Outer Dowsing Offshore Wind

Preliminary Environmental Information Report

Volume 2, Appendix 12.3: Offshore Ornithology Displacement Assessment

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Abbreviations

Acronym	Expanded name
DAS	Digital Aerial Surveys
DCO	Development Consent Order
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
EPP	Evidence Plan Process
ES	Environmental Statement
ETG	Expert Topic Group
GIG	Green Investment Group
GTR4	The Applicant. The special project vehicle created in partnership between Corio Generation (a wholly owned Green Investment Group portfolio company), Gulf Energy Development and TotalEnergies.
MDS	Maximum Design Scenario
OWF	Offshore wind farm
PEIR	Preliminary Environmental Information Report
RSPB	Royal Society for the Protection of Birds
SNCBs	Statutory Nature Conservation Bodies
SPA	Special Protected Area
TE	TotalEnergies
WTGs	Wind turbine generators

Terminology

Term	Definition
Array area	The area offshore within the PEIR Boundary within which the generating stations (including wind turbine generators (WTG) and inter array cables), offshore accommodation platforms, offshore transformer substations and associated cabling are positioned.
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of an impact with the sensitivity of a receptor, in accordance with defined significance criteria.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the Environmental Impact Assessment (EIA) Regulations, including the publication of an Environmental Statement (ES).
EIA Directive	European Union 2011/92/EU of 13 December 2011 (as amended in 2014 by Directive 2014/52/EU).
EIA Regulations	Infrastructure Planning (Environmental Impact Assessment) Regulations 2017.

Term	Definition
Environmental Statement (ES)	The suite of documents that detail the processes and results of the Environmental Impact Assessment.
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial.
Landfall	The location at the land-sea interface where the offshore export cable will come ashore.
Maximum Design Scenario	The maximum design parameters of the combined project assets that result in the greatest potential for change in relation to each impact assessed
Outer Dowsing Offshore Wind	The Project.
Offshore Export Cable Corridor (ECC)	The Offshore Export Cable Corridor (Offshore ECC) is the area within the Preliminary Environmental Information Report (PEIR) Boundary within which the export cable running from the array to landfall will be situated.
Preliminary Environmental Information Report (PEIR)	The PEIR is written in the style of a draft Environmental Statement (ES) and provides information to support and inform the statutory consultation process in the pre-application phase. Following that consultation, the PEIR documentation will be updated to produce the Project's ES that will accompany the application for the Development Consent Order (DCO).
Receptor	A distinct part of the environment on which effects could occur and can be the subject of specific assessments. Examples of receptors include species (or groups) of animals or plants, people (often categorised further such as 'residential' or those using areas for amenity or recreation), watercourses etc.
The Project	Outer Dowsing Offshore Wind including proposed onshore and offshore infrastructure.
Wind turbine generator (WTG)	All the components of a wind turbine, including the tower, nacelle, and rotor.

12 Introduction

12.1 Overview

Project Background

12.1.1 GTR4 Limited (trading as Outer Dowsing Offshore Wind) hereafter referred to as the 'Applicant', is proposing to develop Outer Dowsing Offshore Wind (hereafter "the Project"). The Project will be located approximately 54km from the Lincolnshire coastline in the southern North Sea. The Project will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network (see Volume 1, Chapter 3: Project Description for full details).

12.1.2 This technical annex has been produced to support the assessment of displacement effects on species that are considered sensitive to disturbance and/or displacement from activities associated with and/or the presence of offshore wind farms (OWFs) to support Volume 2, Chapter 12: Offshore and Intertidal Ornithology of the Preliminary Environmental Information Report (PEIR). A separate report (Volume 2, Appendix 12.1: Ornithology Technical Baseline) provides the findings from offshore and intertidal ornithology surveys to determine the receptors that characterise the baseline and are of relevance to the assessment of potential impacts from the Project.

12.1.3 The consideration of offshore and intertidal ornithology for the Project has been discussed with consultees (Natural England and the Royal Society for the Protection of Birds [RSPB]) through the Project Evidence Plan Process (EPP). The latest Natural England and Statutory Nature Conservation Bodies (SNCB) advice has been followed (Parker *et al.*, 2022; MIG-Birds, 2022). Where there is deviation from this guidance, any agreements made with consultees during the EPP regarding the CRM methodology can be found within Volume 2, Chapter 12: Offshore and Intertidal Ornithology, Section 12.3.

Displacement Assessment

12.1.4 Wind turbine generators (WTGs) may directly disturb and displace vulnerable seabirds that would normally reside within and around the Project array area. This potential indirect habitat loss may reduce the area available for those seabirds sensitive to disturbance to forage, loaf and/or moult, particularly during the operational phase. There is also the potential for the construction and decommissioning of WTGs, substations, and cable laying, to directly disturb and displace seabirds within the array area and along the offshore export cable corridor (Offshore ECC). However, these potential impacts are more restricted spatially and temporally by virtue of the nature of those phases of the development.

12.1.5 Six key seabird species, agreed through the EPP (Volume 2, Chapter 12: Offshore and Intertidal Ornithology, Section 12.3), have been identified as requiring a displacement assessment in relation to the Project. These include:

- Common scoter (*Melanitta nigra*);
- Guillemot (*Uria aalge*);
- Razorbill (*Alca torda*); and

- Puffin (*Fratacula arctica*).
- Red-throated diver (*Gavia stellata*);
- Gannet (*Morus bassanus*);

12.1.6 The data contributing to this annex are from the first 18 months of site-specific digital aerial surveys (DAS) (March 2021 to August 2022) of the Project array area plus a 4 km buffer. Abundance data from these surveys are used for the assessment of potential displacement impacts from the array area and appropriate buffers for the five species of interest. In addition, using the data from Lawson *et al.* (2015), red-throated diver and common scoter have been assessed for potential displacement resulting from the offshore export cable laying activities within the Offshore ECC, as is outlined in Section 12.2.9.

12.2 Methodology

Guidance

12.2.1 The methodology for assessing displacement and barrier effects are based on UK joint SNCBs guidance on displacement (MIG-Birds, 2022) and the latest guidance for offshore wind marine environmental assessments published by Natural England (Parker *et al.*, 2022). These guidance documents outline how to present assessment information on the extent and potential consequences of seabird displacement from OWF developments. This approach has been the agreed consultation with EPP and relevant ETGs and also through the Scoping Opinion as the most appropriate method to assess displacement and barrier effects on seabirds. The guidance states that the following inputs are required for the displacement assessments (MIG-Birds, 2022):

- Monthly population estimates presented for a minimum two years pre-consent monitoring or another agreed period of time (currently 18-months of data have been used to inform PEIR);
- Site-based abundance estimates to include birds on water and in flight;
- Counts to be assessed as mean seasonal peaks; and
- Full details of the worst case and typical scenarios for the development footprint and development footprint plus relevant buffer.

12.2.2 In addition, the following inputs can be found within the Volume 2, Appendix 12.1: Ornithology Technical Baseline:

- Full details of the survey techniques;
- Proportions of different age classes of birds;
- Raw count data; and
- Population estimates for development footprint and development footprint plus relevant buffer.

12.2.3 The results presented in this Appendix represent the Maximum Design Scenario (MDS) (i.e. the project design scenario giving rise to the greatest level of estimated displacement impact) and are used to subsequently inform the worst case assessment within Volume 2, Chapter 12: Offshore and Intertidal Ornithology. For displacement impacts the MDS considers that infrastructure would be laid out within the full PEIR Boundary.

12.2.4 Displacement has been defined as *"a reduced number of birds occurring within or immediately adjacent to an OWF"* (Furness *et al.*, 2013). Both flying birds and birds on the water are considered in this displacement assessment as recommended by the SNCBs in their latest guidance (MIG-Birds, 2022). The inclusion of sitting birds within the analysis provides for an assessment of those individuals potentially displaced from an area of sea in which they reside, whilst the inclusion of flying birds provides an assessment of any potential barrier effects to birds moving through the area of interest.

Bio-Seasons

12.2.5 Bio-seasons have been defined from Furness (2015) for each species and are presented in Table 12.1. Depending on the season and species involved, a different number of bio-seasons have been applied during the assessment; these are outlined further below.

12.2.6 The guidance recommends assessing the impacts of displacement based on the overall mean seasonal peak numbers of birds (averaged over the years of survey) in the development footprint and appropriate buffer. For this assessment, DAS data were available for 18-months, including two surveys per month for the 2022 breeding season (March – August 2022). It was deemed that the most appropriate method to deal with the two monthly surveys was to calculate the monthly mean abundance of birds. The mean seasonal peak abundance was then calculated across the same bio-season between years.

Table 12.1: Bio-seasons used in the assessment for various seabird species (Furness, 2015).

Species	Migration-free breeding	Post-breeding migration	Return migration	Migration-free winter	Breeding	Non-breeding
Guillemot	-	-	-	-	Mar-Jul	Aug-Feb
Razorbill	Apr-Jul	Aug-Oct	Jan-Mar	Nov-Dec	-	-
Puffin	-	-	-	-	Apr-Jul	Aug-Mar
Red-throated diver	May-Aug	Sep-Nov	Feb-Apr	Dec-Jan	-	-
Gannet	Apr-Aug	Sep-Nov	Dec-Mar	-	-	-

The Matrix Approach

12.2.7 This report presents displacement matrices for the array area and appropriate buffers for five key species (gannet, puffin, guillemot, razorbill and red-throated diver), and for the Offshore ECC for two key species (red-throated diver and common scoter) that are considered sensitive to disturbance and displacement from the presence of OWFs and/or associated activity including vessel traffic. Following SNCB guidance (MIG-Birds, 2022), displacement matrices include birds within the array area and a 2km buffer for gannet, puffin, guillemot and razorbill, whilst they include birds within a 4km buffer (the maximum extent of the surveys) for red-throated diver. Matrices for the Offshore ECC considered both red-throated diver and common scoter, using bird density data for the Greater Wash SPA extracted from Lawson *et al*. (2016). Based on the evidence presented in Section 12.2.11, a displacement radius of 2km from cable laying vessels was assumed.

12.2.8 Displacement matrices are presented for a minimum of two seasons (breeding and non-breeding), as per SNCB guidance (MIG-Birds, 2022). Additional non-breeding bio-seasons are presented for some species (gannet, razorbill and red-throated diver) as determined by Furness (2015) and recommended for other OWF projects within the southern North Sea (Natural England, 2022) (Table 12.1).

Displacement of Red-Throated Diver and Common Scoter in the Offshore ECC

12.2.9 Seabird species may be at risk of disturbance and displacement effects as a result of construction activities associated with the offshore export cable installation within the offshore ECC, largely as a result of the activity of the cable laying vessel(s) present during the construction period.

12.2.10 The Greater Wash SPA, through which the inshore part of the Offshore ECC passes, is designated for two species which are considered sensitive to disturbance and displacement from vessel activity: red-throated diver and common scoter. Both of these species have been shown to be sensitive to vessels at a distance of up to 1km (Schwemmer *et al*., 2011; Bradbury *et al*., 2014).

12.2.11 Data (Lawson *et al*., 2016) used to assess the numbers and distributions of red-throated diver and common scoter in the Greater Wash SPA have been used to inform the assessment, providing the mean density of both species within the Offshore ECC corridor (as) agreed at the expert topic group (ETG) (Volume 2, Chapter 12, Section 12.3). The displacement of red-throated diver and common scoter was estimated within the Offshore ECC during the migration-free winter bio-season (January and February). Using the available evidence (Fliessbach *et al.,* 2019), and applying a precautionary approach, both species were assumed to be disturbed from an area of 2km surrounding a maximum of three cable laying vessels spread across the full width of the Offshore ECC that lies within the Greater Wash SPA. This is a precautionary approach considering that it is considered highly unlikely that three cable-laying vessels would be operational simultaneously for the installation of cables within the part of the offshore ECC overlapping with the Greater Wash SPA.

Data Limitations

12.2.12 The data within this report for guillemot, razorbill, puffin, red-throated diver and gannet are reliant upon site-specific DAS undertaken over an 18-month period within the Project array area plus a 4km buffer, collected between March 2021 to August 2022. Therefore, the peak monthly abundance estimates between September and February are based on a single DAS estimate at this stage.

12.2.13 The data presented in Lawson *et al.* (2016) for red-throated diver and common scoter densities within the Greater Wash SPA was collected between 2002 and 2008 and therefore may not be truly representative of the densities of these species within the Greater Wash SPA at the current time.

Mean and Peak Abundances

12.2.14 The mean peak abundances for each bio-season for the array area and array area plus an appropriate buffer are presented for each species in Table 12.2. See Volume 2, Appendix 12.1: Ornithology Technical Baseline for monthly abundances throughout the 18 months of DAS. For conciseness, matrices are only provided for the relevant buffer for each species within this report.

Table 12.2: Bio-season mean peak abundances of species in the array area only and the array area + 2km buffer assessed for disturbance and displacement. A maximum array area buffer of 4km was used for red-throated diver.

	Migration free breeding		Post-breeding migration		Return migration		Migration-free winter		Breeding		Non-breeding	
	Array area	Array + Buffer	Array area	Array + Buffer	Array area	Array + Buffer	Array area	Array + Buffer	Array area	Array + Buffer	Array area	Array + Buffer
Guillemot	-	-	-	-	-	-	-	-	15,978	23,173	14,349	22,248
Razorbill	3,688	5,163	1,402	2,339	3,858	5,229	1,795	2,570	-	-	-	-
Puffin	-	-	-	-	-	-	-	-	599	884	877	1,167
Red-throated diver	11	16	18	25	112	217	13	24	-	-	-	-
Gannet	620	847	107	169	128	172	-	-	-	-	-	-

12.3 Results

12.3.1 The following sections display the displacement matrices for the Offshore ECC and array area and relevant buffer zone for each species. The number highlighted in the bottom right of each matrix is the estimated mean peak abundance of individuals within the array area and appropriate buffer.

Displacement of Red-Throated Diver and Common Scoter in the Offshore ECC

12.3.2 The abundance of birds predicted to be prone to displacement within the Offshore ECC was calculated for both the mean and maximum density of red-throated diver and common scoter within the Offshore ECC that lies within the Greater Wash SPA, as calculated from Lawson *et al.* (2016).

12.3.3 The mean and maximum density of red-throated divers estimated to be within the Offshore ECC during the migration free winter bio-season was 0.232 birds km^{-2} and 0.692 birds km^{-2}, respectively. Similarly, the estimated mean and maximum density for common scoter within the ECC was 0.004 birds km^{-2} and 0.029 birds km^{-2}, respectively. Based on three cable laying vessels and a 2km disturbance radius, the total area of disturbance at any time was estimated at a maximum of 37.7km. This resulted in a mean (maximum) abundance of 8.75 (26.0) red-throated diver and 0.14 (1.1) common scoter at risk of displacement (Table 12.4 and Table 12.6).

Table 12.3: Displacement matrix presenting the maximum number of red-throated diver in the Offshore ECC within a 2km buffer surrounding the cable laying vessels only, during the migration-free winter bio-season.

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	1	1	1	1	2	2	2	2	3
20	0	0	0	1	1	2	2	3	3	4	4	5	5
30	0	0	0	1	2	2	3	4	5	5	6	7	8
40	0	0	1	1	2	3	4	5	6	7	8	9	10
50	0	0	1	1	3	4	5	7	8	9	10	12	13
60	0	0	1	2	3	5	6	8	9	11	13	14	16
70	0	0	1	2	4	5	7	9	11	13	15	16	18
80	0	0	1	2	4	6	8	10	13	15	17	19	21
90	0	0	1	2	5	7	9	12	14	16	19	21	23
100	0	1	1	3	5	8	10	13	16	18	21	23	26

Table 12.4: Displacement matrix presenting the mean number of red-throated diver in the Offshore ECC within a 2km buffer surrounding the cable laying vessels only, during the migration-free winter bio-season.

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

Table 12.5: Displacement matrix presenting the maximum number of common scoter in the Offshore ECC within a 2km buffer surrounding the cable laying vessels only, during the migration-free winter bio-season.

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	1
60	0	0	0	0	0	0	0	0	0	0	1	1	1
70	0	0	0	0	0	0	0	0	0	1	1	1	1
80	0	0	0	0	0	0	0	0	1	1	1	1	1
90	0	0	0	0	0	0	0	0	1	1	1	1	1
100	0	0	0	0	0	0	0	1	1	1	1	1	1

Table 12.6: Displacement matrix presenting the mean number of common scoter in the Offshore ECC within a 2km buffer surrounding the cable laying vessels only, during the migration-free winter bio-season.

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0

Gannet

Table 12.7: Gannet return migration displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	1	2	3	5	7	9	10	12	14	15	17
20	0	1	2	3	7	10	14	17	21	24	27	31	34
30	1	1	3	5	10	15	21	26	31	36	41	46	51
40	1	1	3	7	14	21	27	34	41	48	55	62	69
50	1	2	4	9	17	26	34	43	51	60	69	77	86
60	1	2	5	10	21	31	41	51	62	72	82	93	103
70	1	2	6	12	24	36	48	60	72	84	96	108	120
80	1	3	7	14	27	41	55	69	82	96	110	123	137
90	2	3	8	15	31	46	62	77	93	108	123	139	154
100	2	3	9	17	34	51	69	86	103	120	137	154	172

Table 12.8: Gannet breeding season displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	2	4	8	17	25	34	42	51	59	68	76	85
20	2	3	8	17	34	51	68	85	102	119	135	152	169
30	3	5	13	25	51	76	102	127	152	178	203	229	254
40	3	7	17	34	68	102	135	169	203	237	271	305	339
50	4	8	21	42	85	127	169	212	254	296	339	381	423
60	5	10	25	51	102	152	203	254	305	356	406	457	508
70	6	12	30	59	119	178	237	296	356	415	474	533	593
80	7	14	34	68	135	203	271	339	406	474	542	610	677
90	8	15	38	76	152	229	305	381	457	533	610	686	762
100	8	17	42	85	169	254	339	423	508	593	677	762	847

Table 12.9: Gannet post-breeding migration displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	1	2	3	5	7	8	10	12	14	15	17
20	0	1	2	3	7	10	14	17	20	24	27	30	34
30	1	1	3	5	10	15	20	25	30	35	41	46	51
40	1	1	3	7	14	20	27	34	41	47	54	61	68
50	1	2	4	8	17	25	34	42	51	59	68	76	85
60	1	2	5	10	20	30	41	51	61	71	81	91	101
70	1	2	6	12	24	35	47	59	71	83	95	106	118
80	1	3	7	14	27	41	54	68	81	95	108	122	135
90	2	3	8	15	30	46	61	76	91	106	122	137	152
100	2	3	8	17	34	51	68	85	101	118	135	152	169

Guillemot

Table 12.10: Guillemot breeding season displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	23	46	116	232	463	695	927	1,159	1,390	1,622	1,854	2,086	2,317
20	46	93	232	463	927	1,390	1,854	2,317	2,781	3,244	3,708	4,171	4,635
30	58	116	290	579	1,159	1,738	2,317	2,897	3,476	4,055	4,635	5,214	5,793
40	70	139	348	695	1,390	2,086	2,781	3,476	4,171	4,866	5,561	6,257	6,952
50	93	185	463	927	1,854	2,781	3,708	4,635	5,561	6,488	7,415	8,342	9,269
60	116	232	579	1,159	2,317	3,476	4,635	5,793	6,952	8,110	9,269	10,428	11,586
70	139	278	695	1,390	2,781	4,171	5,561	6,952	8,342	9,733	11,123	12,513	13,904
80	162	324	811	1,622	3,244	4,866	6,488	8,110	9,733	11,355	12,977	14,599	16,221
90	185	371	927	1,854	3,708	5,561	7,415	9,269	11,123	12,977	14,831	16,684	18,538
100	209	417	1,043	2,086	4,171	6,257	8,342	10,428	12,513	14,599	16,684	18,770	20,855

Table 12.11: Guillemot non-breeding season displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	22	44	111	222	445	667	890	1,112	1,335	1,557	1,780	2,002	2,225
20	44	89	222	445	890	1,335	1,780	2,225	2,670	3,115	3,560	4,005	4,450
30	56	111	278	556	1,112	1,669	2,225	2,781	3,337	3,893	4,450	5,006	5,562
40	67	133	334	667	1,335	2,002	2,670	3,337	4,005	4,672	5,340	6,007	6,674
50	89	178	445	890	1,780	2,670	3,560	4,450	5,340	6,229	7,119	8,009	8,899
60	111	222	556	1,112	2,225	3,337	4,450	5,562	6,674	7,787	8,899	10,012	11,124
70	133	267	667	1,335	2,670	4,005	5,340	6,674	8,009	9,344	10,679	12,014	13,349
80	156	311	779	1,557	3,115	4,672	6,229	7,787	9,344	10,902	12,459	14,016	15,574
90	178	356	890	1,780	3,560	5,340	7,119	8,899	10,679	12,459	14,239	16,019	17,798
100	200	400	1,001	2,002	4,005	6,007	8,009	10,012	12,014	14,016	16,019	18,021	20,023

Razorbill

Table 12.12: Razorbill return migration displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	5	10	26	52	105	157	209	261	314	366	418	471	523
20	10	21	52	105	209	314	418	523	627	732	837	941	1,046
30	16	31	78	157	314	471	627	784	941	1,098	1,255	1,412	1,569
40	21	42	105	209	418	627	837	1,046	1,255	1,464	1,673	1,882	2,092
50	26	52	131	261	523	784	1,046	1,307	1,569	1,830	2,092	2,353	2,615
60	31	63	157	314	627	941	1,255	1,569	1,882	2,196	2,510	2,824	3,137
70	37	73	183	366	732	1,098	1,464	1,830	2,196	2,562	2,928	3,294	3,660
80	42	84	209	418	837	1,255	1,673	2,092	2,510	2,928	3,347	3,765	4,183
90	47	94	235	471	941	1,412	1,882	2,353	2,824	3,294	3,765	4,235	4,706
100	52	105	261	523	1,046	1,569	2,092	2,615	3,137	3,660	4,183	4,706	5,229

Table 12.13: Razorbill breeding season displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	5	10	26	52	103	155	207	258	310	361	413	465	516
20	10	21	52	103	207	310	413	516	620	723	826	929	1,033
30	15	31	77	155	310	465	620	774	929	1,084	1,239	1,394	1,549
40	21	41	103	207	413	620	826	1,033	1,239	1,446	1,652	1,859	2,065
50	26	52	129	258	516	774	1,033	1,291	1,549	1,807	2,065	2,323	2,582
60	31	62	155	310	620	929	1,239	1,549	1,859	2,168	2,478	2,788	3,098
70	36	72	181	361	723	1,084	1,446	1,807	2,168	2,530	2,891	3,253	3,614
80	41	83	207	413	826	1,239	1,652	2,065	2,478	2,891	3,304	3,717	4,130
90	46	93	232	465	929	1,394	1,859	2,323	2,788	3,253	3,717	4,182	4,647
100	52	103	258	516	1,033	1,549	2,065	2,582	3,098	3,614	4,130	4,647	5,163

Table 12.14: Razorbill post-breeding season displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	2	5	12	23	47	70	94	117	140	164	187	211	234
20	5	9	23	47	94	140	187	234	281	327	374	421	468
30	7	14	35	70	140	211	281	351	421	491	561	632	702
40	9	19	47	94	187	281	374	468	561	655	748	842	936
50	12	23	58	117	234	351	468	585	702	819	936	1,053	1,170
60	14	28	70	140	281	421	561	702	842	982	1,123	1,263	1,403
70	16	33	82	164	327	491	655	819	982	1,146	1,310	1,474	1,637
80	19	37	94	187	374	561	748	936	1,123	1,310	1,497	1,684	1,871
90	21	42	105	211	421	632	842	1,053	1,263	1,474	1,684	1,895	2,105
100	23	47	117	234	468	702	936	1,170	1,403	1,637	1,871	2,105	2,339

Table 12.15: Razorbill migration free winter displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	3	5	13	26	51	77	103	129	154	180	206	231	257
20	5	10	26	51	103	154	206	257	308	360	411	463	514
30	8	15	39	77	154	231	308	386	463	540	617	694	771
40	10	21	51	103	206	308	411	514	617	720	822	925	1,028
50	13	26	64	129	257	386	514	643	771	900	1,028	1,157	1,285
60	15	31	77	154	308	463	617	771	925	1,079	1,234	1,388	1,542
70	18	36	90	180	360	540	720	900	1,079	1,259	1,439	1,619	1,799
80	21	41	103	206	411	617	822	1,028	1,234	1,439	1,645	1,850	2,056
90	23	46	116	231	463	694	925	1,157	1,388	1,619	1,850	2,082	2,313
100	26	51	129	257	514	771	1,028	1,285	1,542	1,799	2,056	2,313	2,570

Puffin

Table 12.16: Atlantic puffin breeding season displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	2	4	9	18	27	35	44	53	62	71	80	88
20	2	4	9	18	35	53	71	88	106	124	141	159	177
30	3	5	13	27	53	80	106	133	159	186	212	239	265
40	4	7	18	35	71	106	141	177	212	247	283	318	354
50	4	9	22	44	88	133	177	221	265	309	354	398	442
60	5	11	27	53	106	159	212	265	318	371	424	477	530
70	6	12	31	62	124	186	247	309	371	433	495	557	619
80	7	14	35	71	141	212	283	354	424	495	566	636	707
90	8	16	40	80	159	239	318	398	477	557	636	716	795
100	9	18	44	88	177	265	354	442	530	619	707	795	884

Table 12.17: Atlantic puffin non-breeding season displacement matrix (array area plus 2km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	2	6	12	23	35	47	58	70	82	93	105	117
20	2	5	12	23	47	70	93	117	140	163	187	210	233
30	4	7	18	35	70	105	140	175	210	245	280	315	350
40	5	9	23	47	93	140	187	233	280	327	373	420	467
50	6	12	29	58	117	175	233	292	350	408	467	525	584
60	7	14	35	70	140	210	280	350	420	490	560	630	700
70	8	16	41	82	163	245	327	408	490	572	654	735	817
80	9	19	47	93	187	280	373	467	560	654	747	840	934
90	11	21	53	105	210	315	420	525	630	735	840	945	1,050
100	12	23	58	117	233	350	467	584	700	817	934	1,050	1,167

Red-Throated Diver

Table 12.18: Red-throated diver return migration displacement matrix (array area plus 4km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	1	2	4	7	9	11	13	15	17	20	22
20	0	1	2	4	9	13	17	22	26	30	35	39	43
30	1	1	3	7	13	20	26	33	39	46	52	59	65
40	1	2	4	9	17	26	35	43	52	61	70	78	87
50	1	2	5	11	22	33	43	54	65	76	87	98	109
60	1	3	7	13	26	39	52	65	78	91	104	117	130
70	2	3	8	15	30	46	61	76	91	106	122	137	152
80	2	3	9	17	35	52	70	87	104	122	139	156	174
90	2	4	10	20	39	59	78	98	117	137	156	176	196
100	2	4	11	22	43	65	87	109	130	152	174	196	217

Table 12.19: Red-throated diver breeding season displacement matrix (array area plus 4km buffer).

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

Table 12.20: Red-throated diver post-breeding migration displacement matrix (array area plus 4km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	1	1	1	1	2	2	2	2	3
20	0	0	0	1	1	2	2	3	3	4	4	5	5
30	0	0	0	1	2	2	3	4	5	5	6	7	8
40	0	0	1	1	2	3	4	5	6	7	8	9	10
50	0	0	1	1	3	4	5	6	8	9	10	11	13
60	0	0	1	2	3	5	6	8	9	11	12	14	15
70	0	0	1	2	4	5	7	9	11	12	14	16	18
80	0	0	1	2	4	6	8	10	12	14	16	18	20
90	0	0	1	2	5	7	9	11	14	16	18	20	23
100	0	1	1	3	5	8	10	13	15	18	20	23	25

Table 12.21: Red-throated diver migration-free winter displacement matrix (array area plus 4km buffer).

Displaced (%)	Mortality Rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	0	1	1	1	1	2	2	2	2
20	0	0	0	0	1	1	2	2	3	3	4	4	5
30	0	0	0	1	1	2	3	4	4	5	6	6	7
40	0	0	0	1	2	3	4	5	6	7	8	9	10
50	0	0	1	1	2	4	5	6	7	8	10	11	12
60	0	0	1	1	3	4	6	7	9	10	12	13	14
70	0	0	1	2	3	5	7	8	10	12	13	15	17
80	0	0	1	2	4	6	8	10	12	13	15	17	19
90	0	0	1	2	4	6	9	11	13	15	17	19	22
100	0	0	1	2	5	7	10	12	14	17	19	22	24

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