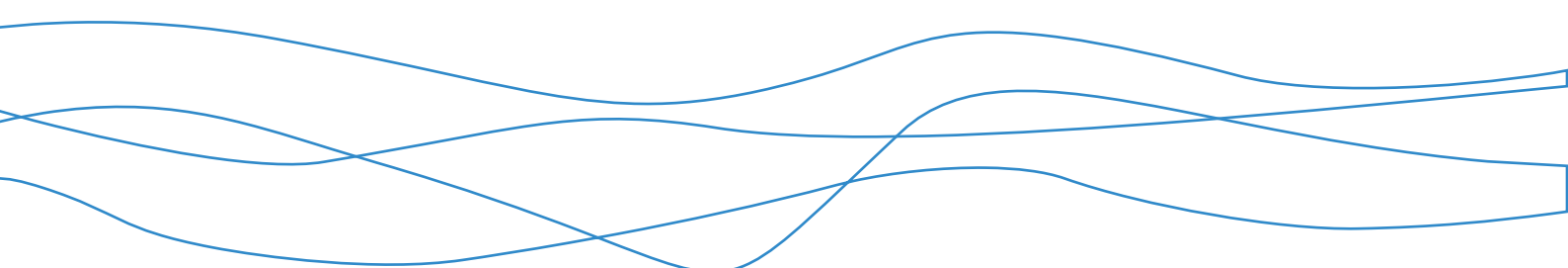




# **Bowdun Offshore Wind Farm, Offshore EIA Report**

Volume 3, Technical Appendix 11.3: Offshore  
Ornithology Displacement Technical Report

TWP-BOW-RPS-OFE-RPT-00021 | April 2026



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## Glossary

Defined Term	Definition
<b>Array Area</b>	The Array Area is the area in which the Offshore Generation Assets will be located.
<b>Bowdun Offshore Wind Farm Limited (BOWFL)</b>	A Special-Purpose Vehicle (SPV) (legal entity) for the purpose of developing the Project. Bowdun Offshore Wind Farm Limited will be the Applicant for the Offshore Application.
<b>Barrier Effects</b>	The effect by which a bird has to make longer transits between a breeding or roosting location to an area of foraging. An Offshore Wind Farm (OWF) could act as a barrier in which a species has to fly around to reach the other side, some species are unlikely to travel through.
<b>Collision</b>	The effect by which a bird may be impacted by direct collision. Birds passing through an offshore wind farm are at risk of colliding with the Wind Turbines (moving and stationary parts).
<b>Digital Aerial Surveys (DAS)</b>	A method for undertaking baseline ornithological data collection surveys. Usually undertaken over a period of 24 months.
<b>Displacement</b>	An impact that occurs when a bird is forced away from an area of habitual usage. This can be temporary (i.e. a ship moving) or permanent (i.e. the placement of offshore infrastructure).
<b>Effect</b>	Term used to express the consequence of an impact (i.e. the result of change or changes) on specific environmental resources or receptors. The significance of an effect is determined by correlating the magnitude of the impact with the importance, or sensitivity of the receptor or resource in accordance with defined significance criteria.
<b>Environmental Impact Assessment (EIA)</b>	Process for the assessment of likely significant environmental effects of a project on the physical, biological, and human environment during construction, Operation and Maintenance (O&M) and decommissioning.
<b>Export Cable Corridor</b>	The area of seabed seaward of Mean High-Water Springs (MHWS) which connects the Array Area with the Landfall within which the Offshore Export Cables will be installed.
<b>Habitats Regulations</b>	A term that refers to the collective legislation that translates the Habitats Directive into specific legal obligations in Scotland, namely: The Conservation (Natural Habitats, &c.) Regulations 1994; The Conservation of Habitats and Species Regulations 2017; and The Conservation of Offshore Marine Habitats and Species Regulations 2017 (in each case as amended).
<b>Habitats Regulations Appraisal (HRA)</b>	An assessment carried out under the Habitats Regulations to determine if a plan or project could adversely affect the integrity of a European Site.
<b>Impact</b>	A change caused by an action that occurs during a project's lifetime.
<b>Inter-Array Cables (IAC)</b>	Cables which link the Wind Turbines to each other and with the Offshore Substation Platforms (OSPs).
<b>Inter-related Effects</b>	The potential effects of multiple impacts from the construction, O&M and decommissioning of the Project, affecting one receptor.
<b>Interconnector Cables</b>	Cables which will connect individual OSFs to each other to provide redundancy against cable failure elsewhere.

<b>Defined Term</b>	<b>Definition</b>
<b>Landfall</b>	The area in which the Offshore Export Cables make landfall and is also the transitional area between the Offshore Transmission Assets and the Onshore Transmission Assets. Located in the Intertidal Area at Benholm.
<b>Offshore Export Cables</b>	Subsea cables used to transmit electricity generated offshore by the Wind Turbines from the OSPs to shore. The Transition Joint Bay is the location where the Offshore Export Cables terminate, and the onshore cabling begins.
<b>Offshore Substation Platform(s) (OSPs)</b>	OSPs comprise the support structure, topside and electrical components used for collecting and/or converting electricity generated by the Wind Turbines for transmission by the Offshore Export Cables.
<b>Operation and Maintenance (O&amp;M)</b>	The phase of the Proposed Development following completion of construction. This phase of development includes routine inspections, repairs and replacement of infrastructure and equipment (including Interconnector Cables and IACs), Scour Protection replenishment or replacement, major component replacement, painting and/or other coating works, removal of marine growth, and replacement of access ladders.
<b>Proposed Development</b>	Term used to define the Offshore Infrastructure associated with the Project seaward of MHWS for which consent is being sought. Further details of the parameters are included in Volume 1, Chapter 3: Project Description.
<b>Qualifying Features</b>	The features for which a European Site has been officially designated to protect.
<b>Scour Protection</b>	Protective materials to avoid sediment being eroded away from the base of the foundations and/or buried subsea cable due to the flow of water.
<b>Statutory Nature Conservation Body (SNCB)</b>	A statutory adviser to the UK and Scottish Governments on Scottish, UK and international nature conservation.
<b>Study Area</b>	For each environmental topic, the baseline environment will be characterised, and the potential environmental impacts will be described within a topic-specific study area. Specific study areas are defined for each topic and are based on the maximum spatial extent across which potential impacts of the Project may be experienced by the relevant receptors (i.e. Zone of Influence).
<b>Thistle Wind Partners (TWP)</b>	Company established for the development of the Project.
<b>Wind Turbines</b>	Structures comprising of a tubular tower, rotor blades, and a nacelle which houses the Wind Turbine generator.

## Acronyms

Acronym	Definition
DAS	Digital Aerial Surveys
EIA	Environmental Impact Assessment
HRA	Habitats Regulations Appraisal
IAC	Inter-Array Cable
IBM	Individual-Based Model
JNCC	Joint Nature Conservation Committee
MHWS	Mean High Water Springs
MRSea	Marine Renewables Strategic Environmental Assessment
O&M	Operation and Maintenance
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
POA	Plan Option Area
SMP	Sectoral Marine Plan
SNCB	Statutory Nature Conservation Body
UK	United Kingdom
TWP	Thistle Wind Partners
VOR	Valued Ornithological Receptor

## Table of Units

Units	Definition
km	Kilometre
km <sup>2</sup>	Square kilometre
%	Percent

# 1 Introduction

- 1.1.1 This Offshore Ornithology Displacement Technical Report presents the offshore ornithology displacement assessment for the offshore elements of the Bowdun Offshore Wind Farm (OWF) (hereafter referred to as the Proposed Development). The Proposed Development covers the Option Lease Area (OLA) comprises of the Array Area, which is located in the E3 Plan Option Area (POA) detailed in the Scottish Sectoral Marine Plan (Scottish Government, 2020), and the Export Cable Corridor, which together form the Site Boundary detailed in Figure 2.1. The Array Area is located 38 km from the Aberdeenshire coast at its closest point, covering an area of 187 km<sup>2</sup>. The Proposed Development will comprise of Wind Turbines (fixed foundations), Inter-Array Cables, Offshore Substation Platforms, Interconnector Cables, Offshore Export Cables and any necessary scour/cable protection. The Export Cable Corridor will include a maximum of three High Voltage Alternating Current Offshore Export Cables, each with a length of up to 70 km and will make Landfall at Benholm, Aberdeenshire.
- 1.1.2 The Offshore Ornithology Study Area has been used to inform this displacement report, and consists of two components (see Figure 1.1):
- The Array Area Study Area consists of the E3 POA and a 12 km buffer in the non-breeding season which extends to the shore in the breeding season. The Array Area Study Area is referred to as the “Digital Aerial Survey (DAS) Area” and the “Extended DAS Area” respectively, when specifically referring to these seasonal study areas; and
  - The Export Cable Corridor Study Area: consisting of the Export Cable Corridor route plus a 10 km buffer up to Mean High Water Springs (MHWS).

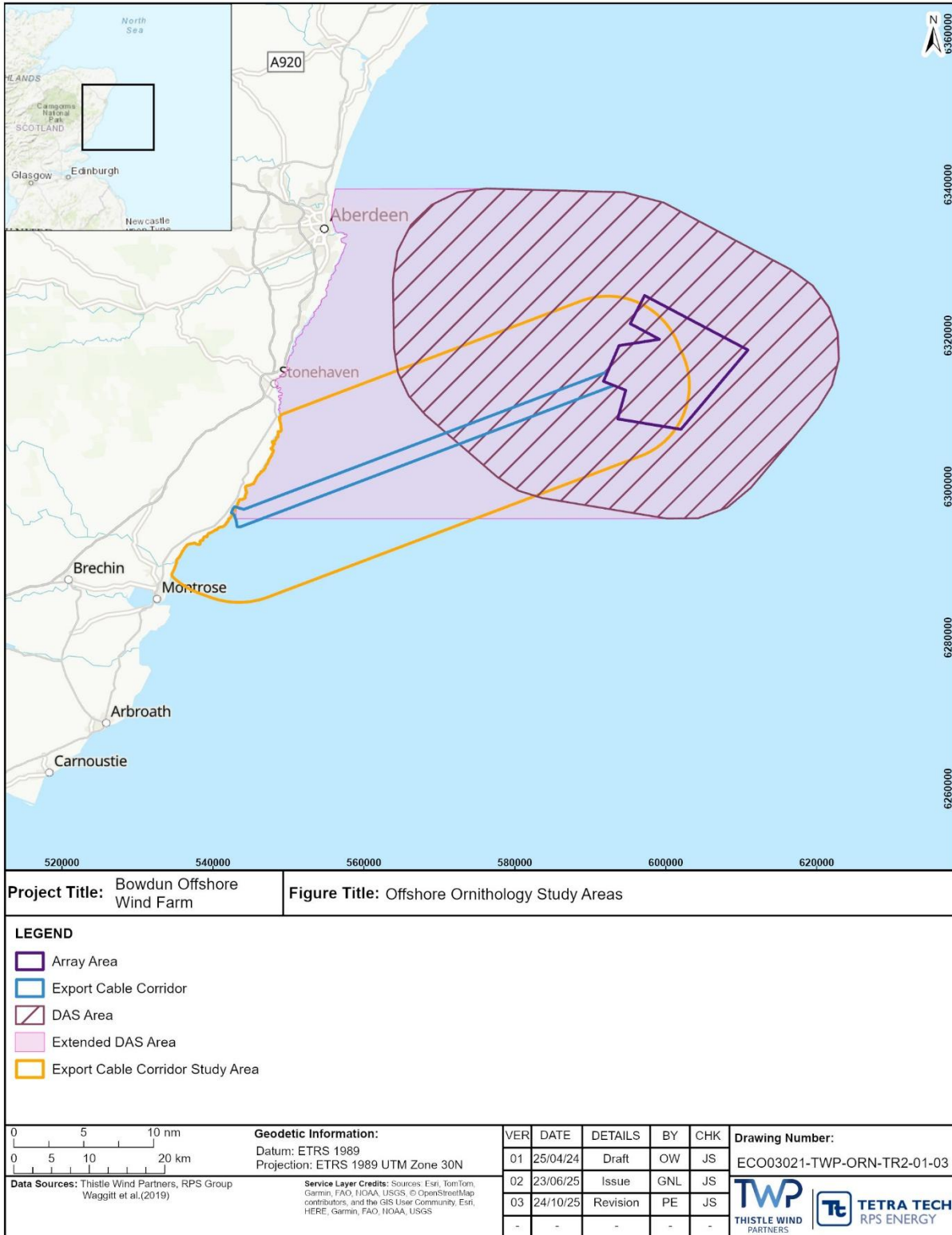


Figure 1.1: Offshore Ornithology Study Area

- 1.1.3 Seabirds can be impacted by OWF developments in a number of ways, including collision, displacement, barrier effects, and disturbance (the latter three are often grouped as ‘distributional impacts’ due to impossibility of quantifying each impact separately), as well as indirect effects like changes in prey availability.
- 1.1.4 Disturbance occurs when a bird's typical activities are disrupted by human activities during the construction, Operation and Maintenance (O&M), and decommissioning phases of an OWF (such as vessel movements and increased noise from construction activities). Birds that use specific marine areas for feeding, resting, and/or commuting may be disturbed by these activities in or near those locations. Consequently, displaced seabirds may relocate to areas already inhabited by other seabirds, leading to increased competition for resources due to higher densities of individuals. Alternatively, they may be forced to move to lower-quality areas (e.g. regions with reduced prey availability). Such disturbances and the resulting displacement could ultimately impact their demographic fitness (i.e. survival rates and breeding success) and may also affect other bird populations in the areas to which the displaced birds relocate. This represents an indirect loss of habitat, reducing the available space for feeding, resting, and moulting for seabird species that may occur at the Proposed Development.
- 1.1.5 Furness *et al.* (2013) define displacement as a decrease in the number of seabirds present within or immediately adjacent to an OWF. Displacement, as an effect, may occur both within the disturbed area and at some distance beyond it, referred to as a ‘buffer’ (e.g. Mendel *et al.*, 2014). Displacement is regarded as a permanent effect, as birds may experience adverse effects due to the loss of feeding areas, necessitating travel to more distant waters for feeding and/or resting.
- 1.1.6 Different species exhibit varying levels of susceptibility to disturbance and displacement. The sensitivity of species to disturbance from OWFs has been categorised by researchers including Garthe and Hüppop (2004), Furness *et al.* (2013), Bradbury *et al.* (2014), Wade *et al.* (2016), and Peschko *et al.* (2024).
- 1.1.7 During the O&M phase, operational Wind Turbines have the potential to directly disturb seabirds, leading to their displacement from the OWF and creating a variable-sized buffer around it. In a review of studies from 20 operational OWFs in Europe, Dierschke *et al.* (2016) evaluated the extent of displacement or attraction among various seabird species. While diver species and northern gannet (hereafter known as ‘gannet’) *Morus bassanus* consistently exhibited strong avoidance of OWFs, other species such as northern fulmar (hereafter known as ‘fulmar’) *Fulmarus glacialis*, common scoter *Melanitta nigra*, Manx shearwater *Puffinus puffinus*, razorbill *Alca torda*, common guillemot (hereafter known as ‘guillemot’) *Uria aalge*, little gull *Larus minutus*, and sandwich tern *Thalasseus sandvicensis* showed less consistent patterns of displacement.
- 1.1.8 The Statutory Nature Conservation Bodies (SNCBs) have developed guidelines for assessing seabird displacement related to OWFs (Joint Nature Conservation Committee (JNCC) *et al.*, 2022). These guidelines advocate for a displacement

matrix approach, which presents the proportions of seabirds that may be displaced or affected as a result of OWF development. The SNCBs note (JNCC *et al.*, 2022) that the impacts of disturbance and displacement are expected to be spatially limited to the footprint of the OWF and its immediate vicinity. Nonetheless, consideration for most species have been given to possible displacement effects up to 2 km from the OWF footprint. For divers and seaducks, this has been extended to possible displacement up to 4 km, and up to 10 km for the most sensitive species such as red-throated diver *Gavia stellata* due to their heightened sensitivity to disturbances from sound, vessels, and helicopter traffic. Thistle Wind Partners (TWP) Limited commissioned a DAS for baseline characterisation extending to a 12 km buffer around the E3 POA in the non-breeding season (September to March inclusive), which extended to the coast during the breeding season (April to August inclusive), to ensure a thorough assessment of displacement effects, both in close proximity to the Array Area and in a broader context.

- 1.1.9 Changes in mortality rates among displaced birds have been documented for waders (e.g. Burton *et al.*, 2006). However, there is a lack of empirical evidence regarding the consequences of seabird displacement in terms of their survival and reproductive success. For waterbirds, including waders, geese, and seaducks, simulations using Individual-Based Models (IBMs) have shown alterations in mortality rates due to changes in individual energy budgets (Pettifor *et al.*, 2000; West *et al.*, 2003; Kaiser *et al.*, 2002). In the absence of comprehensive empirical evidence on displacement, there are multiple precautionary assumptions adopted in SNCB guidance on trying to quantify mortality estimates. As a consequence, the resulting figures are likely to be worst case, rather than the most likely, scenarios.
- 1.1.10 The information from this technical report informs the Environmental Impact Assessment (EIA) and Habitats Regulations Appraisal (HRA) for the Offshore Ornithological receptors of the Proposed Development. This report accompanies the EIA provided in Volume 2, Chapter 11: Offshore Ornithology to support the consent application for the Proposed Development.
- 1.1.11 The aim of this technical report is to:
- outline the methodology and findings of the SNCB matrix approach for assessing seabird displacement resulting from the Proposed Development during the construction, O&M, and decommissioning phases; and
  - present the displacement matrices utilising predicted seabird abundances derived from Marine Renewables Strategic Environmental Assessment (MRSea) modelling outputs for species identified as Valued Ornithological Receptors (VORs).

## 2 Methodology

### 2.1 Introduction

2.1.1 Although NatureScot (2023a) advises the use of SeabORD and displacement matrices in their guidance, due to several practical issues regarding the use and functionality of SeabORD only displacement matrices have been presented. This is following consultation with NatureScot (see Section 11.4 of Volume 2, Chapter 11: Offshore Ornithology).

### 2.2 Species for Consideration

2.2.1 Proposed Development specific data for the displacement assessment was collected during 24 months of DAS, carried out across the extent of the Array Area Study Area consisting of the DAS Area in the non-breeding season (September to March inclusive), and Extended DAS Area in the breeding season (April to August inclusive). Twenty-four monthly surveys were undertaken by APEM Limited from March 2022 to February 2024 inclusive. Further details on the survey area and survey methodology are provided in Section 3.3 of Volume 3, Technical Appendix 11.1: Offshore Ornithology Baseline Characterisation Report.

2.2.2 The displacement matrix method of displacement assessment is only valid when considering the impact associated with the Array Area (plus appropriate recommended buffer only (i.e. up to 2 km for most species, up to 4 km for divers and seaducks and up to 10 km for red-throated diver)). Therefore, only birds recorded within the Array Area (plus appropriate buffer) are considered with this technical report. Species may also be impacted along the Export Cable Corridor, and the assessment covering this area has been presented in Volume 2, Chapter 11: Offshore Ornithology.

2.2.3 The rationale for defining a VOR and list of VORs included in displacement analysis is summarised here. The full methodology and identification of VORs that may be affected by impacts associated with the Proposed Development (including, but not limited to, displacement impacts) is documented in Section 4.3 of Volume 3, Technical Appendix 11.1: Offshore Ornithology Baseline Characterisation Report.

2.2.4 VORs that are potentially affected by displacement and therefore require further analysis were identified using the following criteria:

- identified as a moderate or high vulnerability to displacement impacts (based on Wade *et al.*, 2016; and Bradbury *et al.*, 2014); or
- identified as a moderate or high abundance during DAS with consideration given to the appropriate species-specific buffer (see Paragraph 2.2.2). Abundance during the DAS was identified as follows:
  - Low = <100 birds in all individual surveys;
  - Moderate = 100 to 500 birds in at least one survey; and
  - High = >500 birds in at least one survey.

2.2.5 All VORs identified in Volume 3, Technical Appendix 11.1: Offshore Ornithology Baseline Characterisation Report are provided in Table 2.1. Table 2.1 provides a summary for which VORs are included in displacement analysis.

2.2.6 The following species were selected for displacement analysis:

- Fulmar
- Gannet
- Black-legged kittiwake (hereafter known as ‘kittiwake’) *Rissa tridactyla*
- Guillemot
- Razorbill, and
- Atlantic puffin (hereafter known as ‘puffin’) *Fratercula arctica*.

**Table 2.1: Identification of VORs for Which Analysis of Displacement for the Array Area is Required**

Species	Abundance in the DAS Area	Vulnerability to displacement <sup>1</sup>	Displacement Analysis Required (Yes/No)
<b>Common eider (hereafter known as ‘eider’) <i>Somateria mollissima</i></b>	Low	Moderate	No – species recorded in low abundance.
<b>Fulmar</b>	High	Very low	Yes – species recorded in high abundance and, although their vulnerability to displacement is very low, fulmar are recommended for inclusion by NatureScot (2024).
<b>Manx shearwater</b>	Low	Very low	No – species recorded in low abundance.
<b>Sooty shearwater <i>Ardenna grisea</i></b>	Low	Very low	No – species recorded in low abundance.
<b>European storm petrel <i>Hydrobates pelagicus</i></b>	Low	Very low	No – species recorded in low abundance.
<b>Gannet</b>	High	Very low	Yes – species recorded in high abundance and, although their vulnerability to displacement is very low, Wade <i>et al.</i> (2016) assessed vulnerability to displacement by structures to be high.
<b>Great skua <i>Stercorarius skua</i></b>	Low	Very low	No – species recorded in low abundance.
<b>Kittiwake</b>	High	Very low	Yes – species recorded in high abundance and, although their vulnerability to displacement is very low, kittiwake are recommended for inclusion by NatureScot (2024).
<b>Great black-backed gull <i>Larus marinus</i></b>	Low	Low	No – species recorded in low abundance.
<b>Lesser black-backed gull <i>Larus fuscus</i></b>	Low	Very low	No – species recorded in low abundance.

Species	Abundance in the DAS Area	Vulnerability to displacement <sup>1</sup>	Displacement Analysis Required (Yes/No)
<b>Herring gull <i>Larus argentatus</i></b>	High	Very low	No – although species recorded in high abundance, their vulnerability to displacement is very low. Furthermore, evidence from empirical studies show that gull species can be attracted to wind farms (Leopold <i>et al.</i> , 2013; Vanermen <i>et al.</i> , 2013; Petersen <i>et al.</i> , 2006; Mendel <i>et al.</i> , 2014) which gives confidence that this species does not need to be assessed for displacement.
<b>Common gull <i>Larus canus</i></b>	Low	Low	No – species recorded in low abundance.
<b>Arctic tern <i>Sterna paradisaea</i></b>	Moderate	Low	No – although species recorded in moderate numbers, their vulnerability to displacement is low (Bradbury <i>et al.</i> , 2014; Wade <i>et al.</i> , 2016).
<b>Common tern <i>Sterna hirundo</i></b>	Low	Low	No – species recorded in low abundance.
<b>Guillemot</b>	High	Moderate	Yes – species recorded in high abundance and moderate vulnerability to displacement.
<b>Razorbill</b>	High	Moderate	Yes – species recorded in high abundance and moderate vulnerability to displacement.
<b>Puffin</b>	High	Low	Yes – species recorded in high abundance and, although their vulnerability to displacement is low, Wade <i>et al.</i> (2016) assessed vulnerability to displacement by structures to be moderate.
<b>Snipe <i>Gallinago gallinago</i></b>	Low	High	No – species recorded in low abundance.

<sup>1</sup> Bradbury et al. (2014).

## 2.3 Seasonality

2.3.1 The displacement bio-seasons were established based on the breeding and non-breeding seasons outlined in the NatureScot (2020) guidance, as shown in Table 2.2. In instances where the breeding and non-breeding seasons overlap within a month according to the NatureScot (2020) guidance, surveys have been assigned to a season based on the date the flight was flown (see Table 3.6 of Volume 3, Technical Appendix 11.1: Offshore Ornithology Baseline Characterisation Report).

**Table 2.2: Seasonal Definitions as the Basis for Assessment taken from NatureScot (2020)**

Species	Breeding Season	Non-breeding season
Kittiwake	Mid-April to August	September to mid-April
Guillemot	April to mid-August	mid-August to March
Razorbill	April to mid-August	mid-August to March
Puffin	April to mid-August	mid-August to March
Fulmar	April to mid-September	Mid-September to March
Gannet	Mid-March to September	October to mid-March

## 2.4 Population Estimates

2.4.1 For the VORs identified for displacement analysis (kittiwake, guillemot, razorbill, puffin, gannet, and fulmar; see Table 2.1), a 2 km buffer surrounding the Array Area was deemed suitable for assessing displacement in accordance with NatureScot (2023a).

2.4.2 Model-based estimates were generated using the MRSea package to estimate the number of birds across the Array Area, along with 95% confidence intervals derived from 1,000 bootstraps of the complete DAS dataset, providing a range of uncertainty predicted by the model.

2.4.3 The MRSea model can only be applied to species with at least ten data points and with a non-uniform distribution across the survey area (NatureScot, 2023b). Consequently, design-based estimates for bird numbers and densities were also produced for months where low raw abundances precluded the use of the MRSea model. Additional details on the calculation of these estimates can be found in Section 3.3 of Volume 3, Technical Appendix 11.1: Offshore Ornithology Baseline Characterisation Report.

2.4.4 In cases where birds could not be identified to the species level from DAS images, the next highest taxonomic classification was assigned. There were 21 'unidentified' birds and these were allocated to known species based on the abundance ratios of relevant species within the assigned higher taxonomic group (see Section 3.3 of Volume 3, Technical Appendix 11.1: Offshore Ornithology Baseline Characterisation Report).

2.4.5 To account for birds that were not detected by DAS due to being underwater, such as auks during foraging dives, a correction factor was applied to the number of observed sitting birds based on the known duration each species

spends underwater. The following correction factors, derived from the JNCC (2013) assumptions regarding the proportion of time spent underwater, were applied to each species (in parentheses):

- 1.311 for guillemot (23.75%);
- 1.211 for razorbill (17.4%); and
- 1.165 for puffin (14.2%).

2.4.6 A summary of the monthly abundance estimates for each species present in the Array Area, along with a 2 km buffer over the survey period, is provided in Section 3, with the complete data presented in Volume 3, Technical Appendix 11.1: Offshore Ornithology Baseline Characterisation Report.

2.4.7 The assessment of displacement effects is primarily based on seasonal mean peak population estimates, which include seabirds both on the water and in flight. Mean seasonal peak estimates were calculated using the seasonal definitions from NatureScot (2020) by summing and averaging the abundance estimates across months within defined seasons over the years of DAS. For species where March is part of the non-breeding season, the DAS surveys did not fully cover their non-breeding season in the second year of surveys (the 2023/2024 surveys did not cover March 2024). In those instances, the March 2022 survey was assigned to the final year and included in calculating the mean peak abundance if relevant.

2.4.8 Seasonal mean peak population estimates for each species were calculated using the defined seasons identified in Table 2.2, averaging the peak counts from both years per season to determine the number of seabirds at risk of displacement impacts.

## 2.5 Displacement and Mortality Rates

2.5.1 Species-specific displacement rates during the O&M phase, as outlined in the NatureScot (2023a) guidance, are presented in Table 2.3 and are utilised in this assessment. The recommended displacement rates are applied uniformly across the displacement study area, in accordance with the guidance from the SNCBs (SNCB, 2022a; SNCB, 2022b) and NatureScot (2023a).

2.5.2 The risk of mortality resulting from displacement at an OWF could be influenced by several factors, including the size of the OWF, which determines the extent of habitat loss, the distance birds deviate during flight, the availability of suitable replacement habitats, and potentially the level of increased competition. Mortality rates are also likely to vary by season and species, depending on factors such as morphology, foraging range, foraging rates, and seasonal energy requirements, particularly during chick provisioning (Masden *et al.*, 2010). It is also important to note that mortality rates may be indirectly affected by changes to environmental conditions driven by climate change, such as disruption to food chains from changing sea temperatures. These changes are expected to influence body condition and therefore susceptibility to displacement. A more detailed discussion of the impacts of climate change on seabirds is presented in Section 3.1 of Volume 3, Technical Appendix 11.1: Offshore Ornithology Baseline Characterisation Report.

2.5.3 Recommended mortality rates for the breeding and non-breeding seasons during the construction and decommissioning phases are provided in Table 2.4 (NatureScot, 2023a). NatureScot does not specify a mortality or displacement rate for fulmar due to lack of clear evidence on the species' likely response. However, a mortality and displacement rate for fulmar was established in consultation with NatureScot during a written correspondence on 24 February 2025.

**Table 2.3: Species Displacement and Mortality Rates During the O&M Phase**

Species	Displacement rate	Breeding Season Mortality Rate	Non-Breeding Season Mortality Rate
Kittiwake	30%	1% and 3%	1% and 3%
Guillemot	60%	3% and 5%	1% and 3%
Razorbill	60%	3% and 5%	1% and 3%
Puffin	60%	3% and 5%	1% and 3%
Fulmar	20%	1% and 3%	1% and 3%
Gannet	70%	1% and 3%	1% and 3%

2.5.4 Disturbance and subsequent displacement of seabirds during the construction phase may also result from vessel traffic, construction and piling activities occurring within the Proposed Development. These activities can displace individuals that would typically inhabit the areas within and surrounding the Array Area.

2.5.5 As actual displacement rates during the construction phase are challenging to ascertain, the following methodology is proposed. Given that construction is both spatially and temporally limited, and that any potential displacement effects are unlikely to reach the same magnitude as those during the O&M phase, the displacement level to be applied will be half that of the assessments conducted for the O&M phase. Table 2.4 presents the displacement and mortality rates used in the construction phase assessment.

2.5.6 The decommissioning activities within the Array Area are expected to be equal to or less than those conducted during the construction phase. Therefore, for the purposes of this assessment, it is assumed that the impacts will be similar.

**Table 2.4: Species Displacement and Mortality Rates During the Construction and Decommissioning Phases**

Species	Displacement Rate	Breeding Season Mortality Rate	Non-Breeding Season Mortality Rate
Kittiwake	15%	1% and 3%	1% and 3%
Guillemot	30%	3% and 5%	1% and 3%
Razorbill	30%	3% and 5%	1% and 3%
Puffin	30%	3% and 5%	1% and 3%
Fulmar	10%	1% and 3%	1% and 3%
Gannet	35%	1% and 3%	1% and 3%

### 3 Results

#### 3.1 Kittiwake

3.1.1 Seasonal mean peak estimates of abundance of kittiwake were calculated for the displacement analysis (Table 3.1).

**Table 3.1: Seasonal Mean Peak Estimates of Abundance (Number of Birds) of Kittiwake in the Array Area +2 km Buffer**

Area	Season	Peak year 1	Peak year 2	Mean peak estimate
Array Area +2 km buffer	Breeding	1,721	1,776	1,749
Array Area +2 km buffer	Non-breeding	603	217	410

#### Construction and Decommissioning

3.1.2 MRSea-based mortality estimates for construction and decommissioning phases for kittiwake were calculated for the breeding season (Table 3.2) and non-breeding season (Table 3.3).

**Table 3.2: MRSea Predicted Mortality of Kittiwake During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	2	3	5	9	17	35	52	70	87	105	122	140	157	175
	15%	3	5	8	13	26	52	79	105	131	157	184	210	236	262
	20%	3	7	10	17	35	70	105	140	175	210	245	280	315	350
	25%	4	9	13	22	44	87	131	175	219	262	306	350	394	437
	30%	5	10	16	26	52	105	157	210	262	315	367	420	472	525
	35%	6	12	18	31	61	122	184	245	306	367	429	490	551	612
	40%	7	14	21	35	70	140	210	280	350	420	490	560	630	700
	60%	10	21	31	52	105	210	315	420	525	630	735	840	944	1,049

Mortality level (% of displaced birds at risk of mortality)															
	<b>80%</b>	14	28	42	70	140	280	420	560	700	840	979	1,119	1,259	1,399
	<b>100%</b>	17	35	52	87	175	350	525	700	875	1,049	1,224	1,399	1,574	1,749

**Table 3.3: MRSea Predicted Mortality of Kittiwake During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
<b>Displacement level (% at risk of displacement)</b>		<b>1%</b>	<b>2%</b>	<b>3%</b>	<b>5%</b>	<b>10%</b>	<b>20%</b>	<b>30%</b>	<b>40%</b>	<b>50%</b>	<b>60%</b>	<b>70%</b>	<b>80%</b>	<b>90%</b>	<b>100%</b>
	<b>10%</b>	0	1	1	2	4	8	12	16	21	25	29	33	37	41
	<b>15%</b>	1	1	2	3	6	12	18	25	31	37	43	49	55	62
	<b>20%</b>	1	2	2	4	8	16	25	33	41	49	57	66	74	82
	<b>25%</b>	1	2	3	5	10	21	31	41	51	62	72	82	92	103
	<b>30%</b>	1	2	4	6	12	25	37	49	62	74	86	98	111	123
	<b>35%</b>	1	3	4	7	14	29	43	57	72	86	100	115	129	144
	<b>40%</b>	2	3	5	8	16	33	49	66	82	98	115	131	148	164
	<b>60%</b>	2	5	7	12	25	49	74	98	123	148	172	197	221	246
	<b>80%</b>	3	7	10	16	33	66	98	131	164	197	230	262	295	328
	<b>100%</b>	4	8	12	21	41	82	123	164	205	246	287	328	369	410

**O&M**

3.1.3 MRSea-based mortality estimates for the O&M phase for kittiwake were calculated for the breeding season (Table 3.4) and non-breeding season (Table 3.5).

**Table 3.4: MRSea Predicted Mortality of Kittiwake During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	2	3	5	9	17	35	52	70	87	105	122	140	157	175
	20%	3	7	10	17	35	70	105	140	175	210	245	280	315	350
	30%	5	10	16	26	52	105	157	210	262	315	367	420	472	525
	40%	7	14	21	35	70	140	210	280	350	420	490	560	630	700
	50%	9	17	26	44	87	175	262	350	437	525	612	700	787	875
	60%	10	21	31	52	105	210	315	420	525	630	735	840	944	1,049
	70%	12	24	37	61	122	245	367	490	612	735	857	979	1,102	1,224
	80%	14	28	42	70	140	280	420	560	700	840	979	1,119	1,259	1,399
	90%	16	31	47	79	157	315	472	630	787	944	1,102	1,259	1,417	1,574
	100%	17	35	52	87	175	350	525	700	875	1,049	1,224	1,399	1,574	1,749

**Table 3.5: MRSea Predicted Mortality of Kittiwake During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	0	1	1	2	4	8	12	16	21	25	29	33	37	41
	20%	1	2	2	4	8	16	25	33	41	49	57	66	74	82
	30%	1	2	4	6	12	25	37	49	62	74	86	98	111	123
	40%	2	3	5	8	16	33	49	66	82	98	115	131	148	164
	50%	2	4	6	10	21	41	62	82	103	123	144	164	185	205
	60%	2	5	7	12	25	49	74	98	123	148	172	197	221	246
	70%	3	6	9	14	29	57	86	115	144	172	201	230	258	287
	80%	3	7	10	16	33	66	98	131	164	197	230	262	295	328
	90%	4	7	11	18	37	74	111	148	185	221	258	295	332	369
	100%	4	8	12	21	41	82	123	164	205	246	287	328	369	410

### 3.2 Guillemot

3.2.1 Seasonal mean peak estimates of abundance of guillemot were calculated for the displacement analysis (Table 3.6).

**Table 3.6: Seasonal Peak Abundance Estimates of Common Guillemot in the Array Area +2 km Buffer**

Area	Season	Peak year 1	Peak year 2	Mean peak estimate
Array +2 km buffer	Breeding	19,932	11,987	15,960
Array +2 km buffer	Non-breeding	8,556	27,868	18,212

#### Construction and Decommissioning

3.2.2 MRSea-based mortality estimates for construction and decommissioning phases for guillemot were calculated for the breeding season (Table 3.7) and non-breeding season (Table 3.8).

**Table 3.7: MRSea Predicted Mortality of Guillemot During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	16	32	48	80	160	319	479	638	798	958	1,117	1,277	1,436	1,596
	20%	32	64	96	160	319	638	958	1,277	1,596	1,915	2,234	2,554	2,873	3,192
	30%	48	96	144	239	479	958	1,436	1,915	2,394	2,873	3,351	3,830	4,309	4,788
	40%	64	128	192	319	638	1,277	1,915	2,554	3,192	3,830	4,469	5,107	5,745	6,384
	50%	80	160	239	399	798	1,596	2,394	3,192	3,990	4,788	5,586	6,384	7,182	7,980
	60%	96	192	287	479	958	1,915	2,873	3,830	4,788	5,745	6,703	7,661	8,618	9,576
	70%	112	223	335	559	1,117	2,234	3,351	4,469	5,586	6,703	7,820	8,937	10,054	11,172
	80%	128	255	383	638	1,277	2,554	3,830	5,107	6,384	7,661	8,937	10,214	11,491	12,768
	90%	144	287	431	718	1,436	2,873	4,309	5,745	7,182	8,618	10,054	11,491	12,927	14,364
	100%	160	319	479	798	1,596	3,192	4,788	6,384	7,980	9,576	11,172	12,768	14,364	15,960

**Table 3.8: MRSea Predicted Mortality of Guillemot During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	18	36	55	91	182	364	546	728	911	1,093	1,275	1,457	1,639	1,821
	20%	36	73	109	182	364	728	1,093	1,457	1,821	2,185	2,550	2,914	3,278	3,642
	30%	55	109	164	273	546	1,093	1,639	2,185	2,732	3,278	3,825	4,371	4,917	5,464
	40%	73	146	219	364	728	1,457	2,185	2,914	3,642	4,371	5,099	5,828	6,556	7,285
	50%	91	182	273	455	911	1,821	2,732	3,642	4,553	5,464	6,374	7,285	8,195	9,106
	60%	109	219	328	546	1,093	2,185	3,278	4,371	5,464	6,556	7,649	8,742	9,834	10,927
	70%	127	255	382	637	1,275	2,550	3,825	5,099	6,374	7,649	8,924	10,199	11,474	12,748
	80%	146	291	437	728	1,457	2,914	4,371	5,828	7,285	8,742	10,199	11,656	13,113	14,570
	90%	164	328	492	820	1,639	3,278	4,917	6,556	8,195	9,834	11,474	13,113	14,752	16,391
	100%	182	364	546	911	1,821	3,642	5,464	7,285	9,106	10,927	12,748	14,570	16,391	18,212

**O&M**

3.2.3 MRSea-based mortality estimates for the O&M phase for guillemot were calculated for the breeding season (Table 3.9) and non-breeding season (Table 3.10).

**Table 3.9: MRSea Predicted Mortality of Guillemot During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	16	32	48	80	160	319	479	638	798	958	1,117	1,277	1,436	1,596
	20%	32	64	96	160	319	638	958	1,277	1,596	1,915	2,234	2,554	2,873	3,192
	30%	48	96	144	239	479	958	1,436	1,915	2,394	2,873	3,351	3,830	4,309	4,788
	40%	64	128	192	319	638	1,277	1,915	2,554	3,192	3,830	4,469	5,107	5,745	6,384
	50%	80	160	239	399	798	1,596	2,394	3,192	3,990	4,788	5,586	6,384	7,182	7,980
	60%	96	192	287	479	958	1,915	2,873	3,830	4,788	5,745	6,703	7,661	8,618	9,576
	70%	112	223	335	559	1,117	2,234	3,351	4,469	5,586	6,703	7,820	8,937	10,054	11,172
	80%	128	255	383	638	1,277	2,554	3,830	5,107	6,384	7,661	8,937	10,214	11,491	12,768
	90%	144	287	431	718	1,436	2,873	4,309	5,745	7,182	8,618	10,054	11,491	12,927	14,364
	100%	160	319	479	798	1,596	3,192	4,788	6,384	7,980	9,576	11,172	12,768	14,364	15,960

**Table 3.10: MRSea Predicted Mortality of Guillemot During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	18	36	55	91	182	364	546	728	911	1,093	1,275	1,457	1,639	1,821
	20%	36	73	109	182	364	728	1,093	1,457	1,821	2,185	2,550	2,914	3,278	3,642
	30%	55	109	164	273	546	1,093	1,639	2,185	2,732	3,278	3,825	4,371	4,917	5,464
	40%	73	146	219	364	728	1,457	2,185	2,914	3,642	4,371	5,099	5,828	6,556	7,285
	50%	91	182	273	455	911	1,821	2,732	3,642	4,553	5,464	6,374	7,285	8,195	9,106
	60%	109	219	328	546	1,093	2,185	3,278	4,371	5,464	6,556	7,649	8,742	9,834	10,927
	70%	127	255	382	637	1,275	2,550	3,825	5,099	6,374	7,649	8,924	10,199	11,474	12,748
	80%	146	291	437	728	1,457	2,914	4,371	5,828	7,285	8,742	10,199	11,656	13,113	14,570
	90%	164	328	492	820	1,639	3,278	4,917	6,556	8,195	9,834	11,474	13,113	14,752	16,391
	100%	182	364	546	911	1,821	3,642	5,464	7,285	9,106	10,927	12,748	14,570	16,391	18,212

### 3.3 Razorbill

3.3.1 Seasonal mean peak estimates of abundance of razorbill were calculated for the displacement analysis (Table 3.11).

**Table 3.11: Seasonal Peak Abundance Estimates of Razorbill in the Array Area +2 km Buffer**

Area	Season	Peak year 1	Peak year 2	Mean peak estimate
Array +2 km buffer	Breeding	4,445	904	2,675
Array +2 km buffer	Non-breeding	1,279	177	728

#### Construction and Decommissioning

3.3.2 MRSea-based mortality estimates for construction and decommissioning phases for razorbill were calculated for the breeding season (Table 3.12) and non-breeding season (Table 3.13).

**Table 3.12: MRSea Predicted Mortality of Razorbill During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	3	5	8	13	27	53	80	107	134	160	187	214	241	267
	20%	5	11	16	27	53	107	160	214	267	321	374	428	481	535
	30%	8	16	24	40	80	160	241	321	401	481	562	642	722	802
	40%	11	21	32	53	107	214	321	428	535	642	749	856	963	1,070
	50%	13	27	40	67	134	267	401	535	669	802	936	1,070	1,204	1,337
	60%	16	32	48	80	160	321	481	642	802	963	1,123	1,284	1,444	1,605
	70%	19	37	56	94	187	374	562	749	936	1,123	1,311	1,498	1,685	1,872
	80%	21	43	64	107	214	428	642	856	1,070	1,284	1,498	1,712	1,926	2,140
	90%	24	48	72	120	241	481	722	963	1,204	1,444	1,685	1,926	2,166	2,407
	100%	27	53	80	134	267	535	802	1,070	1,337	1,605	1,872	2,140	2,407	2,675

**Table 3.13: MRSea Predicted Mortality of Razorbill During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	1	1	2	4	7	15	22	29	36	44	51	58	66	73
	20%	1	3	4	7	15	29	44	58	73	87	102	116	131	146
	30%	2	4	7	11	22	44	66	87	109	131	153	175	197	218
	40%	3	6	9	15	29	58	87	116	146	175	204	233	262	291
	50%	4	7	11	18	36	73	109	146	182	218	255	291	328	364
	60%	4	9	13	22	44	87	131	175	218	262	306	349	393	437
	70%	5	10	15	25	51	102	153	204	255	306	357	408	459	510
	80%	6	12	17	29	58	116	175	233	291	349	408	466	524	582
	90%	7	13	20	33	66	131	197	262	328	393	459	524	590	655
	100%	7	15	22	36	73	146	218	291	364	437	510	582	655	728

**O&M**

3.3.3 MRSea-based mortality estimates for the O&M phase for razorbill were calculated for the breeding season (Table 3.14) and non-breeding season (Table 3.15).

**Table 3.14: MRSea Predicted Mortality of Razorbill During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	3	5	8	13	27	54	80	107	134	161	187	214	241	268
	20%	5	11	16	27	54	107	161	214	268	321	375	428	482	535
	30%	8	16	24	40	80	161	241	321	401	482	562	642	722	803
	40%	11	21	32	54	107	214	321	428	535	642	749	856	963	1,070
	50%	13	27	40	67	134	268	401	535	669	803	936	1,070	1,204	1,338
	60%	16	32	48	80	161	321	482	642	803	963	1,124	1,284	1,445	1,605
	70%	19	37	56	94	187	375	562	749	936	1,124	1,311	1,498	1,685	1,873
	80%	21	43	64	107	214	428	642	856	1,070	1,284	1,498	1,712	1,926	2,140
	90%	24	48	72	120	241	482	722	963	1,204	1,445	1,685	1,926	2,167	2,408
	100%	27	54	80	134	268	535	803	1,070	1,338	1,605	1,873	2,140	2,408	2,675

**Table 3.15: MRSea Predicted Mortality of Razorbill During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	1	1	2	4	7	15	22	29	36	44	51	58	66	73
	20%	1	3	4	7	15	29	44	58	73	87	102	116	131	146
	30%	2	4	7	11	22	44	66	87	109	131	153	175	197	218
	40%	3	6	9	15	29	58	87	116	146	175	204	233	262	291
	50%	4	7	11	18	36	73	109	146	182	218	255	291	328	364
	60%	4	9	13	22	44	87	131	175	218	262	306	349	393	437
	70%	5	10	15	25	51	102	153	204	255	306	357	408	459	510
	80%	6	12	17	29	58	116	175	233	291	349	408	466	524	582
	90%	7	13	20	33	66	131	197	262	328	393	459	524	590	655
	100%	7	15	22	36	73	146	218	291	364	437	510	582	655	728

### 3.4 Puffin

3.4.1 Seasonal mean peak estimates of abundance of puffin were calculated for the displacement analysis (Table 3.16).

**Table 3.16: Seasonal Peak Abundance Estimates of Puffin in the Array Area +2 km Buffer**

Area	Season	Peak year 1	Peak year 2	Mean peak estimate
Array +2 km buffer	Breeding	221	532	377
Array +2 km buffer	Non-breeding	862	547	705

#### Construction and Decommissioning

3.4.2 MRSea-based mortality estimates for construction and decommissioning phases for puffin were calculated for the breeding season (Table 3.17) and non-breeding season (Table 3.18).

**Table 3.17: MRSea Predicted Mortality of Puffin During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	0	1	1	2	4	8	11	15	19	23	26	30	34	38
	20%	1	2	2	4	8	15	23	30	38	45	53	60	68	75
	30%	1	2	3	6	11	23	34	45	57	68	79	90	102	113
	40%	2	3	5	8	15	30	45	60	75	90	106	121	136	151
	50%	2	4	6	9	19	38	57	75	94	113	132	151	170	189
	60%	2	5	7	11	23	45	68	90	113	136	158	181	204	226
	70%	3	5	8	13	26	53	79	106	132	158	185	211	238	264
	80%	3	6	9	15	30	60	90	121	151	181	211	241	271	302
	90%	3	7	10	17	34	68	102	136	170	204	238	271	305	339
	100%	4	8	11	19	38	75	113	151	189	226	264	302	339	377

**Table 3.18: MRSea Predicted Mortality of Puffin During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	1	1	2	4	7	14	21	28	35	42	49	56	63	70
	20%	1	3	4	7	14	28	42	56	70	85	99	113	127	141
	30%	2	4	6	11	21	42	63	85	106	127	148	169	190	211
	40%	3	6	8	14	28	56	85	113	141	169	197	225	254	282
	50%	4	7	11	18	35	70	106	141	176	211	247	282	317	352
	60%	4	8	13	21	42	85	127	169	211	254	296	338	380	423
	70%	5	10	15	25	49	99	148	197	247	296	345	395	444	493
	80%	6	11	17	28	56	113	169	225	282	338	395	451	507	564
	90%	6	13	19	32	63	127	190	254	317	380	444	507	571	634
	100%	7	14	21	35	70	141	211	282	352	423	493	564	634	705

**O&M**

3.4.3 MRSea-based mortality estimates for the O&M phase for puffin were calculated for the breeding season (Table 3.19) and non-breeding season (Table 3.20).

**Table 3.19: MRSea Predicted Mortality of Puffin During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	0	1	1	2	4	8	11	15	19	23	26	30	34	38
	20%	1	2	2	4	8	15	23	30	38	45	53	60	68	75
	30%	1	2	3	6	11	23	34	45	57	68	79	90	102	113
	40%	2	3	5	8	15	30	45	60	75	90	106	121	136	151
	50%	2	4	6	9	19	38	57	75	94	113	132	151	170	189
	60%	2	5	7	11	23	45	68	90	113	136	158	181	204	226
	70%	3	5	8	13	26	53	79	106	132	158	185	211	238	264
	80%	3	6	9	15	30	60	90	121	151	181	211	241	271	302
	90%	3	7	10	17	34	68	102	136	170	204	238	271	305	339
	100%	4	8	11	19	38	75	113	151	189	226	264	302	339	377

**Table 3.20: MRSea Predicted Mortality of Puffin During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	1	1	2	4	7	14	21	28	35	42	49	56	63	70
	20%	1	3	4	7	14	28	42	56	70	85	99	113	127	141
	30%	2	4	6	11	21	42	63	85	106	127	148	169	190	211
	40%	3	6	8	14	28	56	85	113	141	169	197	225	254	282
	50%	4	7	11	18	35	70	106	141	176	211	247	282	317	352
	60%	4	8	13	21	42	85	127	169	211	254	296	338	380	423
	70%	5	10	15	25	49	99	148	197	247	296	345	395	444	493
	80%	6	11	17	28	56	113	169	225	282	338	395	451	507	564
	90%	6	13	19	32	63	127	190	254	317	380	444	507	571	634
	100%	7	14	21	35	70	141	211	282	352	423	493	564	634	705

### 3.5 Fulmar

3.5.1 Seasonal mean peak estimates of abundance of fulmar were calculated for the displacement analysis (Table 3.21).

**Table 3.21: Seasonal Peak Abundance Estimates of Fulmar in the Array Area +2 km Buffer**

Area	Season	Peak year 1	Peak year 2	Mean peak estimate
Array +2 km buffer	Breeding	1,440	366	903
Array +2 km buffer	Non-breeding	390	150	270

#### Construction and Decommissioning

3.5.2 MRSea-based mortality estimates for construction and decommissioning phases for fulmar were calculated for the breeding season (Table 3.22) and non-breeding season (Table 3.23).

**Table 3.22: MRSea Predicted Mortality of Fulmar During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5%	0	1	1	2	5	9	14	18	23	27	32	36	41	45
	10%	1	2	3	5	9	18	27	36	45	54	63	72	81	90
	20%	2	4	5	9	18	36	54	72	90	108	126	144	163	181
	30%	3	5	8	14	27	54	81	108	135	163	190	217	244	271
	40%	4	7	11	18	36	72	108	144	181	217	253	289	325	361
	50%	5	9	14	23	45	90	135	181	226	271	316	361	406	452
	75%	7	14	20	34	68	135	203	271	339	406	474	542	610	677
	90%	8	16	24	41	81	163	244	325	406	488	569	650	731	813
	100%	9	18	27	45	90	181	271	361	452	542	632	722	813	903

**Table 3.23: MRSea Predicted Mortality of Fulmar During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5%	0	0	0	1	1	3	4	5	7	8	9	11	12	14
	10%	0	1	1	1	3	5	8	11	14	16	19	22	24	27
	20%	0	1	2	3	5	11	16	22	27	32	38	43	49	54
	30%	0	2	2	4	8	16	24	32	41	49	57	65	73	81
	40%	1	2	3	5	11	22	32	43	54	65	76	86	97	108
	50%	1	3	4	7	14	27	41	54	68	81	95	108	122	135
	75%	1	4	6	10	20	41	61	81	101	122	142	162	182	203
	90%	1	5	7	12	24	49	73	97	122	146	170	194	219	243
	100%	1	5	8	14	27	54	81	108	135	162	189	216	243	270

**O&M**

3.5.3 MRSea-based mortality estimates for the O&M phase for fulmar were calculated for the breeding season (Table 3.24) and non-breeding season (Table 3.25).

**Table 3.24: MRSea Predicted Mortality of Fulmar During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5%	0	1	1	2	5	9	14	18	23	27	32	36	41	45
	10%	1	2	3	5	9	18	27	36	45	54	63	72	81	90
	20%	2	4	5	9	18	36	54	72	90	108	126	144	163	181
	30%	3	5	8	14	27	54	81	108	135	163	190	217	244	271
	40%	4	7	11	18	36	72	108	144	181	217	253	289	325	361
	50%	5	9	14	23	45	90	135	181	226	271	316	361	406	452
	75%	7	14	20	34	68	135	203	271	339	406	474	542	610	677
	90%	8	16	24	41	81	163	244	325	406	488	569	650	731	813
	100%	9	18	27	45	90	181	271	361	452	542	632	722	813	903

**Table 3.25: MRSea Predicted Mortality of Fulmar During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5%	0	0	0	1	1	3	4	5	7	8	9	11	12	14
	10%	0	1	1	1	3	5	8	11	14	16	19	22	24	27
	20%	1	1	2	3	5	11	16	22	27	32	38	43	49	54
	30%	1	2	2	4	8	16	24	32	41	49	57	65	73	81
	40%	1	2	3	5	11	22	32	43	54	65	76	86	97	108
	50%	1	3	4	7	14	27	41	54	68	81	95	108	122	135
	75%	2	4	6	10	20	41	61	81	101	122	142	162	182	203
	90%	2	5	7	12	24	49	73	97	122	146	170	194	219	243
	100%	3	5	8	14	27	54	81	108	135	162	189	216	243	270

### 3.6 Gannet

3.6.1 Seasonal mean peak estimates of abundance of gannet were calculated for the displacement analysis (Table 3.26).

**Table 3.26: Seasonal Peak Abundance Estimates of Gannet in the Array Area +2 km Buffer**

Area	Season	Peak year 1	Peak year 2	Mean peak estimate
Array +2 km buffer	Breeding	767	458	613
Array +2 km buffer	Non-breeding	54	153	104

#### Construction and Decommissioning

3.6.2 MRSea-based mortality estimates for construction and decommissioning phases for gannet were calculated for the breeding season (Table 3.27) and non-breeding season (Table 3.28).

**Table 3.27: MRSea Predicted Mortality of Gannet During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	1	1	2	3	6	12	18	25	31	37	43	49	55	61
	15%	1	2	3	5	9	18	28	37	46	55	64	74	83	92
	20%	1	2	4	6	12	25	37	49	61	74	86	98	110	123
	25%	2	3	5	8	15	31	46	61	77	92	107	123	138	153
	30%	2	4	6	9	18	37	55	74	92	110	129	147	166	184
	35%	2	4	6	11	21	43	64	86	107	129	150	172	193	215
	40%	2	5	7	12	25	49	74	98	123	147	172	196	221	245
	60%	4	7	11	18	37	74	110	147	184	221	257	294	331	368
	80%	5	10	15	25	49	98	147	196	245	294	343	392	441	490
	100%	6	12	18	31	61	123	184	245	307	368	429	490	552	613

**Table 3.28: MRSea Predicted Mortality of Gannet During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the Construction and Decommissioning Phases. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.4 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	0	0	0	1	1	2	3	4	5	6	7	8	9	10
	15%	0	0	0	1	2	3	5	6	8	9	11	12	14	16
	20%	0	0	1	1	2	4	6	8	10	12	14	17	19	21
	25%	0	1	1	1	3	5	8	10	13	16	18	21	23	26
	30%	0	1	1	2	3	6	9	12	16	19	22	25	28	31
	35%	0	1	1	2	4	7	11	14	18	22	25	29	33	36
	40%	0	1	1	2	4	8	12	17	21	25	29	33	37	41
	60%	1	1	2	3	6	12	19	25	31	37	43	50	56	62
	80%	1	2	2	4	8	17	25	33	41	50	58	66	75	83
	100%	1	2	3	5	10	21	31	41	52	62	72	83	93	104

**O&M**

3.6.3 MRSea-based mortality estimates for the O&M phase for gannet were calculated for the breeding season (Table 3.29) and non-breeding season (Table 3.30).

**Table 3.29: MRSea Predicted Mortality of Gannet During the Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	1	1	2	3	6	12	18	25	31	37	43	49	55	61
	20%	1	2	4	6	12	25	37	49	61	74	86	98	110	123
	30%	2	4	6	9	18	37	55	74	92	110	129	147	166	184
	40%	2	5	7	12	25	49	74	98	123	147	172	196	221	245
	50%	3	6	9	15	31	61	92	123	153	184	215	245	276	307
	60%	4	7	11	18	37	74	110	147	184	221	257	294	331	368
	70%	4	9	13	21	43	86	129	172	215	257	300	343	386	429
	80%	5	10	15	25	49	98	147	196	245	294	343	392	441	490
	90%	6	11	17	28	55	110	166	221	276	331	386	441	497	552
	100%	6	12	18	31	61	123	184	245	307	368	429	490	552	613

**Table 3.30: MRSea Predicted Mortality of Gannet During the Non-Breeding Season as a Result of Displacement from the Array Area +2 km Buffer During the O&M Phase. The mortality estimates calculated using the mortality and displacement rates outlined in Table 2.3 are highlighted in orange**

Mortality level (% of displaced birds at risk of mortality)															
		1%	2%	3%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Displacement level (% at risk of displacement)	10%	0	0	0	1	1	2	3	4	5	6	7	8	9	10
	20%	0	0	1	1	2	4	6	8	10	12	14	17	19	21
	30%	0	1	1	2	3	6	9	12	16	19	22	25	28	31
	40%	0	1	1	2	4	8	12	17	21	25	29	33	37	41
	50%	1	1	2	3	5	10	16	21	26	31	36	41	47	52
	60%	1	1	2	3	6	12	19	25	31	37	43	50	56	62
	70%	1	1	2	4	7	14	22	29	36	43	51	58	65	72
	80%	1	2	2	4	8	17	25	33	41	50	58	66	75	83
	90%	1	2	3	5	9	19	28	37	47	56	65	75	84	93
	100%	1	2	3	5	10	21	31	41	52	62	72	83	93	104

## 4 Discussion

- 4.1.1 Displacement rates can be empirically inferred by observing changes in density before and after the construction of an OWF. However, there are numerous confounding factors and inherent uncertainty that make this problematic; individual assessments typically find it challenging to establish a direct causal relationship with the construction of an OWF, given that seabird abundance distribution shows significant spatial and temporal variation due to various biotic and abiotic factors (Pérez-Lapena *et al.*, 2010). Evidence also suggests displacement rates can vary regionally; for instance, it has been observed that guillemots in the south-western part of the German North Sea showed less avoidance of certain OWF areas compared to areas to the north and east (Peschko *et al.*, 2024). This variation may be attributed to ecological conditions, such as bird density and habitat distribution, or it may reflect behavioural responses influenced by visual surroundings and the level of background vessel traffic in the area.
- 4.1.2 Given the potential for regional differences in displacement rates, it is noteworthy that a recent study at the Beatrice OWF, located in the Moray Firth (approximately 150 km north-west of the Array Area), found variable evidence of displacement within and around the wind farm array (MacArthur Green, 2023), although analysis was limited being based on only one year pre- and two years' post-construction data. A review of auk displacement data from 21 different OWFs in the North Sea and Western Waters reported changes in auk abundances ranging from +112% (indicating attraction) to -75% (APEM, 2022a). For gannets, a review indicated displacement rates varying from no significant effect to as high as 98% displacement within an OWF (APEM, 2022b).
- 4.1.3 A recent meta-analysis demonstrated that the large variation in species-specific displacement effects could be partially explained by site-level characteristics such as distance from shore, and study design methodologies including study area footprint (Lamb *et al.*, 2024). Interestingly, Lamb *et al.* (2024) demonstrated that the probability of observing a significant change in species distribution increased with study area footprint, further demonstrating that survey design is important in identifying displacement effects. Caution must therefore be taken in drawing conclusions from individual studies, and consideration given to the robustness of survey and analytical designs. It also highlights the need for collaboration to facilitate meta-analyses to maximise the likelihood of determining species-specific displacement effects.
- 4.1.4 Quantifying mortality rates from displacement effects is even more challenging. It is recognised that estimating the impact of displacement by applying a mortality rate to displaced birds is a flawed approach (SNCB, 2022a; Searle *et al.*, 2018). Impacts do not solely arise from the mortality of displaced individuals; displacement can also lead to the mortality of non-displaced individuals due to increased competition. During the breeding season, displacement may adversely affect juvenile survival if parents experience reduced foraging success or if nests are left unattended for extended periods. Additionally, displacement may have sub-lethal effects that could lead to

population-level impacts, such as decreased productivity due to missed breeding attempts or reduced clutch sizes. These complexities render the estimation of a displacement mortality rate from empirical observations a challenging issue. However, studies that have examined mortality rates (reviewed in APEM, 2022a; 2022b) found that the evidence does not support a 10% mortality rate for either auks or gannets, with the most credible conclusion being that the impact on mortality rates is negligible.

4.1.5 Consequently, while this technical report presents a range of displacement rates (10% to 100%) and mortality rates (1% to 100%), it should be acknowledged that the upper end of the mortality rate range (i.e. above 10% mortality rate) is considered overly precautionary and not substantiated by the available evidence (APEM, 2022a; 2022b). The lower end of the provided range (e.g. below a 10% mortality rate) is deemed more plausible, although even this lower end is considered to incorporate a degree of precaution, given the variability of results found in the literature, at different scales and including studies conducted in Scottish waters that report lower or negligible displacement for some species (albeit with a degree of uncertainty, and based on limited duration of data).

4.1.6 It is acknowledged however, that any OWF effects do not occur in ecological isolation, and that environmental pressures, particularly from climate change, will make seabirds increasingly susceptible to mortality from displacement effects. It is therefore sensible to consider both precautionary and more likely scenarios for displacement mortality estimates.

## 5 Summary

- 5.1.1 Table 5.1 summarises the displacement matrices with the most likely displacement mortality for each VOR, which were estimated after applying the proposed displacement and mortality rates (from Table 2.3 and Table 2.4) and includes the species-specific bio-seasons (from Table 2.2), Array Area + 2 km abundance estimates and the results from Section 3.

**Table 5.1: Summary of Displacement Analyses Undertaken for the Array Area +2 km**

Species	Phase	Season	Seasonal mean peak population (Array Area +2 km buffer)	Displacement rates (%)	Mortality Rates (%)	Displacement Mortality (Range) (MRSea)
<b>Kittiwake</b>	Construction and Decommissioning	Breeding	1,749	15%	1% to 3%	3 to 8
		Non-breeding	410		1% to 3%	1 to 2
	O&M	Breeding	1,749	30%	1% to 3%	5 to 16
		Non-breeding	410		1% to 3%	1 to 4
<b>Guillemot</b>	Construction and Decommissioning	Breeding	15,960	30%	3% to 5%	144 to 239
		Non-breeding	18,212		1% to 3%	55 to 164
	O&M	Breeding	15,960	60%	3% to 5%	287 to 479
		Non-breeding	18,212		1% to 3%	109 to 328
<b>Razorbill</b>	Construction and Decommissioning	Breeding	2,675	30%	3% to 5%	24 to 40
		Non-breeding	728		1% to 3%	2 to 7
	O&M	Breeding	2,675	60%	3% to 5%	48 to 80
		Non-breeding	728		1% to 3%	4 to 13
<b>Puffin</b>	Construction and Decommissioning	Breeding	377	30%	3% to 5%	3 to 6
		Non-breeding	705		1% to 3%	2 to 6
	O&M	Breeding	377	60%	3% to 5%	7 to 11
		Non-breeding	705		1% to 3%	4 to 13
<b>Fulmar</b>	Construction and Decommissioning	Breeding	903	10%	1% to 3%	1 to 3
		Non-breeding	270		1% to 3%	0 to 1
	O&M	Breeding	903	20%	1% to 3%	2 to 5
		Non-breeding	270		1% to 3%	1 to 2
<b>Gannet</b>	Construction and Decommissioning	Breeding	613	35%	1% to 3%	2 to 6
		Non-breeding	104		1% to 3%	0 to 1

Species	Phase	Season	Seasonal mean peak population (Array Area +2 km buffer)	Displacement rates (%)	Mortality Rates (%)	Displacement Mortality (Range) (MRSea)
	O&M	Breeding	613	70%	1% to 3%	4 to 13
		Non-breeding	104		1% to 3%	1 to 2

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