52	59	67	74
7	9	17	26	35	43	52	61	69	78	87
8	10	20	30	40	50	59	69	79	89	99
9	11	22	33	45	56	67	78	89	100	111
10	12	25	37	50	62	74	87	99	111	124
20	25	50	74	99	124	149	173	198	223	248
30	37	74	111	149	186	223	260	297	334	371
50	62	124	186	248	310	371	433	495	557	619
75	93	186	279	371	464	557	650	743	836	929
100	124	248	371	495	619	743	867	990	1114	1238

347. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the autumn migration period is 102,986 (591,874 x 0.174). The addition of a maximum of 87 to this increases the background mortality rate by 0.08%, which is below the 1% threshold for detectability.

12.6.2.1.4.3.3 Winter

348. During the winter period, the maximum mean peak abundance in the array areas and 2km buffer was 4,117 individuals. The estimated number of razorbills subject to mortality during the winter period due to displacement from the array areas (and 2km buffer; **Table 12-56**) is between 12 and 288 individuals.

Table 12-56 Displacement Matrix Presenting the Number of Razorbill in the Array Areas (and 2km Buffer) During the Winter Period That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	4	8	12	16	21	25	29	33	37	41
2	8	16	25	33	41	49	58	66	74	82
3	12	25	37	49	62	74	86	99	111	124
4	16	33	49	66	82	99	115	132	148	165
5	21	41	62	82	103	124	144	165	185	206
6	25	49	74	99	124	148	173	198	222	247
7	29	58	86	115	144	173	202	231	259	288
8	33	66	99	132	165	198	231	263	296	329
9	37	74	111	148	185	222	259	296	333	371
10	41	82	124	165	206	247	288	329	371	412
20	82	165	247	329	412	494	576	659	741	823
30	124	247	371	494	618	741	865	988	1112	1235
50	206	412	618	823	1029	1235	1441	1647	1853	2059
75	309	618	926	1235	1544	1853	2161	2470	2779	3088
100	412	823	1235	1647	2059	2470	2882	3294	3705	4117

349. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the winter is 38,040 (218,622 x 0.174). The addition of a maximum of 288 to this increases the background mortality rate by 0.76%, which is below the 1% threshold for detectability.

12.6.2.1.4.3.4 Spring migration

350. During the spring migration period, the maximum mean peak abundance in the array areas and 2km buffer was 8,628 individuals. The estimated number of razorbills subject to mortality during the spring migration period due to displacement from the array areas (and 2km buffer; **Table 12-57**) is between 26 and 604 individuals.

Table 12-57 Displacement Matrix Presenting the Number of Razorbill in the Array Areas (and 2km Buffer) During Spring Migration That May Be Subject to Mortality (Highlighted).

Mortality (%)	**Displacement (%)**									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	9	17	26	35	43	52	60	69	78	86
2	17	35	52	69	86	104	121	138	155	173
3	26	52	78	104	129	155	181	207	233	259
4	35	69	104	138	173	207	242	276	311	345
5	43	86	129	173	216	259	302	345	388	431
6	52	104	155	207	259	311	362	414	466	518
7	60	121	181	242	302	362	423	483	544	604
8	69	138	207	276	345	414	483	552	621	690
9	78	155	233	311	388	466	544	621	699	777
10	86	173	259	345	431	518	604	690	777	863
20	173	345	518	690	863	1035	1208	1380	1553	1726
30	259	518	777	1035	1294	1553	1812	2071	2330	2588
50	431	863	1294	1726	2157	2588	3020	3451	3883	4314
75	647	1294	1941	2588	3236	3883	4530	5177	5824	6471
100	863	1726	2588	3451	4314	5177	6040	6902	7765	8628

351. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals expected to die in the spring migration season is 102,986 (591,874 x 0.174). The addition of a maximum of 604 to this increases the background mortality rate by 0.59%, which is below the 1% threshold for detectability.

12.6.2.1.4.3.5 Annual

352. Summed across the year the maximum mean peak abundance in the array areas and 2km buffer was 19,296 individuals. The estimated number of razorbills subject to mortality combined across all seasons due to displacement from the array areas (and 2km buffer; **Table 12-58**) is between 58 and 1,351 individuals.

Table 12-58 Displacement Matrix Presenting the Number of Razorbill in the Array Areas (and 2km buffer) Combined Across the Breeding, Autumn Migration, Winter and Spring Migration Periods That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	19	39	58	77	96	116	135	154	174	193
2	39	77	116	154	193	232	270	309	347	386
3	58	116	174	232	289	347	405	463	521	579
4	77	154	232	309	386	463	540	617	695	772
5	96	193	289	386	482	579	675	772	868	965
6	116	232	347	463	579	695	810	926	1042	1158
7	135	270	405	540	675	810	946	1081	1216	1351
8	154	309	463	617	772	926	1081	1235	1389	1544
9	174	347	521	695	868	1042	1216	1389	1563	1737
10	193	386	579	772	965	1158	1351	1544	1737	1930
20	386	772	1158	1544	1930	2316	2701	3087	3473	3859
30	579	1158	1737	2316	2894	3473	4052	4631	5210	5789
50	965	1930	2894	3859	4824	5789	6754	7718	8683	9648
75	1447	2894	4342	5789	7236	8683	10130	11578	13025	14472
100	1930	3859	5789	7718	9648	11578	13507	15437	17366	19296

353. At the average baseline mortality rate for razorbill of 0.174 (**Table 12-13**) the number of individuals from the largest BDMPS population expected to die across all seasons is 102,986 (591,874 x 0.174). The addition of a maximum of 1,351 to this increases the background mortality rate by 1.31%, which is above the 1% threshold for detectability.

354. The number of individuals from the biogeographic population expected to die across all seasons is 297,018 (1,707,000 x 0.174). The addition of a maximum of 1351 to this increases the mortality rate by 0.45%. Thus, the increase in background mortality is between 0.45% and 1.31%.

355. While the upper end of this range is above the 1% threshold, this is only achieved through a combination of worst case assumptions (the smaller reference population estimate, the worst case displacement and mortality rates). Even a small reduction in the precaution would reduce this effect to 1% (e.g. 7.5% mortality instead of 10%). Therefore the magnitude of impact for razorbill assessed against the BDMPS population is considered to be low.

356. The sensitivity of razorbill to operational displacement is considered to be medium and the magnitude of annual impact at the array areas is low when assessed against the BDMPS population and negligible when assessed against the biogeographic population. Therefore the significance of the annual effect on razorbill due to operational displacement at the array areas is assessed as minor.

357. A table summarising the razorbill operational displacement assessment is provided below (**Table 12-43**).

12.6.2.1.4.4 Summary of Operational Displacement Assessment - Razorbill

Table 12-59 Summary of Razorbill Operational Displacement Assessment for DBS East, DBS West and Combined (Projects). Note that the Project Total is Less Than the Sum of East and West Due to Overlap of the Individual 2km Buffers.

Razorbills		**DBS East**	**DBS West**	**Projects**
Baseline average annual mortality				0.174
Breeding season	Reference population (subadult component of nonbreeding BDMPS)			94,007
	Displacement mortality (@80% x 1%)	103	281	372
	Increase in background mortality (%)	0.63	1.72	2.27
Autumn	Reference population			591,874
	Displacement mortality (@70% x 10%)	46	52	87
	Increase in background mortality (%)	0.04	0.05	0.08
Winter	Reference population			218,622
	Displacement mortality (@70% x 10%)	272	129	288
	Increase in background mortality (%)	0.72	0.34	0.76
Spring	Reference population			591,874
	Displacement mortality (@70% x 10%)	556	163	604
	Increase in background mortality (%)	0.55	0.16	0.59
Annual (BDMPS)	Reference population (Nonbreeding season BDMPS)			591,874
	Displacement mortality (@70% x 10%)	986	625	1,351
	Increase in background mortality (%)	0.96	0.61	1.31
	Significance	Minor	Minor	Minor
Annual (biogeographic)	Biogeographical population			1,707,000
	Displacement mortality (@70% x 10%)	986	625	1,351
	Increase in background mortality (%)	0.33	0.21	0.45

	Significance	Minor	Minor	Minor

12.6.2.1.5 Puffin

12.6.2.1.5.1 Significance of Effect – DBS East in Isolation

12.6.2.1.5.1.1 Breeding Season

358. During the breeding season, the maximum mean peak abundance in the DBS East array area and 2km buffer was 78 individuals. The estimated number of puffins subject to mortality during the breeding period due to displacement from the DBS East (and 2km buffer; **Table 12-60**) is up to 5 individuals.

Table 12-60 Displacement Matrix Presenting the Number of Puffins in the DBS East Array Area (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	0	0	0	0	0	1	1	1	1
2	0	0	0	1	1	1	1	1	1	2
3	0	0	1	1	1	1	2	2	2	2
4	0	1	1	1	2	2	2	2	3	3
5	0	1	1	2	2	2	3	3	4	4
6	0	1	1	2	2	3	3	4	4	5
7	1	1	2	2	3	3	4	4	5	5
8	1	1	2	2	3	4	4	5	6	6
9	1	1	2	3	4	4	5	6	6	7
10	1	2	2	3	4	5	5	6	7	8
20	2	3	5	6	8	9	11	12	14	16
30	2	5	7	9	12	14	16	19	21	23
50	4	8	12	16	20	23	27	31	35	39
75	6	12	18	23	29	35	41	47	53	59
100	8	16	23	31	39	47	55	62	70	78

359. At the average baseline mortality rate for adult puffin of 0.167 (**Table 12-13**) the number of individuals from the FFC SPA population expected to die in the breeding season is 935 (5,600 x 0.167). The addition of a maximum of 5 to this increases the background mortality rate by 0.53%, which is below the 1% threshold for detectability.

360. However, since the wind farm is within foraging range from the FFC SPA, it is likely that a proportion of the birds recorded during the surveys would be sub-adults. If it is assumed that the potential subadult population in the region during the breeding season is 104,381 (the sub-adult proportion of the spring BDMPS), then at the baseline mortality rate for puffin (0.167, **Table 12-13**) the number of individuals expected to die in the breeding season is 17,432 (104,381 x 0.167). The addition of a maximum of 5 to this increases the background mortality rate by 0.03%, which is below the 1% threshold for detectability. Therefore, the impact is expected to lie between these two values (0.03% to 0.53).

12.6.2.1.5.1.2 Nonbreeding Season

361. During the nonbreeding season, the maximum mean peak abundance in the DBS East array area and 2km buffer was 462 individuals. The estimated number of puffins subject to mortality during the nonbreeding period due to displacement from the DBS East (and 2km buffer; **Table 12-61**) is between 1 and 32 individuals.

Table 12-61 Displacement Matrix Presenting the Number of Puffins in the DBS East Array Area (and 2km Buffer) During the Nonbreeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	2	2	3	3	4	4	5
2	1	2	3	4	5	6	6	7	8	9
3	1	3	4	6	7	8	10	11	12	14
4	2	4	6	7	9	11	13	15	17	18
5	2	5	7	9	12	14	16	18	21	23
6	3	6	8	11	14	17	19	22	25	28
7	3	6	10	13	16	19	23	26	29	32
8	4	7	11	15	18	22	26	30	33	37
9	4	8	12	17	21	25	29	33	37	42
10	5	9	14	18	23	28	32	37	42	46
20	9	18	28	37	46	55	65	74	83	92
30	14	28	42	55	69	83	97	111	125	139
50	23	46	69	92	116	139	162	185	208	231
75	35	69	104	139	173	208	243	277	312	347
100	46	92	139	185	231	277	323	370	416	462

362. At the average baseline mortality rate for puffin of 0.167 (**Table 12-13**) the number of individuals expected to die in the nonbreeding period is 38,737 (231,957 x 0. 167). The addition of a maximum of 32 to this increases the background mortality rate by 0.08%, which is below the 1% threshold for detectability.

12.6.2.1.5.1.3 Annual

363. Summed across the year the maximum mean peak abundance in the DBS East array area and 2km buffer was 540 individuals. The estimated number of puffins subject to mortality combined across all seasons due to displacement from the DBS East (and 2km buffer; **Table 12-62**) is between 2 and 38 individuals.

Table 12-62 Displacement Matrix Presenting the Number of Puffins in the DBS East Array Area (and 2km Buffer) Combined Across the Breeding and Nonbreeding Seasons That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	1	2	2	3	3	4	4	5	5
2	1	2	3	4	5	6	8	9	10	11
3	2	3	5	6	8	10	11	13	15	16
4	2	4	6	9	11	13	15	17	19	22
5	3	5	8	11	14	16	19	22	24	27
6	3	6	10	13	16	19	23	26	29	32
7	4	8	11	15	19	23	26	30	34	38
8	4	9	13	17	22	26	30	35	39	43
9	5	10	15	19	24	29	34	39	44	49
10	5	11	16	22	27	32	38	43	49	54
20	11	22	32	43	54	65	76	86	97	108
30	16	32	49	65	81	97	113	130	146	162
50	27	54	81	108	135	162	189	216	243	270
75	41	81	122	162	203	243	284	324	365	405
100	54	108	162	216	270	324	378	432	486	540

364. At the average baseline mortality rate for puffin of 0.167 (**Table 12-13**) the number of individuals from the BDMPS population expected to die across all seasons is 38,737 (231,957 x 0. 167). The addition of a maximum of 38 to this increases the background mortality rate by 0.1%, which is below the 1% threshold for detectability.

365. The number of individuals from the biogeographic population expected to die across all seasons is 1,977,280 (11,840,000 x 0. 167). The addition of a maximum of 38 to this increases the mortality rate by <0.01%. Thus, the increase in background mortality is between <0.01% and 0.1%.

366. The sensitivity of puffin to operational displacement is considered to be low and the magnitude of annual impact at DBS East is negligible, therefore the annual effect on puffin due to operational displacement at DBS East is assessed as negligible.

12.6.2.1.5.2 Significance of Effect – DBS West in Isolation

12.6.2.1.5.2.1 Breeding Season

367. During the breeding season, the maximum mean peak abundance in the DBS West array area and 2km buffer was 263 individuals. The estimated number of puffins subject to mortality during the breeding period due to displacement from the DBS West (and 2km buffer; **Table 12-63**) is between 1 and 18 individuals.

Table 12-63 Displacement Matrix Presenting the Number of Puffins in the DBS West Array Area (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	1	1	2	2	2	2	3
2	1	1	2	2	3	3	4	4	5	5
3	1	2	2	3	4	5	6	6	7	8
4	1	2	3	4	5	6	7	8	9	11
5	1	3	4	5	7	8	9	11	12	13
6	2	3	5	6	8	9	11	13	14	16
7	2	4	6	7	9	11	13	15	17	18
8	2	4	6	8	11	13	15	17	19	21
9	2	5	7	9	12	14	17	19	21	24
10	3	5	8	11	13	16	18	21	24	26
20	5	11	16	21	26	32	37	42	47	53
30	8	16	24	32	39	47	55	63	71	79
50	13	26	39	53	66	79	92	105	118	132
75	20	39	59	79	99	118	138	158	178	197
100	26	53	79	105	132	158	184	210	237	263

368. At the average baseline mortality rate for adult puffin of 0.167 (**Table 12-13**) the number of individuals from the FFC SPA population expected to die in the breeding season is 935 (5,600 x 0.167). The addition of a maximum of 18 to this increases the background mortality rate by 1.92%, which is above the 1% threshold for detectability.

369. However, since the wind farm is within foraging range from the FFC SPA, it is likely that a proportion of the birds recorded during the surveys would be sub-adults. If it is assumed that the potential subadult population in the region during the breeding season is 104,381 (the sub-adult proportion of the spring BDMPS), then at the baseline mortality rate for puffin (0.167, **Table 12-13**) the number of individuals expected to die in the breeding season is 17,432 (104,381 x 0.167). The addition of a maximum of 18 to this increases the background mortality rate by 0.1%, which is below the 1% threshold for detectability. Therefore, the impact is expected to lie between these two values (0.1% to 1.92%).

12.6.2.1.5.2.2 Nonbreeding Season

370. During the nonbreeding season, the maximum mean peak abundance in the DBS West array area and 2km buffer was 351 individuals The estimated number of puffins subject to mortality during the nonbreeding period due to displacement from the DBS West (and 2k buffer; **Table 12-64**) is between 1 and 25 individuals.

Table 12-64 Displacement Matrix Presenting the Number of Puffins in the DBS West Array Area (and 2km Buffer) During the Nonbreeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	1	2	2	2	3	3	4
2	1	1	2	3	4	4	5	6	6	7
3	1	2	3	4	5	6	7	8	9	11
4	1	3	4	6	7	8	10	11	13	14
5	2	4	5	7	9	11	12	14	16	18
6	2	4	6	8	11	13	15	17	19	21
7	2	5	7	10	12	15	17	20	22	25
8	3	6	8	11	14	17	20	22	25	28
9	3	6	9	13	16	19	22	25	28	32
10	4	7	11	14	18	21	25	28	32	35
20	7	14	21	28	35	42	49	56	63	70
30	11	21	32	42	53	63	74	84	95	105
50	18	35	53	70	88	105	123	140	158	176
75	26	53	79	105	132	158	184	211	237	263
100	35	70	105	140	176	211	246	281	316	351

371. At the average baseline mortality rate for puffin of 0.167 (**Table 12-13**) the number of individuals expected to die in the nonbreeding period is 38,737 (231,957x 0. 167). The addition of a maximum of 25 to this increases the background mortality rate by 0.06%, which is below the 1% threshold for detectability.

12.6.2.1.5.2.3 Annual

372. Summed across the year the maximum mean peak abundance in the DBS West array area and 2km buffer was 614 individuals. The estimated number of puffins subject to mortality combined across all seasons due to displacement from the DBS West (and 2km buffer; **Table 12-65**) is between 2 and 43 individuals.

Table 12-65 Displacement Matrix Presenting the Number of Puffins in the DBS West Array Area (and 2km Buffer) Across the Breeding and Nonbreeding Season That May Be Subject To Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	1	2	2	3	4	4	5	6	6
2	1	2	4	5	6	7	9	10	11	12
3	2	4	6	7	9	11	13	15	17	18
4	2	5	7	10	12	15	17	20	22	25
5	3	6	9	12	15	18	21	25	28	31
6	4	7	11	15	18	22	26	29	33	37
7	4	9	13	17	21	26	30	34	39	43
8	5	10	15	20	25	29	34	39	44	49
9	6	11	17	22	28	33	39	44	50	55
10	6	12	18	25	31	37	43	49	55	61
20	12	25	37	49	61	74	86	98	111	123
30	18	37	55	74	92	111	129	147	166	184
50	31	61	92	123	154	184	215	246	276	307
75	46	92	138	184	230	276	322	368	414	461
100	61	123	184	246	307	368	430	491	553	614

373. At the average baseline mortality rate for puffin of 0.167 (**Table 12-13**) the number of individuals expected to die from the BDMPS population across all seasons is 38,737 (231,957 x 0. 167). The addition of a maximum of 43 to this increases the background mortality rate by 0.11%, which is below the 1% threshold for detectability.

374. The number of individuals from the biogeographic population expected to die across all seasons is 1,977,280 (11,840,000 x 0. 167). The addition of a maximum of 43 to this increases the mortality rate by <0.01%. Thus, the increase in background mortality is between <0.01% and 0.11%.

375. The sensitivity of puffin to operational displacement is considered to be low and the magnitude of annual impact at DBS West is negligible, therefore the annual effect on puffin due to operational displacement at DBS West is assessed as negligible.

12.6.2.1.5.3 Significance of Effect – DBS East and DBS West Together

12.6.2.1.5.3.1 Breeding Season

376. During the breeding season, the maximum mean peak abundance in the array areas and 2km buffer was 343 individuals. The estimated number of puffins subject to mortality during the breeding period due to displacement from the DBS West (and 2km buffer; **Table 12-66**) is between 1 and 24 individuals.

Table 12-66 Displacement Matrix Presenting the Number of Puffins in the Array Areas (and 2km Buffer) During the Breeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	0	1	1	1	2	2	2	3	3	3
2	1	1	2	3	3	4	5	5	6	7
3	1	2	3	4	5	6	7	8	9	10
4	1	3	4	5	7	8	10	11	12	14
5	2	3	5	7	9	10	12	14	15	17
6	2	4	6	8	10	12	14	16	19	21
7	2	5	7	10	12	14	17	19	22	24
8	3	5	8	11	14	16	19	22	25	27
9	3	6	9	12	15	19	22	25	28	31
10	3	7	10	14	17	21	24	27	31	34
20	7	14	21	27	34	41	48	55	62	69
30	10	21	31	41	51	62	72	82	93	103
50	17	34	51	69	86	103	120	137	154	172
75	26	51	77	103	129	154	180	206	232	257
100	34	69	103	137	172	206	240	274	309	343

377. At the average baseline mortality rate for adult puffin of 0.167 (**Table 12-13**) the number of individuals from the FFC SPA population expected to die in the breeding season is 935 (5,600 x 0.167). The addition of a maximum of 24 to this increases the background mortality rate by 2.6%, which is above the 1% threshold for detectability.

378. However, since the wind farm is within foraging range from the FFC SPA, it is likely that a proportion of the birds recorded during the surveys would be sub-adults. If it is assumed that the potential subadult population in the region during the breeding season is 104,381 (the sub-adult proportion of the spring BDMPS), then at the baseline mortality rate for puffin (0.167, **Table 12-13**) the number of individuals expected to die in the breeding season is 17,432 (104,381 x 0.167). The addition of a maximum of 24 to this increases the background mortality rate by 0.14%, which is below the 1% threshold for detectability. Therefore, the impact is expected to lie between these two values (0.14% to 2.6%).

12.6.2.1.5.3.2 Nonbreeding season

379. During the nonbreeding season, the maximum mean peak abundance in the array areas and 2km buffer was 786 individuals. The estimated number of puffins subject to mortality during the nonbreeding period due to displacement from the DBS West (and 2k buffer; **Table 12-67**) is between 2 and 55 individuals.

Table 12-67 Displacement Matrix Presenting the Number of Puffins in the Array Areas (and 2km Buffer) During the Nonbreeding Season That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
1	1	2	2	3	4	5	6	6	7	8
2	2	3	5	6	8	9	11	13	14	16
3	2	5	7	9	12	14	17	19	21	24
4	3	6	9	13	16	19	22	25	28	31
5	4	8	12	16	20	24	28	31	35	39
6	5	9	14	19	24	28	33	38	42	47
7	6	11	17	22	28	33	39	44	50	55
8	6	13	19	25	31	38	44	50	57	63
9	7	14	21	28	35	42	50	57	64	71
10	8	16	24	31	39	47	55	63	71	79
20	16	31	47	63	79	94	110	126	141	157
30	24	47	71	94	118	141	165	189	212	236
50	39	79	118	157	197	236	275	314	354	393
75	59	118	177	236	295	354	413	472	531	590
100	79	157	236	314	393	472	550	629	707	786

380. At the average baseline mortality rate for puffin of 0.167 (**Table 12-13**) the number of individuals expected to die in the nonbreeding period is 38,737 (231,957x 0. 167). The addition of a maximum of 55 to this increases the background mortality rate by 0.14%, which is below the 1% threshold for detectability.

12.6.2.1.5.3.3 Annual

381. Summed across the year the maximum mean peak abundance in the array areas and 2km buffer was 1,129 individuals. The estimated number of puffins subject to mortality combined across all seasons due to displacement from the DBS West (and 2km buffer; **Table 12-68**) is between 3 and 79 individuals.

Table 12-68 Displacement Matrix Presenting the Number of Puffins in the Array Areas (and 2km Buffer) Combined Across the Breeding and Nonbreeding Seasons That May Be Subject to Mortality (Highlighted).

Mortality (%)	Displacement (%)									
	10	20	30	40	50	60	70	80	90	100
1	1	2	3	5	6	7	8	9	10	11
2	2	5	7	9	11	14	16	18	20	23
3	3	7	10	14	17	20	24	27	30	34
4	5	9	14	18	23	27	32	36	41	45
5	6	11	17	23	28	34	40	45	51	56
6	7	14	20	27	34	41	47	54	61	68
7	8	16	24	32	40	47	55	63	71	79
8	9	18	27	36	45	54	63	72	81	90
9	10	20	30	41	51	61	71	81	91	102
10	11	23	34	45	56	68	79	90	102	113
20	23	45	68	90	113	135	158	181	203	226
30	34	68	102	135	169	203	237	271	305	339
50	56	113	169	226	282	339	395	452	508	565
75	85	169	254	339	423	508	593	677	762	847
100	113	226	339	452	565	677	790	903	1016	1129

382. At the average baseline mortality rate for puffin of 0.167 (**Table 12-13**) the number of individuals expected to die from the BDMPS population across all seasons is 38,737 (231,957 x 0. 167). The addition of a maximum of 79 to this increases the background mortality rate by 0.2%, which is below the 1% threshold for detectability.

383. The number of individuals from the biogeographic population expected to die across all seasons is 1,977,280 (11,840,000 x 0. 167). The addition of a maximum of 79 to this increases the mortality rate by <0.01%. Thus, the increase in background mortality is between <0.01% and 0.2%.

384. The sensitivity of puffin to displacement is considered to be low and the magnitude of annual impact at the array areas is negligible, therefore the annual effect on puffin due to operational displacement at the array areas is assessed as negligible.

385. A table summarising the puffin operational displacement assessment is provided below (**Table 12-69**).

12.6.2.1.5.4 Summary of Operational Displacement Assessment - Puffin

Table 12-69 Summary of Puffin Operational Displacement Assessment for DBS East, DBS West and Combined (Projects). Note that the Project Total is Less Than the Sum of East and West Due to Overlap of the Individual 2km Buffers.

Puffin		DBS East	DBS West	Projects
Baseline average annual mortality				0.167
Breeding season	Reference population (adults from FFC SPA only)			5,600
	Displacement mortality (@70% x 10%)	5	18	24
	Increase in background mortality (%)	0.53	1.92	2.6
	Reference population (subadult component of nonbreeding BDMPS)			104,381
	Increase in background mortality (%)	0.03	0.1	0.14
Non breeding season	Reference population			231,957
	Displacement mortality (@70% x 10%)	32	25	55
	Increase in background mortality (%)	0.08	0.06	0.14
Annual (BDMPS)	Reference population (Nonbreeding season BDMPS)			231,957
	Displacement mortality (@70% x 10%)	38	43	79
	Increase in background mortality (%)	0.1	0.11	0.2
	Significance	Negligible	Negligible	Negligible
Annual (biogeographic)	Biogeographical population			11,840,000
	Displacement mortality (@70% x 10%)	38	43	79
	Increase in background mortality (%)	<0.01	<0.01	<0.01
	Significance	Negligible	Negligible	Negligible

12.6.2.2 Impact 4 Indirect Impacts Through Effects on Habitats and Prey Species During Operation

386. Indirect disturbance and displacement of birds may occur during the operational phase of the Projects if there are impacts on prey species and the habitats of prey species. These indirect effects include those resulting from the production of underwater noise (e.g. the turning of the wind turbines), electro-magnetic fields (EMF) and the generation of suspended sediments (e.g. due to scour or maintenance activities) that may alter the behaviour or availability of bird prey species.

387. Underwater noise and EMF may cause fish and mobile invertebrates to avoid the operational area and also affect their physiology and behaviour. Suspended sediments may cause fish and mobile invertebrates to avoid the operational area and may smother and hide immobile benthic prey. These mechanisms could result in less prey being available within the operational area to foraging seabirds. Changes in fish and invertebrate communities due to changes in presence of hard substrate (resulting in colonisation by epifauna) may also occur, and changes in fishing activity could influence the communities present.

388. With regard to noise impacts on fish, **Chapter 10 Fish and Shellfish Ecology** discusses the potential impacts upon fish relevant to ornithology as prey species. With regard to behavioural changes related to underwater noise impacts on fish during the operation of the Projects, **Chapter 10 Fish and Shellfish Ecology** concludes that the effects on fish and shellfish species to operational noise is considered to of minor adverse significance. With a non-significant effect on fish that are bird prey species, it could be concluded that the indirect effects on seabirds occurring in or around the array areas and offshore export cable corridor during the operational phase would also be of minor adverse significance. This would be the case irrespective of whether just one of DBS East or DBS West is built, or both.

389. With regard to changes to the seabed and to suspended sediment levels, **Chapter 9 Benthic and Intertidal Ecology** discusses the nature of any change and impact. It identifies that changes in physical processes and temporary habitat disturbance would be of negligible significance. With negligible effects on benthic habitats and species, it could be concluded that the indirect impact on seabirds occurring in or around the array areas and offshore export cable corridor during the operational phase is similarly a negligible adverse effect. This would be the case irrespective of whether just one of DBS East or DBS West is built, or both.

390. With regard to EMF effects, these are identified as very localised (<10m; Gill *et al.* 2005) with the majority of cables being buried to up to 1m depth, further reducing the effect of EMF. The magnitude of impact is considered negligible on benthic communities, and so it could be concluded that the indirect effect on seabirds occurring in or around the array areas and offshore export cable corridor during the operational phase is similarly a negligible adverse effect.

391. Very little is known about potential long-term changes in invertebrate and fish communities due to colonisation of hard substrate and changes in fishing pressures associated with offshore wind farms. Whilst the impact of the colonisation of introduced hard substrate is seen as a minor adverse effect 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 predicted to be of negligible magnitude and negligible significance (either beneficially or adversely) in EIA terms.

12.6.2.3 Impact 5 Collision Risk

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

393. Initial screening for species to include in the collision risk assessment is presented in **Table 12-70**. Species where risk of collision was assessed as very low were screened out (e.g. low flying species such as auks). Species where risk of collision was assessed as low were screened out if their abundance in flight was very low or low (e.g. species associated with nearshore waters such as terns). To be precautionary, all species where the risk of collision was assessed as medium or high were screened in, even if their abundance in flight was very low.

Table 12-70 Collision Risk Screening. Species Were Screened in on the Basis of Columns Two and Three.

Receptor	Risk of collisions[1]	Estimated density of birds in flight at the array areas	Screening Result (IN or OUT)
Fulmar	Low	High	**IN**
Gannet	Medium	Medium	**IN**
Arctic skua	Medium	Very low	**IN**
Great skua	Medium	Very low	**IN**
Puffin	Very low	Low	**OUT**
Razorbill	Very low	High	**OUT**
Common guillemot	Very low	High	**OUT**
Common tern	Low	Very low	**OUT**
Arctic tern	Low	Very low	**OUT**
Kittiwake	Medium	High	**IN**
Little gull	Medium	Very low	**IN**
Common gull	Medium	Very low	**IN**
Lesser black-backed gull	High	Low	**IN**
Herring gull	High	Low	**IN**
Great black-backed gull	High	Low	**IN**
[1]Garthe and Hüppop, 2004; Furness and Wade, 2012, Wade *et al.*, 2016			

394. Collision Risk Modelling (CRM) has been used in this assessment to estimate the risk to birds associated with the Projects' array areas. CRM, using the Band model (Band, 2012) has been used to produce predictions of mortality for particular species across biological seasons and annually. The approach to CRM is summarised here and further details are provided in **Appendix 12.6**.

395. The assessment is based on collision risk for each key seabird species from the Band CRM Option 2. This option uses generic estimates of flight height for each species based on the percentage of birds flying at Potential Collision Height (PCH) derived from data from a number of offshore array areas, presented in Johnston *et al*. (2014a, 2014b).

396. Modelling was undertaken based on the two indicative wind turbine maximum design scenarios described in **Chapter 5 Project Description**, i.e. the 200 Small wind turbines scenario (turbine parameter set 1, **Appendix 12.6**) and the 95 Large wind turbines scenario (turbine parameter set 2, Appendix 12.6).

397. CRM has been run using the deterministic Band model (Band, 2012), incorporating uncertainty in flight densities by estimating collisions using the mean values and upper and lower 95% confidence intervals (note that as agreed with Natural England through the ETG, stochastic collision risk modelling will also be included in the DCO application). While other model parameters can also be adjusted across ranges of values to provide further estimates of uncertainty, variation in flight density typically accounts for the largest component of overall variation (by some margin) and thus only this parameter has been varied in the current assessment. Avoidance rates and Nocturnal Activity Factors (NAF) used for CRM were those advised by Natural England (**Table 12-71**); and proportions at collision height (based on the generic dataset in Johnston *et al*. 2014a, 2014b).

Table 12-71 Parameters Used in CRM

<table>
<tr><th>Species</th><th>Avoidance Rate</th><th>Nocturnal activity factor (1 to 5 / %)</th></tr>
<tr><td>Arctic skua</td><td>99.0</td><td>1 / 0%</td></tr>
<tr><td>Great skua</td><td>99.0</td><td>1 / 0%</td></tr>
<tr><td>Common gull / Little gull</td><td>99.5</td><td>3 / 50%</td></tr>
<tr><td>Fulmar</td><td>99.0</td><td>4 / 75%</td></tr>
<tr><td rowspan="3">Gannet</td><td>99.2</td><td rowspan="3">1.32 / 8%</td></tr>
<tr><td>99.72*</td></tr>
<tr><td>99.88*</td></tr>
<tr><td rowspan="2">Great black-backed gull</td><td rowspan="2">99.4</td><td>3 / 50%</td></tr>
<tr><td>2 / 25%</td></tr>
<tr><td rowspan="2">Herring gull</td><td rowspan="2">99.4</td><td>3 / 50%</td></tr>
<tr><td>2 / 25%</td></tr>
<tr><td rowspan="2">Kittiwake</td><td rowspan="2">99.2</td><td>3 / 50%</td></tr>
<tr><td>2 / 25%</td></tr>
<tr><td rowspan="2">Lesser black-backed gull</td><td rowspan="2">99.4</td><td>3 / 50%</td></tr>
<tr><td>2 / 25%</td></tr>
</table>

**Following Natural England interim advice on CRM, macro-avoidance has been accounted for by a reduction of density of birds in flight based on the level of macro-avoidance displayed by this species. A project has been commissioned by NE to inform this rate, in the interim NE advise the use of a range of macro avoidance rates between 65% - 85% or a single rate of 70%*

398. The nocturnal activity parameter (**Table 12-71**) used in the CRM defines the level of nocturnal flight activity of each seabird species, expressed in relation to daytime flight activity levels. For example, a value of 50% for the nocturnal activity factor is appropriate for a species which is half as active at night as during the day. This factor is used to enable estimation of nocturnal collision risk from survey data collected during daylight, with the total collision risk the sum of those for day and night.

399. The nocturnal activity factors used here for each species are from Natural England's Interim CRM guidance, which are based on Garthe and Hüppop (2004) other than gannet which is from Furness *et al* (2018).

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

401. The following sections provide a summary of the outputs for assessment, using the seasons defined in **Table 12-11**. An overview of annual collision risk estimates for all species (using the deterministic Band model Option 2) is presented in **Table 12-72** for the Small and Large wind turbine scenarios. This table includes a range of estimates for species where CRM was run for variations in nocturnal activity, and for gannet, macro-avoidance rate. Following review of the flight densities, several species initially screened in (great skua, Arctic skua, common gull and little gull) were present in such low numbers that there was little justification for further consideration and the species were screened out. These species will be reviewed following the addition of the second year of data to ensure all species at risk of more than very small collisions are assessed.

Table 12-72 Annual Collision Risk Estimates for the Array Areas Combined (Deterministic Band Model Option 2, Avoidance Rates as per Table 12-11). Values are the Mean Number of Birds and 95% Confidence Intervals. For Species Screened in for Assessment, the 200 Small Turbine Scenario Gave the Highest Collision Risks.

Species	Species parameters used (NAF and avoidance rate)	200 Small wind turbine scenario	95 Large wind turbine scenario
Fulmar	N/A	0.23 (0.04-0.49)	0.18 (0.03-0.38)
Gannet	Avoidance rate 99.88%	5.44 (3.34-7.62)	3.7 (2.28-5.18)
	Avoidance rate 99.72%	12.7 (7.79-17.77)	8.64 (5.31-12.09)
	Avoidance rate 99.2%	36.29 (22.26-50.74)	24.7 (15.15-34.54)
Kittiwake	NAF 50%	254.57 (170.54-344.39)	181.32 (121.47-245.3)
	NAF 25%	211.38 (141.41-286.33)	150.56 (100.72-203.94)
Lesser black-backed gull	NAF 50%	0.46 (0-1.82)	0.32 (0-1.25)
	NAF 25%	0.42 (0-1.64)	0.28 (0-1.12)
Herring gull	NAF 50%	1.38 (0-4.17)	0.95 (0-2.85)
	NAF 25%	1.13 (0-3.41)	0.77 (0-2.33)
Great black-backed gull	NAF 50%	6.04 (0-16.63)	4.08 (0-11.23)
	NAF 25%	4.8 (0-13.24)	3.23 (0-8.95)

402. The annual collision risk estimates presented in **Table 12-72** were used to identify species to be scoped in for assessment in relation to collision risk, and to identify the worst-case scenario for each species scoped in. For all species, the worst-case was the more numerous small wind turbine scenario. The species considered further in relation to collision risks are gannet, kittiwake, lesser black-backed gull, great black-backed gull and herring gull. The seasonal collision estimates for these species are presented in **Table 12-73**.

Table 12-73 Seasonal Collision Risk Estimates for the Worst Case Scenario Wind Turbine (1). Values are the Mean Number of Predicted Collisions (Mean and 95% Confidence Intervals Derived From Density Estimates)

Species	Array	Breeding season	Autumn migration	Non-breeding/ Winter	Spring Migration	Annual
Gannet (AR 99.88%)	East	1.86 (1.16-2.65)	0.85 (0.57-1.11)	-	0 (0-0)	2.71 (1.74-3.76)
	West	2.16 (1.25-3.05)	0.58 (0.35-0.8)	-	0 (0-0)	2.73 (1.6-3.86)
	all	4.02 (2.41-5.7)	1.43 (0.92-1.91)	-	0 (0-0)	5.44 (3.34-7.62)
Gannet (AR 99.72%)	East	4.35 (2.72-6.15)	1.98 (1.35-2.6)	-	0 (0-0)	6.32 (4.06-8.77)
	West	5.02 (2.91-7.12)	1.36 (0.82-1.88)	-	0 (0-0)	6.38 (3.73-9)
	all	9.37 (5.63-13.27)	3.34 (2.17-4.48)	-	0 (0-0)	12.7 (7.79-17.77)
Gannet (AR 99.2%)	East	12.39 (7.77-17.6)	5.66 (3.83-7.45)	-	0 (0-0)	18.06 (11.61-25.04)
	West	14.37 (8.31-20.33)	3.87 (2.34-5.37)	-	0 (0-0)	18.23 (10.65-25.7)
	all	26.76 (16.08-37.93)	9.53 (6.17-12.82)	-	0 (0-0)	36.29 (22.26-50.74)
Great black-backed gull (NAF 50%)	East	0 (0-0)	-	1.95 (0-5.39)	-	1.95 (0-5.39)
	West	1.24 (0-3.57)	-	2.84 (0-7.67)	-	4.09 (0-11.24)
	all	1.24 (0-3.57)	-	4.79 (0-13.06)	-	6.04 (0-16.63)
Great black-backed gull (NAF 25%)	East	0 (0-0)	-	1.48 (0-4.11)	-	1.49 (0-4.11)
	West	1.14 (0-3.27)	-	2.17 (0-5.86)	-	3.31 (0-9.13)
	all	1.14 (0-3.27)	-	3.65 (0-9.97)	-	4.8 (0-13.24)
	East	0 (0-0)	-	0.46 (0-1.32)	-	0.46 (0-1.32)
	West	0.51 (0-1.59)	-	0.41 (0-1.27)	-	0.92 (0-2.85)

Species	Array	Breeding season	Autumn migration	Non-breeding/ Winter	Spring Migration	Annual
Herring gull (NAF 50%)	all	0.51 (0-1.59)	-	0.87 (0-2.59)	-	1.38 (0-4.17)
Herring gull (NAF 25%)	East	0 (0-0)	-	0.35 (0-1.01)	-	0.35 (0-1.01)
	West	0.47 (0-1.46)	-	0.3 (0-0.95)	-	0.78 (0-2.4)
	all	0.47 (0-1.46)	-	0.65 (0-1.96)	-	1.13 (0-3.41)
Kittiwake (NAF 50%)	East	101.12 (72.82-132.52)	31.82 (20.96-43.45)	-	16.15 (8.92-24.79)	149.08 (102.71-200.74)
	West	71.95 (46.38-98)	18.56 (10.01-27.1)	-	14.97 (11.44-18.57)	105.49 (67.83-143.65)
	all	173.07 (119.2-230.52)	50.38 (30.97-70.55)	-	31.12 (20.36-43.36)	254.57 (170.54-344.39)
Kittiwake (NAF 25%)	East	85.57 (61.22-112.78)	25.28 (16.59-34.59)	-	12.32 (6.83-18.88)	123.17 (84.65-166.25)
	West	62.09 (40.11-84.46)	14.67 (7.9-21.41)	-	11.45 (8.75-14.21)	88.21 (56.76-120.08)
	all	147.66 (101.33-197.24)	39.95 (24.49-56)	-	23.77 (15.58-33.09)	211.38 (141.41-286.33)
Lesser black-backed gull (NAF 50%)	West	0	0	0	0	0
	East	0.46 (0-1.82)	0.49 (0-1.46)	0 (0-0)	0 (0-0)	0.46 (0-1.82)

Species	Array	Breeding season	Autumn migration	Non-breeding/ Winter	Spring Migration	Annual
Lesser black-backed gull (NAF 25%)	East	0.42 (0-1.64)	0.49 (0-1.46)	0 (0-0)	0 (0-0)	0.420-1.64)

403. Impacts during the non-breeding periods have been assessed in relation to the relevant BDMPS (Furness, 2015). Where there is potential for impacts during the breeding season, these have been assessed in relation to reference populations calculated as described in the assessment for a given species.

12.6.2.3.1.1 Breeding Season Reference Populations for Collision Assessment

12.6.2.3.1.1.1 Gannet

404. The nearest gannet breeding colony to the proposed development is Bempton Cliffs within the Flamborough and Filey Coast SPA. The SPA is 100km from the Projects array areas at the nearest point (**Table 12-9**). This is within the mean maximum foraging range of gannets, estimated as 315km (Woodward *et al*., 2019).

405. Additional mortality of gannet during the breeding season has been assessed in relation to the Flamborough and Filey Coast SPA reference population. The SPA population at designation was 11,061 pairs, increasing to 13,392 pairs in 2017 (Aitken *et al*., 2017) with a small decrease to 13,125 pairs recorded in 2022 (Clarkson *et al*., 2022). These equate to a total population size during the breeding season of approximately 47,727 (calculated as individual adults and multiplied up to include subadult birds, based on the adult proportion of 0.55 from Furness, 2015). The Clarkson *et al*. (2022) estimate has been used as the reference population, being closer in time to baseline surveys.

406. During the nonbreeding seasons the gannet BDMPS populations for the North Sea have been used as the reference populations. For the annual assessment impacts have been considered in relation to the largest of the BDMPS populations and also to the biogeographic population (Furness, 2015).

12.6.2.3.1.1.2 Kittiwake

407. The nearest large breeding concentration of kittiwakes to the Projects array areas is the Flamborough and Filey Coast SPA, 100km from the array areas at the closest point. The mean maximum foraging range of kittiwake from breeding colonies is estimated at 156km (Woodward *et al*., 2019). Therefore, connectivity with this SPA in the breeding season has been assumed.

408. However, while the RSPB's Future of the Atlantic Marine Environments (FAME) studies have shown some extremely long foraging trips for this species (as reported in various publications such as Fair Isle Bird Observatory annual reports) those extreme values tend to occur at colonies where food supply is extremely poor and breeding success is low (for example Orkney and Shetland). Daunt *et al*. (2002) point out that seabirds, as central place foragers, have an upper limit to their potential foraging range from the colony, set by time constraints. For example, they assess this limit to be 73km for kittiwake based on foraging flight speed and time required to catch food, based on observations of birds from the Isle of May. This means that kittiwakes would be unable to consistently travel more than 73km from the colony and provide enough food to keep chicks alive. Hamer *et al*. (1993) recorded kittiwake foraging ranges exceeding 40km in 1990 when sandeel stock biomass was very low and breeding success at the study colony in Shetland was 0.0 chicks per nest, but <5km in 98% of trips in 1991 when sandeel abundance was higher and breeding success was 0.98 chicks per nest. Kotzerka *et al*. (2010) reported a maximum foraging range of 59km, with a mean range of around 25km for a kittiwake colony in Alaska.

409. Consequently, as well as assessing collisions against the SPA population, the breeding season impact on kittiwake has also been assessed against an alternative reference population, based on the observation that immature birds tend to remain in wintering areas. Thus, the number of immature birds in the relevant populations during the breeding season may be estimated as the proportion of the relevant BDMPS (i.e. spring, the one immediately preceding the breeding season) which are sub-adults. This can be calculated as 47% of the spring migration BDMPS population (Furness, 2015). This yields a breeding season reference population of 296,956 (Spring BDMPS for the UK North Sea and Channel, 627,816 x 47%).

12.6.2.3.1.1.3 Lesser Black-backed Gull

410. There are no breeding colonies for this species within foraging range of the array areas. Consequently, the breeding season impact on lesser black-backed gulls has been assessed against a reference population estimated from the observation that immature birds tend to remain in wintering areas. Thus, the number of immature birds in the relevant population during the breeding season can be calculated as 42% (the proportion of sub-adults in the population, see) of the nonbreeding BDMPS populations of lesser black-backed gull. This results in a breeding season population of nonbreeding lesser black-backed gull of 16,512 (nonbreeding BDMPS for the UK North Sea and Channel, 39,314 x 42%).

12.6.2.3.1.1.4 Herring Gull

411. There are no herring gull breeding colonies for this species within foraging range of the array areas. Consequently, the breeding season impact has been assessed against a reference population estimated from the observation that immature birds tend to remain in wintering areas. Thus, the number of immature birds in the relevant population during the breeding season can be calculated as 53% (the proportion of sub-adults in the population, see **Table 12-13**) of the nonbreeding BDMPS populations of herring gull. This results in a breeding season population of nonbreeding herring gull of 247,251 (nonbreeding BDMPS for the UK North Sea and Channel, 466,511 x 53%).

12.6.2.3.1.1.5 Great Black-backed Gull

412. There are no great black-backed gull breeding colonies within foraging range of the array areas. Consequently, the breeding season impact on great black-backed gull has been assessed against a reference population estimated from the observation that immature birds tend to remain in wintering areas. Thus, the number of immature birds in the relevant population during the breeding season can be calculated as 42% (the proportion of sub-adults in the population, see **Table 12-13**Error! Reference source not found.) of the nonbreeding BDMPS populations of great black-backed gull (Furness, 2015). This yields a breeding season population of nonbreeding great black-backed gull of 38,388 (nonbreeding BDMPS for the UK North Sea and Channel, 91,399 x 42%).

12.6.2.3.1.2 Nonbreeding Season Reference Populations for Collision Assessment

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

12.6.2.3.1.3 Collision Impacts

414. The impacts of mortality caused by collisions on the populations are assessed in terms of the change in the baseline mortality rate which could result. It has been assumed that all age classes are equally at risk of collisions (i.e. in proportion to their presence in the population), therefore it is necessary to calculate an average baseline mortality rate for all age classes for each species assessed. These were calculated using the different survival rates for each age class and their relative proportions in the population.

415. The first step is to calculate an average survival rate. The demographic rates for each species were taken from reviews of the relevant literature (e.g. Horswill and Robinson, 2015) and recent examples of population modelling (e.g. EATL, 2016). The rates were entered into a matrix population model to calculate the expected proportions in each age class. For each age class, the survival rate was multiplied by its proportion and the total for all ages summed to give the average survival rate for all ages. Taking this value away from 1 gives the average mortality rate. The demographic rates and the age class proportions, and average mortality rates calculated from them are presented in **Table 12-13**.

416. The percentage increases in background mortality rates of seasonal and annual populations due to predicted collisions with the Projects' wind turbines, summed across DBS East and DBS West, are shown in **Table 12-74** to **Table 12-78** for all species using avoidance rates recommended by Natural England (**Table 12-71**).

417. The sensitivity of gannet to collision risk is considered to be medium and the magnitude of annual impact at the array areas is negligible when assessed against the BDMPS population and negligible when assessed against the biogeographic population. Therefore, the significance of the annual effect on gannet due to collision risk at the array areas is assessed as minor.

418. The sensitivity of kittiwake to collision risk is considered to be medium and the magnitude of annual impact at the array areas is negligible when assessed against the BDMPS population and negligible when assessed against the biogeographic population. Therefore, the significance of the annual effect on kittiwake due to collision risk at the array areas is assessed as minor.

419. The sensitivity of lesser black-backed gull to collision risk is considered to be high and the magnitude of annual impact at the array areas is negligible when assessed against the BDMPS population and negligible when assessed against the biogeographic population. Therefore, the significance of the annual effect on lesser black-backed gull due to collision risk at the array areas is assessed as minor.

420. The sensitivity of herring gull to collision risk is considered to be high and the magnitude of annual impact at the array areas is negligible when assessed against the BDMPS population and negligible when assessed against the biogeographic population. Therefore, the significance of the annual effect on herring gull due to collision risk at the array areas is assessed as minor.

421. The sensitivity of great black-backed gull to collision risk is considered to be high and the magnitude of annual impact at the array areas is negligible when assessed against the BDMPS population and negligible when assessed against the biogeographic population. Therefore, the significance of the annual effect on great black-backed gull due to collision risk at the array areas is assessed as minor.

Table 12-74 Predicted Gannet Collisions at DBS East and DBS West combined and Percentage Increases in the Background Mortality Rate of Seasonal and Annual Populations for the Worst Case Wind Turbine Scenario (1). Note that the Annual Mortalities Have Been Assessed Against Both the Biogeographic Populations and the Largest BDMPS in Order to Indicate the Range of Likely Effects

Species		Avoidance rate: 99.88%			Avoidance rate: 99.72%		
Gannet							
		Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.
Baseline average annual mortality				0.191			0.191
Breeding season	Reference population			47,727			47,727
	Seasonal mortality	4.02	2.41	5.7	9.37	5.63	13.27
	Increase in background mortality (%)	0.048	0.029	0.068	0.112	0.067	0.159
Autumn	Reference population			456,298			456,298
	Seasonal mortality	1.43	0.92	1.91	3.34	2.17	4.48
	Increase in background mortality (%)	0.002	0.001	0.002	0.004	0.002	0.005
Spring	Reference population			248,835			248,835
	Seasonal mortality	0	0	0	0	0	0
	Increase in background mortality (%)	0	0	0	0	0	0
Annual largest BDMPS	Reference population			456,298			456,298
	Annual mortality	5.44	3.34	7.62	12.7	7.79	17.77
	Increase in background mortality (%)	0.006	0.004	0.009	0.015	0.009	0.020
Annual bio-geographic	Reference population			1,180,000			1,180,000
	Annual mortality	5.44	3.34	7.62	12.7	7.79	17.77
	Increase in background mortality (%)	0.002	0.001	0.003	0.006	0.003	0.008

Table 12-75 Predicted Kittiwake Collisions at DBS East and DBS West combined and Percentage Increases in the Background Mortality Rate of Seasonal and Annual Populations for the Worst Case Wind Turbine Scenario (1). Note that the Annual Mortalities Have Been Assessed Against Both the Biogeographic Populations and the Largest BDMPS in Order to Indicate the Range of Likely Effects

Species		**Nocturnal activity factor: 50%**			**Nocturnal activity factor: 25%**		
Kittiwake							
		Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.
Baseline average annual mortality				0.156			0.156
Breeding season	Reference population			16,8204			16,8204
	Seasonal mortality	173.07	119.2	230.52	147.66	101.33	197.24
	Increase in background mortality (%)	0.660	0.454	0.879	0.563	0.386	0.752
Autumn	Reference population			829,937			829,937
	Seasonal mortality	50.38	30.97	70.55	39.95	24.49	56
	Increase in background mortality (%)	0.039	0.024	0.054	0.031	0.019	0.043
Spring	Reference population			627,816			627,816
	Seasonal mortality	31.12	20.36	43.36	23.77	15.58	33.09
	Increase in background mortality (%)	0.032	0.021	0.044	0.024	0.016	0.034
Annual largest BDMPS	Reference population			829,937			829,937
	Annual mortality	254.57	170.54	344.39	211.38	141.41	286.33
	Increase in background mortality (%)	0.197	0.132	0.266	0.163	0.109	0.221
Annual bio-geographic	Reference population			5,100,000			5,100,000
	Annual mortality	254.57	170.54	344.39	211.38	141.41	286.33
	Increase in background mortality (%)	0.032	0.021	0.043	0.027	0.018	0.036

Table 12-76 Predicted Lesser Black-Backed Gull Collisions at DBS East and DBS West combined and Percentage Increases in the Background Mortality Rate of Seasonal and Annual Populations for the Worst Case Wind Turbine Scenario (1). Note that the Annual Mortalities Have Been Assessed Against Both the Biogeographic Populations and the Largest BDMPS in Order to Indicate the Range of Likely Effects

Species		**Nocturnal activity factor: 50%**			**Nocturnal activity factor: 25%**		
Lesser Black-backed Gull							
		Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.
Baseline average annual mortality				0.126			0.126
Breeding season	Reference population			16,512			16,512
	Seasonal mortality	0.46	0	1.82	0.42	0	1.64
	Increase in background mortality (%)	0.022	0	0.087	0.020	0	0.079
Autumn	Reference population			209,007			209,007
	Seasonal mortality	0	0	0	0	0	0
	Increase in background mortality (%)	0	0	0	0	0	0
Winter / non-breeding	Reference population			39,314			39,314
	Seasonal mortality	0	0	0	0	0	0
	Increase in background mortality (%)	0	0	0	0	0	0
Spring	Reference population			197,483			197,483
	Seasonal mortality	0	0	0	0	0	0
	Increase in background mortality (%)	0	0	0	0	0	0
Annual largest BDMPS	Reference population			209,007			209,007
	Annual mortality	0.46	0	1.82	0.42	0	1.64
	Increase in background mortality (%)	0.002	0	0.007	0.002	0	0.006
Annual bio-geographic	Reference population			854,000			854,000
	Annual mortality	0.46	0	1.82	0.42	0	1.64

Species		Nocturnal activity factor: 50%			Nocturnal activity factor: 25%		
	Increase in background mortality (%)	<0.001	0	0.002	<0.001	0	0.002

Table 12-77 Predicted Herring Gull Collisions at DBS East and DBS West combined and Percentage Increases in the Background Mortality Rate of Seasonal and Annual Populations for the Worst Case Wind Turbine Scenario (1). Note that the Annual Mortalities Have Been Assessed Against Both the Biogeographic Populations and the Largest BDMPS in Order to Indicate the Range of Likely Effects

Species		Nocturnal activity factor: 50%			Nocturnal activity factor: 25%		
Herring gull							
		Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.
Baseline average annual mortality				0.172			0.172
Breeding season	Reference population			247,251			247,251
	Seasonal mortality	0.57	0	1.59	0.47	0	1.46
	Increase in background mortality (%)	0.001	0	0.004	0.001	0	0.003
Winter / non-breeding	Reference population			466,511			466,511
	Seasonal mortality	0.87	0	2.59	0.65	0	1.96
	Increase in background mortality (%)	0.001	0	0.003	0.001	0	0.002
Annual largest BDMPS	Reference population			466,511			466,511
	Annual mortality	1.38	0	4.17	1.13	0	3.41
	Increase in background mortality (%)	0.002	0	0.005	0.001	0	0.004
Annual bio-geographic	Reference population			1,098,000			1,098,000
	Annual mortality	1.38	0	4.17	1.13	0	3.41
	Increase in background mortality (%)	<0.001	0	0.002	<0.001	0	0.002

Table 12-78 Predicted Great Black-Backed Gull Collisions at DBS East and DBS West combined and Percentage Increases in the Background Mortality Rate of Seasonal and Annual Populations for the Worst Case Wind Turbine Scenario (1). Note that the Annual Mortalities Have Been Assessed Against Both the Biogeographic Populations and the Largest BDMPS in Order to Indicate the Range of Likely Effects

Species		Nocturnal activity factor: 50%			Nocturnal activity factor: 25%		
Great black-backed gull							
		Mean	Lower c.i.	Upper c.i.	Mean	Lower c.i.	Upper c.i.
Baseline average annual mortality				0.185			0.185
Breeding season	Reference population			38,388			38,388
	Seasonal mortality	1.24	0	3.57	1.14	0	3.27
	Increase in background mortality (%)	0.017	0	0.05	0.016	0	0.046
Winter / non-breeding	Reference population			91,399			91,399
	Seasonal mortality	4.79	0	13.06	3.65	0	9.97
	Increase in background mortality (%)	0.028	0	0.077	0.022	0	0.059
Annual largest BDMPS	Reference population			91,399			91,399
	Annual mortality	6.04	0	16.63	4.8	0	13.24
	Increase in background mortality (%)	0.036	0	0.098	0.028	0	0.078
Annual bio-geographic	Reference population			235,000			235,000
	Annual mortality	6.04	0	16.63	4.8	0	13.24
	Increase in background mortality (%)	0.014	0	0.038	0.011	0	0.030

12.6.2.4 Impact 6 Combined Operational Collision Risk and Displacement

12.6.2.4.1.1 Gannet

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

423. As noted above (**Table 12-72**), the estimated annual gannet collision mortality associated with the Projects is 12.7 (7.79-17.77). The estimated mortality for gannet displacement is up to 17 birds at a displacement rate of 60-80% and mortality of 1% (Impact 3, **Table 12-32**).

424. Based on the largest Annual BDMPS for the UK North Sea and Channel, of 456,298 (Furness, 2015) and baseline mortality of 0.191 (**Table 12-13Error! Reference source not found.**), 87,153 individual gannets would be expected to die each year; the addition of a maximum of 29.7 individuals would represent an 0.03% increase in annual mortality. Based on the annual biogeographic population with connectivity to UK waters of 1,180,000 (Furness, 2015), 225,380 individuals would be expected to die; the addition of a maximum of 29.7 individuals would represent an 0.01% increase in mortality. These magnitudes of increase would not materially alter the background mortality of the population and would be undetectable.

425. The sensitivity of gannet to combined displacement and collision risk is considered to be medium and the magnitude of annual impact at the Projects is negligible when assessed against the BDMPS population and negligible when assessed against the biogeographic population. Therefore, the significance of the annual effect on gannet due to combined displacement and collision risk from the Projects is assessed as minor.

426. The same conclusion can also be made with respect to the potential individual effects from DBS East and DBS West, since these would necessarily be of lower magnitude.

12.6.3 Potential Effects During Decommissioning

427. There are two potential impacts that may affect bird populations during the decommissioning phase of the Projects that have been screened in. These are:

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

428. Any impacts generated during the decommissioning phase of the Projects are expected to be similar, or of reduced magnitude, to those generated during the construction phase, as certain activities such as piling would not be required. This is because it would generally involve a reverse of the construction phase through the removal of some structures and materials installed.

429. It is anticipated that any future activities would be programmed in close consultation with the relevant statutory marine and nature conservation bodies, to allow any future guidance and best practice to be incorporated to minimise any potential impacts.

12.6.3.1 Impact 7 Direct Disturbance and Displacement

430. Disturbance and displacement are likely to occur due to the presence of working vessels and crews and the movement, noise and light associated with these. Such activities have already been assessed for relevant bird species in the construction section above and have been found to be of negligible to minor negative magnitude. Any impacts generated during the decommissioning phase of the Projects 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. The resultant effect on a range of species of low to medium sensitivity to disturbance is of negligible to minor adverse significance.

12.6.3.2 Impact 8 Indirect Impacts Through Effects on Habitats and Prey Species

431. Indirect impacts such as displacement of seabird prey species are likely to occur as structures are removed. Such activities have already been assessed for relevant bird species in the construction section above and have been found to be of negligible magnitude.

432. Any impacts generated during the decommissioning phase of the Projects 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. The resultant effect on a range of species of low to high sensitivity to disturbance is of negligible to minor adverse significance.

12.7 Cumulative Effects

433. The cumulative effects assessment for offshore ornithology will be undertaken in accordance with the approach to the assessment of cumulative effects for offshore ornithology that has been applied by the Secretary of State when consenting offshore wind farms and confirmed in recent consent decisions. It will also follow the approach set out in guidance from the Planning Inspectorate (Planning Inspectorate, 2015) and from the renewables industry (RenewableUK, 2013 and The Crown Estate, 2019).

434. Wherever possible the cumulative assessment will be quantitative (i.e. where data in an appropriate format have been obtained). However, the level of data available and the ease with which impacts can be combined across the wind farms is variable, reflecting the availability of relevant data for older projects and the approach to assessment taken. Where this has not been possible (e.g. for older projects), a qualitative assessment will be undertaken.

435. For this preliminary cumulative assessment the effects for the Projects have been added to the totals from the published cumulative assessment for the most recently agreed and consented wind farms. At the time of producing this PEIR, the most recent cumulative wind farm totals were for the East Anglia ONE North and East Anglia TWO projects, hence those have been used here.

12.7.1 Screening for Cumulative Effects

436. The potential impacts arising from the proposed the Projects that were screened in for assessment for the project alone have also been considered in **Table 12-79** for the potential for cumulative impacts with other projects (as defined below).

Table 12-79 Screening for Potential Cumulative Effects.

Impact	Potential for Cumulative impact	Data Confidence[1]	Rationale
Construction			
Impact 1: Direct disturbance and displacement:	Yes	Medium	There is a possibility of temporal and spatial coincidence of disturbance / displacement from other plans or projects in the area acting on the same populations.
Impact 2: Indirect impacts through effects on habitats and prey species	No	Low	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is small and it is dependent on a temporal and spatial co-incidence of disturbance / displacement from other plans or projects.
Operation			
Impact 3: Direct disturbance and displacement	Yes	High	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Impact 4: Indirect impacts through effects on habitats and prey species	No	Low	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is small
Impact 5: Collision risk	Yes	High	There is a sufficient likelihood of a cumulative impact to justify a detailed, quantitative cumulative impact assessment.
Impact 6: Combined operational collision risk and displacement	Yes	Medium	There is a sufficient likelihood of a cumulative impact to justify quantitative cumulative impact assessment.
Decommissioning			
Impact 7: Direct disturbance and displacement	No	Low	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is small and it is dependent on a temporal and spatial co-incidence of disturbance / displacement from other plans or proposed projects.

Impact	Potential for Cumulative impact	Data Confidence[1]	Rationale
Impact 8: Indirect impacts through effects on habitats and prey species	No	Low	The likelihood that there would be a cumulative impact is low because the contribution from the proposed project is small and it is dependent on a temporal and spatial co-incidence of disturbance / displacement from other plans or projects.
1. Indicates the degree of confidence; medium / low reflects lower confidence in older assessments which used variable methods.			

12.7.2 Projects Considered for Cumulative Impacts

437. The projects and plans selected as relevant to the assessment of impacts to offshore ornithology are based upon an initial screening exercise undertaken on a long list. Each project, plan or activity has been considered and scoped in or out on the basis of effect–receptor pathway, data confidence and the temporal and spatial scales involved.

438. In addition, other offshore wind farms, the classes of projects that could potentially be considered for the cumulative assessment of offshore ornithological receptors include:

- Marine aggregate extraction;
- Oil and gas exploration and extraction;
- Sub-sea cables and pipelines; and
- Commercial shipping.

439. With respect to these activities, the cumulative assessment takes into account the fact that birds are expected to already be habituated to long-term, on-going activities and therefore these may be considered to be part of the baseline conditions, and therefore it is important to avoid double-counting or exaggeration of potential impacts. On this basis it is not expected that the Projects will contribute to cumulative effects with the activities in the above list, and therefore these have been scoped out and the cumulative assessment is focused on offshore wind farms.

440. The identification of offshore wind farms to include in the cumulative assessment of offshore ornithological receptors has been based on:

- Approved plans;
- Constructed projects;
- Approved but as yet unconstructed projects; and
- Projects for which an application has been submitted, determination is currently under consideration and which may be consented before the proposed Projects.

441. The wind farms listed in **Table 12-80** have been assigned to four Tiers as follows:

- Tier 1: projects that are built and operational;
- Tier 2: projects under construction;
- Tier 3: consented projects; and
- Tier 4: Application submitted or in planning.

Table 12-80 Projects Considered Within the Offshore Ornithology Cumulative Effect Assessment.

Tier	Project	Distance to Array Areas (km)
1	Beatrice	460
1	Beatrice Demonstrator	460
1	Blyth Demonstration Project	184
1	Dudgeon	120
1	East Anglia ONE	230
1	European Offshore Wind Deployment Centre	340
1	Galloper	260
1	Greater Gabbard	260
1	Gunfleet Sands	300
1	Hornsea Project One	40
1	Hornsea Project Two	90
1	Humber Gateway	128
1	Hywind	345
1	Kentish Flats	335
1	Kentish Flats Extension	335
1	Kincardine	330
1	Lincs	155
1	London Array	300
1	Lynn and Inner Dowsing (LID)	160
1	Methil	330

Tier	Project	Distance to Array Areas (km)
1	Moray East	445
1	Race Bank	135
1	Rampion	480
1	Scroby Sands	190
1	Sheringham Shoal	142
1	Teesside	225
1	Thanet	320
1	Triton Knoll	115
1	Westermost Rough	125
2	Dogger Bank Creyke Beck Projects A and B	10
2	Moray West	450
2	Neart na Gaoithe	275
2	Seagreen A and B	270
3	Dogger Bank Teesside Projects A (now Dogger Bank C) and B (now Sofia)	35
3	East Anglia ONE North	215
3	East Anglia THREE	190
3	East Anglia TWO	230
3	Hornsea Project Three - revised	50
3	Inch Cape	280
3	Norfolk Boreas	145
3	Norfolk Vanguard	155
4	Dudgeon Offshore Extension Project	120
4	Hornsea 4	40
4	Rampion 2 (PEIR)	480
4	Sheringham Shoal Extension Project	140

442. The level of data available and the ease with which impacts can be combined across the wind farms is quite variable, reflecting the availability of relevant data for older projects and the approach to assessment taken. Wherever possible the cumulative assessment is quantitative (i.e. where data in an appropriate format have been obtained). Where this has not been possible (e.g. for older projects) a qualitative assessment has been undertaken.

12.7.3 Cumulative Assessment of Construction: Direct Disturbance and Displacement

443. This section has not been assessed for this PEIR, but a full assessment will be provided in the ES.

444. In advance of the ES assessment, it is anticipated that the risk of significant cumulative displacement effects resulting from construction activities at the Projects will be low since, for any given wind farm, these are both spatially small in scale (confined to the vicinity of construction activity, e.g. around a construction vessel) and temporally short term (occurring only during the period of construction itself), and moreover the two combine such that the effects occur for only a short time in any particular location. Thus, the potential for these to combine across projects is limited and the likelihood of significant effects is expected to be small.

12.7.4 Cumulative Assessment of Operational Displacement

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

446. A review of the BDMPS regions for each species indicated that for gannet, guillemot, razorbill and puffin all the wind farms identified for inclusion in the cumulative assessment in **Table 12-80** have the potential to contribute to cumulative effects.

12.7.4.1 Gannet

447. The annual total of gannets at risk of displacement from the Projects array areas is estimated as 2,075 individuals (summing the seasonal peak means within the arrays and 2km buffers) for the annual period (**Table 12-32**).

448. The annual number of birds at risk of displacement from offshore wind farms in the UK North Sea and Channel BDMPS, which has been calculated as 45,922. When the estimated numbers at risk due to the Projects are included (2,075), this would increase to 47,997 birds. The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.7.4.2 Guillemot

449. The annual total of guillemots at risk of displacement from the Projects array areas is estimated as 56,929 individuals (summing the seasonal peak means within the arrays and 2km buffers) for the annual period (**Table 12-42**).

450. The estimated annual cumulative total of guillemots at risk of displacement from wind farms in the North Sea is 341,495 individuals, which rises to 398,424 individuals when including the Projects (56,929). The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.7.4.3 Razorbill

451. The annual total of razorbills at risk of displacement from the Projects array areas is estimated as 19,296 individuals across the migration-free breeding, autumn migration, winter, and spring migration periods; **Table 12-58**).

452. The estimated annual cumulative total of razorbills at risk of displacement from wind farms in the North Sea is 123,851 individuals, which rises to 143,147 individuals when including the Projects (19,296). The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.7.4.4 Puffin

453. The annual total of puffins at risk of displacement from the Projects array areas is estimated as 1,129 individuals for breeding and nonbreeding periods; **Table 12-68**).

454. The estimated annual cumulative total of puffins at risk of displacement from wind farms in the North Sea is 44,908 individuals, which rises to 46,037 individuals when including the Projects (1,129). The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.7.5 Cumulative Assessment of Operational Collision Risk

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

456. It is considered that all of the wind farms identified for inclusion in the cumulative assessment in **Table 12-80** have the potential to contribute to a cumulative effect.

12.7.5.1 Gannet

457. The annual number of birds at risk of collision from offshore wind farms in the UK North Sea and Channel BDMPS, which has been calculated as 2,939.8. When the estimated numbers at risk due to the Projects are included (5.44), this would increase to 2,945.2 collisions. The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.7.5.2 Kittiwake

458. The annual number of kittiwakes at risk of collision from offshore wind farms in the UK North Sea and Channel BDMPS, which has been calculated as 4,014.7. When the estimated numbers at risk due to the Projects are included (254.6), this would increase to 4,269.3 collisions. The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.7.5.3 Lesser Black-backed Gull

459. The annual number of lesser black-backed gull at risk of collision from offshore wind farms in the UK North Sea and Channel BDMPS has been calculated as 529.7. When the estimated numbers at risk due to the Projects are included (0.42), this would increase to 530.1 collisions. The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.7.5.4 Herring Gull

460. The annual number of herring gull at risk of collision from offshore wind farms in the UK North Sea and Channel BDMPS, which has been calculated as 763.1 When the estimated numbers at risk due to the Projects are included (1.13), this would increase to 764.2 collisions. The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.7.5.5 Great Black-backed Gull

461. The annual number of great black-backed gull at risk of collision from offshore wind farms in the UK North Sea and Channel BDMPS, which has been calculated as 979.4 When the estimated numbers at risk due to the Projects are included (6.04), this would increase to 985.4 collisions. The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.7.6 Cumulative Assessment of Operational Collision Risk and Displacement

12.7.6.1 Gannet

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

463. As noted above, the estimated cumulative annual total for gannet collision mortality is 2,945. The estimated cumulative total for gannet displacement is 288 to 384 birds. The existing total is expected to increase when projects, which are not yet determined are included, however the contribution from those projects is not yet finalised and subject to change.

12.8 Potential Monitoring Requirements

464. Monitoring requirements will be described in the In-Principal 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.

465. It is important that monitoring should studies be designed to address both site specific concerns and also contribute to the wider understanding of offshore wind farm effects on seabirds. Since the monitoring should therefore build on existing and planned monitoring, it is too early to define what the focus should be, but it is likely to reflect the impacts discussed in this assessment, namely displacement and collision risks.

12.9 Transboundary Effects

466. Collisions and displacement of offshore ornithology receptors will also be predicted to occur at offshore wind farms located outside UK territorial waters. This means that potential transboundary impacts are greater than that quantitatively assessed in the CEA presented above (section 12.7).

467. It is considered that the spatial scale and hence seabird reference populations sizes against which transboundary assessment would be conducted are considerably larger than those against which UK cumulative impacts have been assessed. However, robust information on the sizes of these populations is not available. a further complication is that the methods used to assess potential offshore wind farm impacts varies by country, and the outputs of impact assessments are not directly comparable. As a result, quantitative transboundary impact assessment is not possible. A limited attempt at quantifying this was attempted recently as part of the Strategic Environmental Assessment North Seas Energy (SEANSE) project (DHI, 2020a, 2020b). It provides a useful indicator of the level of potential impacts on offshore ornithology receptors beyond UK waters, and suggests that in the majority of cases, impacts on offshore ornithology receptors are largest in UK waters. However, there are a range of limitations that make the approach taken in the SEANSE project unsuitable for quantitative impact assessment purposes.

468. However, overall the increase in the reference populations that would result from the expansion of the area of search is anticipated to exceed the increase in impacts from the inclusion of non-UK offshore wind farms, with the result that the magnitude of transboundary cumulative impacts would be reduced below those assessed for each species presented in section 12.7.

12.10 Interactions

469. This section considers the potential for the impacts on offshore ornithology receptors that have been identified and assessed in this PEIR chapter to interact with one other. These are presented in a matrix to simplify presentation Table 12-81. No potential interactions between the impacts assessed have been identified.

Table 12-81 Summary of Potential interactions

Impacts		
Construction		
	Impact 1: Direct disturbance and displacement from increased vessel activity	Impact 2: Indirect Impacts Through Effects on Habitats and Prey Species During Construction
Impact 1: Direct disturbance and displacement from increased vessel activity		No interaction Birds that have been displaced cannot be impacted by prey availability effects, which are highly localized to the source of impact.
Impact 2: Indirect Impacts Through Effects on Habitats and Prey Species During Construction	No interaction Birds that are subject to prey availability effects, which are highly localized to the source of impact, can only be present if they have not been displaced by construction activities.	

Operation			
	Impact 3: Disturbance and displacement from offshore infrastructure	Impact 4: Indirect Impacts Through Effects on Habitats and Prey Species During Operation	Impact 5: Collision risk

Impacts			
Impact 3: Disturbance and displacement from offshore infrastructure		No interaction Birds that are displaced from the wind farm would not be subject to prey availability effects as these will only occur within the wind farm.	No interaction Birds that are displaced from the wind farm are not at risk of collision (except gannet which has been considered separately).
Impact 4: Indirect Impacts Through Effects on Habitats and Prey Species During Operation	No interaction Birds that are subject to reduced prey availability effects, which will only occur within the wind farm, have not been displaced.		No interaction Birds susceptible to indirect effects which occur within the wind farm have not been involved in collisions.
Impact 5: Collision risk	No interaction Birds that are at risk of collisions have not been displaced from the wind farm (except gannet which has been considered separately).	No interaction Birds involved in collisions would not be susceptible to indirect effects which occur within the wind farm.	
Decommissioning			
It is anticipated that the decommissioning impacts will be similar in nature to those of construction.			

12.11 Inter-relationships

470. The construction, operation and decommissioning of the Projects has the potential to result in a range of effects on offshore ornithology receptors, and these may be inter-related with other receptor groups. With respect to the impacts assessed for offshore ornithology receptors in this PEIR chapter, only indirect effects on habitats and prey are considered to be relevant.

471. The potential inter-relationships are summarised in **Table 12-82**, which indicates where assessments carried out in other PEIR chapters have been used to inform the offshore ornithology assessment.

Table 12-82 Summary of Potential inter-relationships

Impact	Related topic	Basis for consideration	Section where addressed
Construction			
Impact 2: Indirect impacts through effects on habitats and prey species during construction	Chapter 9 Benthic and Intertidal Ecology Chapter 10 Fish and Shellfish Ecology	Potential impacts on benthic and intertidal ecology and on fish and shellfish ecology during construction could affect prey resource for offshore ornithology receptors	12.6.1.2
Operation			
Impact 4: Indirect impacts through effects on habitats and prey species during operation	Chapter 9 Benthic and Intertidal Ecology Chapter 10 Fish and Shellfish Ecology	Potential impacts on benthic and intertidal ecology and on fish and shellfish ecology during operation could affect prey resource for offshore ornithology receptors	12.6.2.2
Decommissioning			
Impact 8: Indirect impacts through effects on habitats and prey species	As per construction	As per construction	12.6.3.2

12.12 Summary

472. This chapter has provided a characterisation of the existing environment for Offshore Ornithology based on both existing and array area specific survey data which has established that there are potential risks to seabirds from cumulative displacement and collisions risk. The impact assessment is summarised in **Table 12-83**.

473. Only the first 12 months of survey data were available to inform this PEIR and the baseline seabird densities and abundances are expected to change when the second year has been included in the analysis. As such, although consideration of impact magnitude and significance has been provided these should be treated as preliminary at this stage as the second year of data is expected to alter the figures on which the assessment is based. Full consideration of these aspects will be provided in the Offshore Ornithology ES chapter submitted with the DCO application.

Table 12-83 Summary of Potential Likely Significant Effects on Offshore Ornithology

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect
Construction						
Impact 1: Direct disturbance and displacement from increased vessel activity	Gannet, Guillemot, Razorbill, Puffin	Low-Medium	Negligible	Negligible-Minor Adverse	N/A	Negligible-Minor Adverse
Impact 2: Indirect impacts through effects on habitats and prey species	Seabirds	Low-High	Negligible	Negligible-Minor Adverse	N/A	Negligible-Minor Adverse
Operation						
Impact 3: Disturbance and displacement from offshore infrastructure	Gannet, Guillemot, Razorbill, Puffin	Low-Medium	Negligible-Low	Negligible–Minor Adverse	N/A	Negligible–Minor Adverse

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect
Impact 4: Indirect impacts through effects on habitats and prey species	Seabirds	Low	Negligible	Negligible	N/A	Negligible
Impact 5: Collision Risk	Fulmar, Gannet, Arctic skua, Great skua, Kittiwake, Little gull, Common gull, Lesser black-backed gull, Herring gull, Great black-backed gull	Low - High	Negligible	Negligible-Minor Adverse	N/A	Negligible-Minor Adverse
Impact 6: Combined operational collision risk and displacement	Gannet	Medium	Negligible	Negligible	N/A	Minor Adverse
Decommissioning						

Potential Impact	Receptor	Sensitivity	Magnitude of Impact	Pre-mitigation Effect	Mitigation Measures Proposed	Residual Effect
Impact 7: Direct disturbance and displacement	Gannet, Guillemot, Razorbill, Puffin	Low-Medium	Negligible	Negligible-Minor Adverse	N/A	Negligible-Minor Adverse
Impact 8: Indirect impacts through effects on habitats and prey species	Seabirds	Low-High	Negligible	Negligible-Minor Adverse	N/A	Negligible-Minor Adverse

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