GREEN VOLT

Technical Appendix 12.2

Offshore Ornithology Displacement Analysis

Offshore EIA Report: Volume 2

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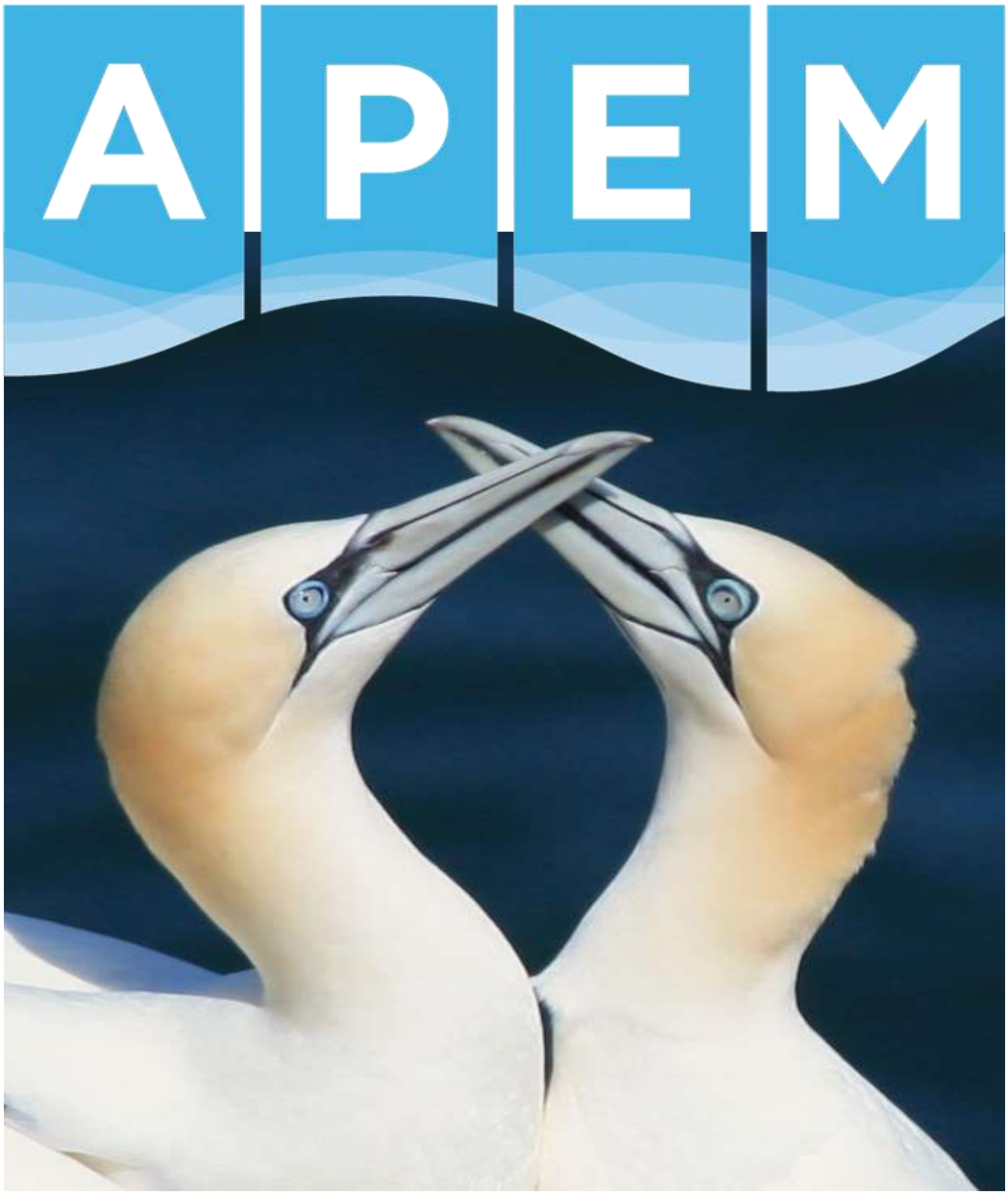

Green Volt Offshore Wind Farm

Appendix 12.2: Offshore Ornithology Displacement Analysis

Green Volt Offshore Wind Ltd.

APEM Ref: P00008351

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1. Introduction

1.1 Project Background

Green Volt Offshore Wind Limited ('the Applicant') is proposing to develop the Green Volt Offshore Wind Farm (OWF) (from here on referred to as 'Green Volt') as a proposed floating offshore wind farm. The proposed site is approximately 75 kilometres (km) northeast of the Aberdeenshire coast in northern North Sea, Scotland (**Figure 1**). The proposed array area covers an area of 116 km, whilst the survey area included a 4 km buffer surrounding the array area providing coverage of the total study area of approximately 391 km^2. Green Volt will comprise both offshore and onshore infrastructure, including an offshore generating station (the wind farm), export cables to landfall and an onshore substation for connection to the electricity transmission network (please see **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 5: Offshore Project Description** for full details on the Project Design).

APEM Ltd (hereafter APEM) was commissioned by the Applicant to undertake a study of offshore ornithology that characterise the area that may be influenced by Green Volt. A separate report (**Appendix 12.1: Offshore and Intertidal Ornithology Baseline Technical Report**) provides the findings from offshore and intertidal ornithology data to determine the receptors that characterise the baseline and are of relevance to the assessment of potential impacts from Green Volt. This technical annex has been produced to support **Green Volt Offshore Wind Farm Environmental Impact Assessment Report Chapter 12: Offshore and Intertidal Ornithology**.

The consideration of offshore ornithology for Green Volt has been discussed with consultees through the Green Volt Stakeholder Ornithology Meetings; of which Nature Scot, Marine Scotland Science (MSS), Marine Scotland Licensing Operations Team (MS-LOT) and the Royal Society for the Protection of Birds (RSPB) are members. Agreements made with consultees within the Green Volt Stakeholder Ornithology meeting process are set out in Section 12.3 Consultation and Engagement within **Chapter 12: Offshore and Intertidal Ornithology**.

1.2 Displacement Analysis

The presence of Wind Turbine Generators (WTGs) in the marine environment has the potential to directly disturb and displace seabirds that would normally reside within and around the area of sea where Green Volt is proposed. This in effect represents indirect habitat loss, potentially reducing the area available for those seabirds that are sensitive to disturbance to forage, loaf and/ or moult in the way that they are currently able to within and around Green Volt. There is also the potential for the construction and decommissioning of WTGs, substations and cable laying to directly disturb and displace seabirds, though the nature of such potential impacts is more restricted spatially and temporally by virtue of the nature of those phases of the development.

Following consultation in the Green Volt Stakeholder Ornithology meetings, five seabird species have been identified for which potential disturbance and displacement should be considered in relation to Green Volt. These are:

- Gannet, *Morus bassanus*;
- Kittiwake *Rissa tridactyla;*
- Guillemot *Uria aalge*;
- Razorbill, *Alca torda*; and
- Puffin, *Fratercula arctica*.

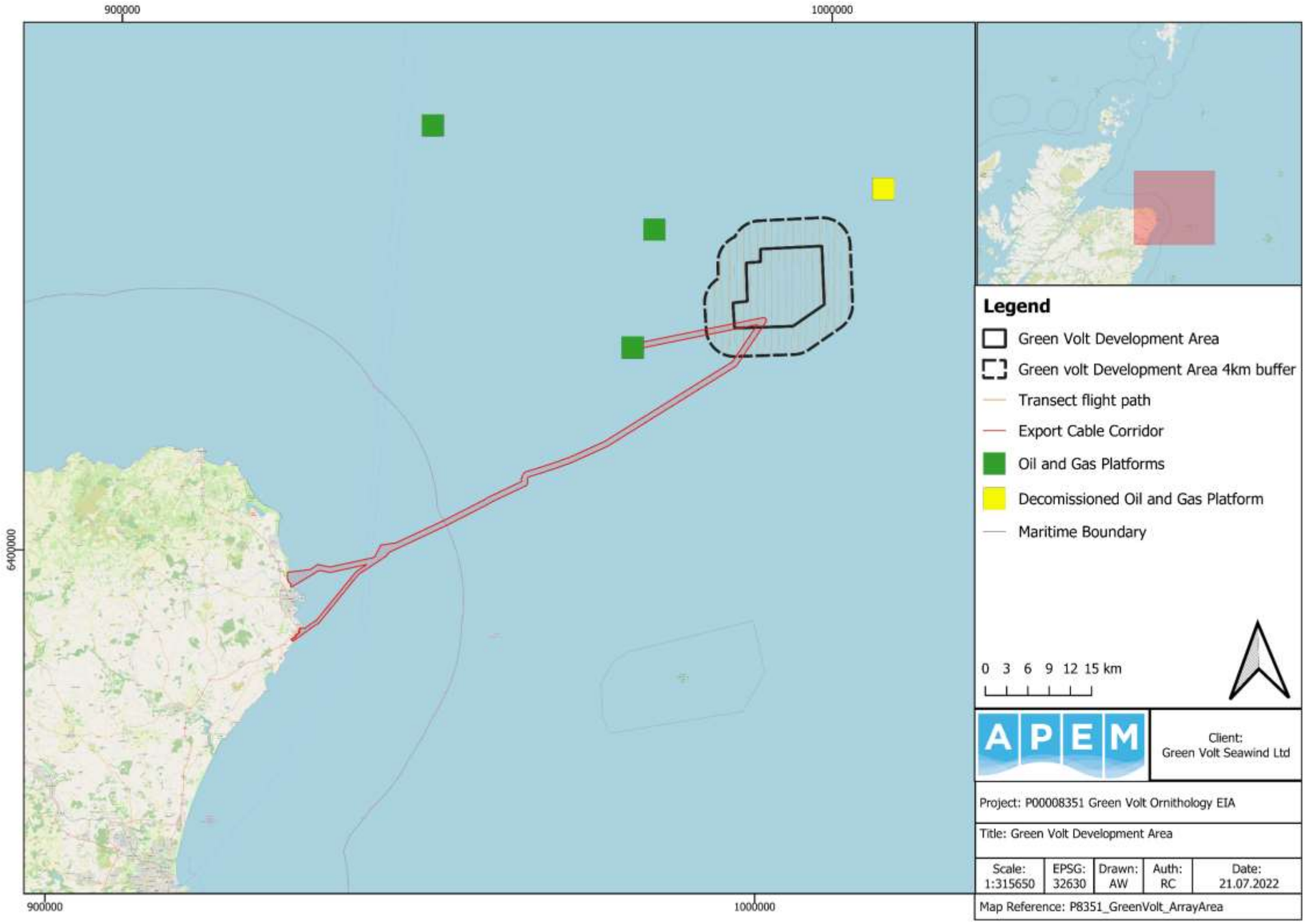
2. Methods

2.1 Buffers for Displacement

The main assessment on disturbance and displacement is found within **Chapter 12: Offshore and Intertidal Ornithology**. The scale of the potential displacement applied in this report is in response to guidance in the literature (SNCBs, updated 2022), comments received to date from the Green Volt Stakeholder Ornithology meetings (see **Section 12.3** in **Chapter 12**) and supporting evidence from post-construction monitoring reviews and other seabird behaviour studies related to offshore wind farms.

With consideration of the generic guidance (SNCBs, updated 2022), this report presents displacement matrices that consider gannet, kittiwake, guillemot, razorbill and puffin. These matrices present abundances for gannet, kittiwake, guillemot and razorbill and puffin within the Green Volt array area plus a 2 km buffer during different bio-seasons.

Figure 1 Location of Green Volt array area (and 4 km buffer zone) used for estimating abundances for displacement analysis.



2.2 Data sources for displacement matrices

The data contributing to this annex are taken from the 24 months of aerial digital surveys undertaken across the Green Volt study area, which comprised the proposed array area and a 4 km buffer, from May 2020 to April 2022, inclusive. Full details of the site-specific surveys can be found in Appendix 12.1**: Offshore and Intertidal Ornithology Baseline Technical Report.** These data are inclusive of apportionment of unidentified birds and corrections for availability bias, where appropriate.

Displacement matrices are presented for each of the five species (gannet, kittiwake, guillemot, razorbill and puffin) separately for each bio-season. For all species, displacement matrices are presented for the array area and the array area plus 2 km buffer. For all species both flying and 'sitting' (including birds observed diving, landing and taking off) abundances were included in the displacement analysis, as agreed in the Green Volt Stakeholder Ornithology meetings, to allow for an account of barrier effect to be incorporated into the displacement assessments for each species. Note that barrier effects are considered separately in **Chapter 12: Offshore and Intertidal Ornithology**.

2.3 Data limitations

The data within this annex for all five species are reliant upon site-specific high-resolution aerial digital video surveys undertaken across the Green Volt study area. These data are considered to be the most reliable source for characterising the baseline environment for offshore ornithology for Green Volt. However, using these data to characterise the abundances for each species within individual bio-seasons (as described in Section 2.5) is subject to interpretation, given variation in migratory movements between species and between years, the age classification of birds within each bio-season, connectivity to breeding colonies and other factors. Therefore, these data may be used for the assessments within the Environmental Impact Assessment report (EIAR) Chapter and the Report to Inform Appropriate Assessment (RIAA)) in differing manners, depending upon additional factors considered when assessing the potential impacts and / or effects of displacement on these species.

2.4 Presentation of displacement by bio-seasons

Bird behaviour and abundance is recognised to differ across a calendar year dependent upon the bio-season. Separate bio-seasons are recognised in **Appendix 12.1: Offshore and Intertidal Ornithology Baseline Technical Report** in order to establish the level of importance any seabird species has within the Green Volt study area during any particular period of time. Species-specific seasons for the Green Volt study area (**Table 1**) have been defined primarily referring to the guidance note from NatureScot, who have provided suggested definitions for all regularly occurring birds in the Scottish marine environment (NatureScot, 2020). Additional consideration was also provided to the UK bio-seasons compiled in Furness (2015), where appropriate.

The bio-seasons are defined for the Green Volt study area as breeding and non-breeding following NatureScot guidance and pre-breeding migration, migration-free breeding, post-breeding migration, migration-free winter, bio-seasons following (Furnace, 2015). The use of either two separate or over two bio-seasons for different species are used to understand the relevance of the Green Volt study area during different periods within the annual cycle of seabirds. It should be noted that bespoke bio-

seasons are applicable for each seabird species considered for this project based on site-specific evidence in support of the guidance from NatureScot (2020) and Furness (2015), with different combinations used depending on the biology and life history of a species within this study area.

NatureScot (2020) advise two main bio-seasons are proposed for use, which include a breeding bio-season when birds are strongly associated with their nest site / colony and a non-breeding bio-season when birds are on migration or reside in their wintering locations.

Furness (2015) advises that there are multiple different components, where some species are recommended to consider two bio-seasons (similar to NatureScot, 2020), whilst others are determined to have up to four different bio-seasons (e.g. razorbill), which include a pre-breeding migration bio-season (when birds are migrating to breeding colonies), a migration-free breeding bio-season (when birds are attending colonies, nesting and provisioning young), a post-breeding migration bio-season (when birds are migrating to wintering areas or dispersing from colonies) and a migration-free winter bio-season (when non-breeding birds are over-wintering in an area).

For the Green Volt study area both methods were considered alongside site-specific evidence on seabird behaviour to assigned the most appropriate bio-seasons for the baseline characterisation for use in impact assessment and subsequently for use in displacement analysis in **Table 1**.

For kittiwake a number of options are presented for consideration at this stage, with two and three bio-season options; using two bio-seasons defined by NatureScot guidance and three bio-seasons by incorporating the migratory periods pre- and post-breeding defined in Furness (2015). These options are provided to maximise interpretation of peak abundance estimates and behaviour over the Green Volt study area of this species. Gannet is presented with three bio-seasons to account for extensive population movements occurring during migratory periods.

Table 1 Bio-season colour coding.

Bio-season	Gannet	Kittiwake	Guillemot	Razorbill	Puffin
Return Migration (Green)	Dec – Mar	Jan-(mid) Apr	N/A	N/A	N/A
Migration-free Breeding (Purple)	Apr – Sep	(mid) Apr-Aug	N/A	N/A	N/A
Post-breeding Migration (Orange)	Oct – Nov	Sep-Dec	N/A	N/A	N/A
Migration-free Winter (Grey/Blue)	N/A	N/A	N/A	N/A	N/A
Breeding (Pink)	N/A	(mid) Apr-Aug	Mar – (mid) Aug	Apr-(mid) Aug	Apr- (mid) Aug
Extended Non-breeding (Yellow)	N/A	Sep-(mid) Apr	(mid) Aug-Feb	(mid) Aug-Mar	(mid) Aug- Mar

2.5 Bio-season mean peak abundances

As per the SNCBs joint interim advice note (SNCBs, updated 2022), data considered within displacement assessments are to be based on bio-season mean peak abundances. The bio-season mean peak abundances are calculated as the highest recorded monthly abundance within each bio-season averaged across the two years' worth of data. It should be noted that calculating bio-season abundance in such a way can be considered precautionary, as it is highly unlikely that the abundance within a given bio-season remains at such a high abundance, especially when considering the non-breeding bio-season. The calculated bio-season mean peak abundances used for these analyses are presented in **Table 2**.

Table 2 Bio-season mean peak abundances in the Green Volt array area and corresponding buffers (all behaviours).

Bio-Season	Survey Area	Gannet	Kittiwake	Guillemot	Razorbill	Puffin
Return Migration	Green Volt array area	49	31	N/A	N/A	N/A
	Green Volt array area plus 2 km buffer	102	83	N/A	N/A	N/A
Migration-free Breeding	Green Volt array area	120	143	N/A	N/A	N/A
	Green Volt array area plus 2 km buffer	198	183	N/A	N/A	N/A
Post-breeding Migration	Green Volt array area	16	76	N/A	N/A	N/A
	Green Volt array area plus 2 km buffer	24	149	N/A	N/A	N/A
Breeding	Green Volt array area	N/A	143	2,480	183	134
	Green Volt array area plus 2 km buffer	N/A	183	4,429	457	250
Non-breeding	Green Volt array area	N/A	76	9,676	42	20
	Green Volt array area plus 2 km buffer	N/A	149	16,105	58	41

3. Results

3.1 Gannet displacement matrices

Table 3 Gannet return migration displacement matrix (based on an abundance of 49 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4	5
20	0	0	0	0	0	0	1	2	3	4	5	6	7	8	9	10
30	0	0	0	0	1	1	1	3	4	6	7	9	10	12	13	15
40	0	0	0	1	1	1	2	4	6	8	10	12	14	16	18	20
50	0	0	0	1	1	1	2	5	7	10	12	15	17	20	22	25
60	0	0	1	1	1	1	3	6	9	12	15	18	21	24	26	29
70	0	0	1	1	1	2	3	7	10	14	17	21	24	27	31	34
80	0	0	1	1	2	2	4	8	12	16	20	24	27	31	35	39
90	0	0	1	1	2	2	4	9	13	18	22	26	31	35	40	44
100	0	0	1	1	2	2	5	10	15	20	25	29	34	39	44	49

Table 4 **Gannet return migration displacement matrix (based on an abundance of 102 for Green Volt array area plus 2 km buffer).**

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
10	0	0	0	0	0	1	1	2	3	4	5	6	7	8	9	10
20	0	0	0	1	1	1	2	4	6	8	10	12	14	16	18	20
30	0	0	1	1	1	2	3	6	9	12	15	18	21	24	28	31
40	0	0	1	1	2	2	4	8	12	16	20	24	29	33	37	41
50	0	1	1	2	2	3	5	10	15	20	26	31	36	41	46	51
60	0	1	1	2	2	3	6	12	18	24	31	37	43	49	55	61
70	0	1	1	2	3	4	7	14	21	29	36	43	50	57	64	71
80	0	1	2	2	3	4	8	16	24	33	41	49	57	65	73	82
90	0	1	2	3	4	5	9	18	28	37	46	55	64	73	83	92
100	0	1	2	3	4	5	10	20	31	41	51	61	71	82	92	102

Table 5 **Gannet migration-free breeding displacement matrix (based on an abundance of 120 for Green Volt array area only).**

Displacement (%)	Mortality rates (%)															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
10	0	0	0	0	0	1	1	2	4	5	6	7	8	10	11	12
20	0	0	0	1	1	1	2	5	7	10	12	14	17	19	22	24
30	0	0	1	1	1	2	4	7	11	14	18	22	25	29	32	36
40	0	0	1	1	2	2	5	10	14	19	24	29	34	38	43	48
50	0	1	1	2	2	3	6	12	18	24	30	36	42	48	54	60
60	0	1	1	2	3	4	7	14	22	29	36	43	50	58	65	72
70	0	1	2	3	3	4	8	17	25	34	42	50	59	67	76	84
80	0	1	2	3	4	5	10	19	29	38	48	58	67	77	86	96
90	0	1	2	3	4	5	11	22	32	43	54	65	76	86	97	108
100	0	1	2	4	5	6	12	24	36	48	60	72	84	96	108	120

Table 6 **Gannet migration-free breeding displacement matrix (based on an abundance of 198 for Green Volt array area plus 2 km buffer).**

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2
10	0	0	0	1	1	1	2	4	6	8	10	12	14	16	18	20
20	0	0	1	1	2	2	4	8	12	16	20	24	28	32	36	40
30	0	1	1	2	2	3	6	12	18	24	30	36	42	48	53	59
40	0	1	2	2	3	4	8	16	24	32	40	48	55	63	71	79
50	0	1	2	3	4	5	10	20	30	40	50	59	69	79	89	99
60	0	1	2	4	5	6	12	24	36	48	59	71	83	95	107	119
70	0	1	3	4	6	7	14	28	42	55	69	83	97	111	125	139
80	0	2	3	5	6	8	16	32	48	63	79	95	111	127	143	158
90	0	2	4	5	7	9	18	36	53	71	89	107	125	143	160	178
100	0	2	4	6	8	10	20	40	59	79	99	119	139	158	178	198

Table 7 Gannet post-breeding migration displacement matrix (based on an abundance of 16 for Green Volt array area only).

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

Table 8 **Gannet post-breeding migration displacement matrix (based on an abundance of 24 for Green Volt array area plus 2 km buffer).**

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

Table 9 Gannet annual displacement matrix (based on an abundance of 185 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2
10	0	0	0	1	1	1	2	4	6	7	9	11	13	15	17	19
20	0	0	1	1	1	2	4	7	11	15	19	22	26	30	33	37
30	0	1	1	2	2	3	6	11	17	22	28	33	39	44	50	56
40	0	1	1	2	3	4	7	15	22	30	37	44	52	59	67	74
50	0	1	2	3	4	5	9	19	28	37	46	56	65	74	83	93
60	0	1	2	3	4	6	11	22	33	44	56	67	78	89	100	111
70	0	1	3	4	5	6	13	26	39	52	65	78	91	104	117	130
80	0	1	3	4	6	7	15	30	44	59	74	89	104	118	133	148
90	0	2	3	5	7	8	17	33	50	67	83	100	117	133	150	167
100	0	2	4	6	7	9	19	37	56	74	93	111	130	148	167	185

Table 10 Gannet annual displacement matrix (based on an abundance of 324 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1	1	1	2	2	2	3	3	3
10	0	0	1	1	1	2	3	6	10	13	16	19	23	26	29	32
20	0	1	1	2	3	3	6	13	19	26	32	39	45	52	58	65
30	0	1	2	3	4	5	10	19	29	39	49	58	68	78	87	97
40	0	1	3	4	5	6	13	26	39	52	65	78	91	104	117	130
50	0	2	3	5	6	8	16	32	49	65	81	97	113	130	146	162
60	0	2	4	6	8	10	19	39	58	78	97	117	136	156	175	194
70	0	2	5	7	9	11	23	45	68	91	113	136	159	181	204	227
80	0	3	5	8	10	13	26	52	78	104	130	156	181	207	233	259
90	0	3	6	9	12	15	29	58	87	117	146	175	204	233	262	292
100	0	3	6	10	13	16	32	65	97	130	162	194	227	259	292	324

3.2 Kittiwake displacement matrices

Table 11 Kittiwake return-migration displacement matrix (based on an abundance of 31 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	1	1	1	2	2	2	2	3	3
20	0	0	0	0	0	0	1	1	2	2	3	4	4	5	6	6
30	0	0	0	0	0	0	1	2	3	4	5	6	7	7	8	9
40	0	0	0	0	0	1	1	2	4	5	6	7	9	10	11	12
50	0	0	0	0	1	1	2	3	5	6	8	9	11	12	14	16
60	0	0	0	1	1	1	2	4	6	7	9	11	13	15	17	19
70	0	0	0	1	1	1	2	4	7	9	11	13	15	17	20	22
80	0	0	0	1	1	1	2	5	7	10	12	15	17	20	22	25
90	0	0	1	1	1	1	3	6	8	11	14	17	20	22	25	28
100	0	0	1	1	1	2	3	6	9	12	16	19	22	25	28	31

Table 12 Kittiwake return-migration displacement matrix (based on an abundance of 83 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
10	0	0	0	0	0	0	1	2	2	3	4	5	6	7	7	8
20	0	0	0	0	1	1	2	3	5	7	8	10	12	13	15	17
30	0	0	0	1	1	1	2	5	7	10	12	15	17	20	22	25
40	0	0	1	1	1	2	3	7	10	13	17	20	23	27	30	33
50	0	0	1	1	2	2	4	8	12	17	21	25	29	33	37	42
60	0	0	1	1	2	2	5	10	15	20	25	30	35	40	45	50
70	0	1	1	2	2	3	6	12	17	23	29	35	41	46	52	58
80	0	1	1	2	3	3	7	13	20	27	33	40	46	53	60	66
90	0	1	1	2	3	4	7	15	22	30	37	45	52	60	67	75
100	0	1	2	2	3	4	8	17	25	33	42	50	58	66	75	83

Table 13 Kittiwake migration-free breeding displacement matrix (based on an abundance of 143 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
10	0	0	0	0	1	1	1	3	4	6	7	9	10	11	13	14
20	0	0	1	1	1	1	3	6	9	11	14	17	20	23	26	29
30	0	0	1	1	2	2	4	9	13	17	21	26	30	34	39	43
40	0	1	1	2	2	3	6	11	17	23	29	34	40	46	51	57
50	0	1	1	2	3	4	7	14	21	29	36	43	50	57	64	72
60	0	1	2	3	3	4	9	17	26	34	43	51	60	69	77	86
70	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
80	0	1	2	3	5	6	11	23	34	46	57	69	80	92	103	114
90	0	1	3	4	5	6	13	26	39	51	64	77	90	103	116	129
100	0	1	3	4	6	7	14	29	43	57	72	86	100	114	129	143

Table 14 Kittiwake migration-free breeding displacement matrix (based on an abundance of 183 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2
10	0	0	0	1	1	1	2	4	5	7	9	11	13	15	16	18
20	0	0	1	1	1	2	4	7	11	15	18	22	26	29	33	37
30	0	1	1	2	2	3	5	11	16	22	27	33	38	44	49	55
40	0	1	1	2	3	4	7	15	22	29	37	44	51	59	66	73
50	0	1	2	3	4	5	9	18	27	37	46	55	64	73	82	92
60	0	1	2	3	4	5	11	22	33	44	55	66	77	88	99	110
70	0	1	3	4	5	6	13	26	38	51	64	77	90	102	115	128
80	0	1	3	4	6	7	15	29	44	59	73	88	102	117	132	146
90	0	2	3	5	7	8	16	33	49	66	82	99	115	132	148	165
100	0	2	4	5	7	9	18	37	55	73	92	110	128	146	165	183

Table 15 Kittiwake post-breeding migration displacement matrix (based on an abundance of 76 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
10	0	0	0	0	0	0	1	2	2	3	4	5	5	6	7	8
20	0	0	0	0	1	1	2	3	5	6	8	9	11	12	14	15
30	0	0	0	1	1	1	2	5	7	9	11	14	16	18	21	23
40	0	0	1	1	1	2	3	6	9	12	15	18	21	24	27	30
50	0	0	1	1	2	2	4	8	11	15	19	23	27	30	34	38
60	0	0	1	1	2	2	5	9	14	18	23	27	32	36	41	46
70	0	1	1	2	2	3	5	11	16	21	27	32	37	43	48	53
80	0	1	1	2	2	3	6	12	18	24	30	36	43	49	55	61
90	0	1	1	2	3	3	7	14	21	27	34	41	48	55	62	68
100	0	1	2	2	3	4	8	15	23	30	38	46	53	61	68	76

Table 16 Kittiwake post-breeding migration displacement matrix (based on an abundance of 149 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
10	0	0	0	0	1	1	1	3	4	6	7	9	10	12	13	15
20	0	0	1	1	1	1	3	6	9	12	15	18	21	24	27	30
30	0	0	1	1	2	2	4	9	13	18	22	27	31	36	40	45
40	0	1	1	2	2	3	6	12	18	24	30	36	42	48	54	60
50	0	1	1	2	3	4	7	15	22	30	37	45	52	60	67	75
60	0	1	2	3	4	4	9	18	27	36	45	54	63	72	80	89
70	0	1	2	3	4	5	10	21	31	42	52	63	73	83	94	104
80	0	1	2	4	5	6	12	24	36	48	60	72	83	95	107	119
90	0	1	3	4	5	7	13	27	40	54	67	80	94	107	121	134
100	0	1	3	4	6	7	15	30	45	60	75	89	104	119	134	149

Table 17 Kittiwake breeding displacement matrix (based on an abundance of 143 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
10	0	0	0	0	1	1	1	3	4	6	7	9	10	11	13	14
20	0	0	1	1	1	1	3	6	9	11	14	17	20	23	26	29
30	0	0	1	1	2	2	4	9	13	17	21	26	30	34	39	43
40	0	1	1	2	2	3	6	11	17	23	29	34	40	46	51	57
50	0	1	1	2	3	4	7	14	21	29	36	43	50	57	64	72
60	0	1	2	3	3	4	9	17	26	34	43	51	60	69	77	86
70	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
80	0	1	2	3	5	6	11	23	34	46	57	69	80	92	103	114
90	0	1	3	4	5	6	13	26	39	51	64	77	90	103	116	129
100	0	1	3	4	6	7	14	29	43	57	72	86	100	114	129	143

Table 18 Kittiwake breeding displacement matrix (based on an abundance of 183 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2
10	0	0	0	1	1	1	2	4	5	7	9	11	13	15	16	18
20	0	0	1	1	1	2	4	7	11	15	18	22	26	29	33	37
30	0	1	1	2	2	3	5	11	16	22	27	33	38	44	49	55
40	0	1	1	2	3	4	7	15	22	29	37	44	51	59	66	73
50	0	1	2	3	4	5	9	18	27	37	46	55	64	73	82	92
60	0	1	2	3	4	5	11	22	33	44	55	66	77	88	99	110
70	0	1	3	4	5	6	13	26	38	51	64	77	90	102	115	128
80	0	1	3	4	6	7	15	29	44	59	73	88	102	117	132	146
90	0	2	3	5	7	8	16	33	49	66	82	99	115	132	148	165
100	0	2	4	5	7	9	18	37	55	73	92	110	128	146	165	183

Table 19 Kittiwake non-breeding displacement matrix (based on an abundance of 76 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
10	0	0	0	0	0	0	1	2	2	3	4	5	5	6	7	8
20	0	0	0	0	1	1	2	3	5	6	8	9	11	12	14	15
30	0	0	0	1	1	1	2	5	7	9	11	14	16	18	21	23
40	0	0	1	1	1	2	3	6	9	12	15	18	21	24	27	30
50	0	0	1	1	2	2	4	8	11	15	19	23	27	30	34	38
60	0	0	1	1	2	2	5	9	14	18	23	27	32	36	41	46
70	0	1	1	2	2	3	5	11	16	21	27	32	37	43	48	53
80	0	1	1	2	2	3	6	12	18	24	30	36	43	49	55	61
90	0	1	1	2	3	3	7	14	21	27	34	41	48	55	62	68
100	0	1	2	2	3	4	8	15	23	30	38	46	53	61	68	76

Table 20 Kittiwake non-breeding displacement matrix (based on an abundance of 149 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
10	0	0	0	0	1	1	1	3	4	6	7	9	10	12	13	15
20	0	0	1	1	1	1	3	6	9	12	15	18	21	24	27	30
30	0	0	1	1	2	2	4	9	13	18	22	27	31	36	40	45
40	0	1	1	2	2	3	6	12	18	24	30	36	42	48	54	60
50	0	1	1	2	3	4	7	15	22	30	37	45	52	60	67	75
60	0	1	2	3	4	4	9	18	27	36	45	54	63	72	80	89
70	0	1	2	3	4	5	10	21	31	42	52	63	73	83	94	104
80	0	1	2	4	5	6	12	24	36	48	60	72	83	95	107	119
90	0	1	3	4	5	7	13	27	40	54	67	80	94	107	121	134
100	0	1	3	4	6	7	15	30	45	60	75	89	104	119	134	149

Table 21 Kittiwake annual displacement matrix (based on an abundance of 250 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3
10	0	0	1	1	1	1	3	5	8	10	13	15	18	20	23	25
20	0	1	1	2	2	3	5	10	15	20	25	30	35	40	45	50
30	0	1	2	2	3	4	8	15	23	30	38	45	53	60	68	75
40	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
50	0	1	3	4	5	6	13	25	38	50	63	75	88	100	113	125
60	0	2	3	5	6	8	15	30	45	60	75	90	105	120	135	150
70	0	2	4	5	7	9	18	35	53	70	88	105	123	140	158	175
80	0	2	4	6	8	10	20	40	60	80	100	120	140	160	180	200
90	0	2	5	7	9	11	23	45	68	90	113	135	158	180	203	225
100	0	3	5	8	10	13	25	50	75	100	125	150	175	200	225	250

Table 22 Kittiwake annual displacement matrix (based on an abundance of 415 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1	1	2	2	2	3	3	4	4
10	0	0	1	1	2	2	4	8	12	17	21	25	29	33	37	42
20	0	1	2	2	3	4	8	17	25	33	42	50	58	66	75	83
30	0	1	2	4	5	6	12	25	37	50	62	75	87	100	112	125
40	0	2	3	5	7	8	17	33	50	66	83	100	116	133	149	166
50	0	2	4	6	8	10	21	42	62	83	104	125	145	166	187	208
60	0	2	5	7	10	12	25	50	75	100	125	149	174	199	224	249
70	0	3	6	9	12	15	29	58	87	116	145	174	203	232	261	291
80	0	3	7	10	13	17	33	66	100	133	166	199	232	266	299	332
90	0	4	7	11	15	19	37	75	112	149	187	224	261	299	336	374
100	0	4	8	12	17	21	42	83	125	166	208	249	291	332	374	415

3.3 Guillemot displacement matrices

Table 23 Guillemot breeding displacement matrix (based on an abundance of 2,480 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	1	1	2	5	7	10	12	15	17	20	22	25
10	0	2	5	7	10	12	25	50	74	99	124	149	174	198	223	248
20	0	5	10	15	20	25	50	99	149	198	248	298	347	397	446	496
30	0	7	15	22	30	37	74	149	223	298	372	446	521	595	670	744
40	0	10	20	30	40	50	99	198	298	397	496	595	694	794	893	992
50	0	12	25	37	50	62	124	248	372	496	620	744	868	992	1,116	1,240
60	0	15	30	45	60	74	149	298	446	595	744	893	1,042	1,190	1,339	1,488
70	0	17	35	52	69	87	174	347	521	694	868	1,042	1,215	1,389	1,562	1,736
80	0	20	40	60	79	99	198	397	595	794	992	1,190	1,389	1,587	1,786	1,984
90	0	22	45	67	89	112	223	446	670	893	1,116	1,339	1,562	1,786	2,009	2,232
100	0	25	50	74	99	124	248	496	744	992	1,240	1,488	1,736	1,984	2,232	2,480

Table 24 Guillemot breeding displacement matrix (based on an abundance of 4,429 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	1	2	2	4	9	13	18	22	27	31	35	40	44
10	0	4	9	13	18	22	44	89	133	177	221	266	310	354	399	443
20	0	9	18	27	35	44	89	177	266	354	443	531	620	709	797	886
30	0	13	27	40	53	66	133	266	399	531	664	797	930	1,063	1,196	1,329
40	0	18	35	53	71	89	177	354	531	709	886	1,063	1,240	1,417	1,594	1,772
50	0	22	44	66	89	111	221	443	664	886	1,107	1,329	1,550	1,772	1,993	2,215
60	0	27	53	80	106	133	266	531	797	1,063	1,329	1,594	1,860	2,126	2,392	2,657
70	0	31	62	93	124	155	310	620	930	1,240	1,550	1,860	2,170	2,480	2,790	3,100
80	0	35	71	106	142	177	354	709	1,063	1,417	1,772	2,126	2,480	2,835	3,189	3,543
90	0	40	80	120	159	199	399	797	1,196	1,594	1,993	2,392	2,790	3,189	3,587	3,986
100	0	44	89	133	177	221	443	886	1,329	1,772	2,215	2,657	3,100	3,543	3,986	4,429

Table 25 Guillemot non-breeding displacement matrix (based on an abundance of 9,676 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	2	3	4	5	10	19	29	39	48	58	68	77	87	97
10	0	10	19	29	39	48	97	194	290	387	484	581	677	774	871	968
20	0	19	39	58	77	97	194	387	581	774	968	1,161	1,355	1,548	1,742	1,935
30	0	29	58	87	116	145	290	581	871	1,161	1,451	1,742	2,032	2,322	2,613	2,903
40	0	39	77	116	155	194	387	774	1,161	1,548	1,935	2,322	2,709	3,096	3,483	3,870
50	0	48	97	145	194	242	484	968	1,451	1,935	2,419	2,903	3,387	3,870	4,354	4,838
60	0	58	116	174	232	290	581	1,161	1,742	2,322	2,903	3,483	4,064	4,644	5,225	5,806
70	0	68	135	203	271	339	677	1,355	2,032	2,709	3,387	4,064	4,741	5,419	6,096	6,773
80	0	77	155	232	310	387	774	1,548	2,322	3,096	3,870	4,644	5,419	6,193	6,967	7,741
90	0	87	174	261	348	435	871	1,742	2,613	3,483	4,354	5,225	6,096	6,967	7,838	8,708
100	0	97	194	290	387	484	968	1,935	2,903	3,870	4,838	5,806	6,773	7,741	8,708	9,676

Table 26 **Guillemot non-breeding displacement matrix (based on an abundance of 16,105 for Green Volt array area plus 2 km buffer).**

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	2	3	5	6	8	16	32	48	64	81	97	113	129	145	161
10	0	16	32	48	64	81	161	322	483	644	805	966	1,127	1,288	1,449	1,611
20	0	32	64	97	129	161	322	644	966	1,288	1,611	1,933	2,255	2,577	2,899	3,221
30	0	48	97	145	193	242	483	966	1,449	1,933	2,416	2,899	3,382	3,865	4,348	4,832
40	0	64	129	193	258	322	644	1,288	1,933	2,577	3,221	3,865	4,509	5,154	5,798	6,442
50	0	81	161	242	322	403	805	1,611	2,416	3,221	4,026	4,832	5,637	6,442	7,247	8,053
60	0	97	193	290	387	483	966	1,933	2,899	3,865	4,832	5,798	6,764	7,730	8,697	9,663
70	0	113	225	338	451	564	1,127	2,255	3,382	4,509	5,637	6,764	7,891	9,019	10,146	11,274
80	0	129	258	387	515	644	1,288	2,577	3,865	5,154	6,442	7,730	9,019	10,307	11,596	12,884
90	0	145	290	435	580	725	1,449	2,899	4,348	5,798	7,247	8,697	10,146	11,596	13,045	14,495
100	0	161	322	483	644	805	1,611	3,221	4,832	6,442	8,053	9,663	11,274	12,884	14,495	16,105

Table 27 Guillemot annual displacement matrix (based on an abundance of 12,156 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	1	2	4	5	6	12	24	36	49	61	73	85	97	109	122
10	0	12	24	36	49	61	122	243	365	486	608	729	851	972	1,094	1,216
20	0	24	49	73	97	122	243	486	729	972	1,216	1,459	1,702	1,945	2,188	2,431
30	0	36	73	109	146	182	365	729	1,094	1,459	1,823	2,188	2,553	2,917	3,282	3,647
40	0	49	97	146	194	243	486	972	1,459	1,945	2,431	2,917	3,404	3,890	4,376	4,862
50	0	61	122	182	243	304	608	1,216	1,823	2,431	3,039	3,647	4,255	4,862	5,470	6,078
60	0	73	146	219	292	365	729	1,459	2,188	2,917	3,647	4,376	5,106	5,835	6,564	7,294
70	0	85	170	255	340	425	851	1,702	2,553	3,404	4,255	5,106	5,956	6,807	7,658	8,509
80	0	97	194	292	389	486	972	1,945	2,917	3,890	4,862	5,835	6,807	7,780	8,752	9,725
90	0	109	219	328	438	547	1,094	2,188	3,282	4,376	5,470	6,564	7,658	8,752	9,846	10,940
100	0	122	243	365	486	608	1,216	2,431	3,647	4,862	6,078	7,294	8,509	9,725	10,940	12,156

Table 28 Guillemot annual displacement matrix (based on an abundance of 20,534 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	2	4	6	8	10	21	41	62	82	103	123	144	164	185	205
10	0	21	41	62	82	103	205	411	616	821	1,027	1,232	1,437	1,643	1,848	2,053
20	0	41	82	123	164	205	411	821	1,232	1,643	2,053	2,464	2,875	3,285	3,696	4,107
30	0	62	123	185	246	308	616	1,232	1,848	2,464	3,080	3,696	4,312	4,928	5,544	6,160
40	0	82	164	246	329	411	821	1,643	2,464	3,285	4,107	4,928	5,750	6,571	7,392	8,214
50	0	103	205	308	411	513	1,027	2,053	3,080	4,107	5,134	6,160	7,187	8,214	9,240	10,267
60	0	123	246	370	493	616	1,232	2,464	3,696	4,928	6,160	7,392	8,624	9,856	11,088	12,320
70	0	144	287	431	575	719	1,437	2,875	4,312	5,750	7,187	8,624	10,062	11,499	12,936	14,374
80	0	164	329	493	657	821	1,643	3,285	4,928	6,571	8,214	9,856	11,499	13,142	14,784	16,427
90	0	185	370	554	739	924	1,848	3,696	5,544	7,392	9,240	11,088	12,936	14,784	16,633	18,481
100	0	205	411	616	821	1,027	2,053	4,107	6,160	8,214	10,267	12,320	14,374	16,427	18,481	20,534

3.4 Razorbill displacement matrices

Table 29 Razorbill breeding displacement matrix (based on an abundance of 183 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2
10	0	0	0	1	1	1	2	4	5	7	9	11	13	15	16	18
20	0	0	1	1	1	2	4	7	11	15	18	22	26	29	33	37
30	0	1	1	2	2	3	5	11	16	22	27	33	38	44	49	55
40	0	1	1	2	3	4	7	15	22	29	37	44	51	59	66	73
50	0	1	2	3	4	5	9	18	27	37	46	55	64	73	82	92
60	0	1	2	3	4	5	11	22	33	44	55	66	77	88	99	110
70	0	1	3	4	5	6	13	26	38	51	64	77	90	102	115	128
80	0	1	3	4	6	7	15	29	44	59	73	88	102	117	132	146
90	0	2	3	5	7	8	16	33	49	66	82	99	115	132	148	165
100	0	2	4	5	7	9	18	37	55	73	92	110	128	146	165	183

Table 30 Razorbill breeding displacement matrix (based on an abundance of 457 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4	5
10	0	0	1	1	2	2	5	9	14	18	23	27	32	37	41	46
20	0	1	2	3	4	5	9	18	27	37	46	55	64	73	82	91
30	0	1	3	4	5	7	14	27	41	55	69	82	96	110	123	137
40	0	2	4	5	7	9	18	37	55	73	91	110	128	146	165	183
50	0	2	5	7	9	11	23	46	69	91	114	137	160	183	206	229
60	0	3	5	8	11	14	27	55	82	110	137	165	192	219	247	274
70	0	3	6	10	13	16	32	64	96	128	160	192	224	256	288	320
80	0	4	7	11	15	18	37	73	110	146	183	219	256	292	329	366
90	0	4	8	12	16	21	41	82	123	165	206	247	288	329	370	411
100	0	5	9	14	18	23	46	91	137	183	229	274	320	366	411	457

Table 31 Razorbill non-breeding displacement matrix (based on an abundance of 42 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	1	1	2	2	3	3	3	4	4
20	0	0	0	0	0	0	1	2	3	3	4	5	6	7	8	8
30	0	0	0	0	1	1	1	3	4	5	6	8	9	10	11	13
40	0	0	0	1	1	1	2	3	5	7	8	10	12	13	15	17
50	0	0	0	1	1	1	2	4	6	8	11	13	15	17	19	21
60	0	0	1	1	1	1	3	5	8	10	13	15	18	20	23	25
70	0	0	1	1	1	1	3	6	9	12	15	18	21	24	26	29
80	0	0	1	1	1	2	3	7	10	13	17	20	24	27	30	34
90	0	0	1	1	2	2	4	8	11	15	19	23	26	30	34	38
100	0	0	1	1	2	2	4	8	13	17	21	25	29	34	38	42

Table 32 Razorbill non-breeding displacement matrix (based on an abundance of 58 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
10	0	0	0	0	0	0	1	1	2	2	3	3	4	5	5	6
20	0	0	0	0	0	1	1	2	3	5	6	7	8	9	10	12
30	0	0	0	1	1	1	2	3	5	7	9	10	12	14	16	17
40	0	0	0	1	1	1	2	5	7	9	12	14	16	19	21	23
50	0	0	1	1	1	1	3	6	9	12	15	17	20	23	26	29
60	0	0	1	1	1	2	3	7	10	14	17	21	24	28	31	35
70	0	0	1	1	2	2	4	8	12	16	20	24	28	32	37	41
80	0	0	1	1	2	2	5	9	14	19	23	28	32	37	42	46
90	0	1	1	2	2	3	5	10	16	21	26	31	37	42	47	52
100	0	1	1	2	2	3	6	12	17	23	29	35	41	46	52	58

Table 33 Razorbill annual displacement matrix (based on an abundance of 225 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2
10	0	0	0	1	1	1	2	5	7	9	11	14	16	18	20	23
20	0	0	1	1	2	2	5	9	14	18	23	27	32	36	41	45
30	0	1	1	2	3	3	7	14	20	27	34	41	47	54	61	68
40	0	1	2	3	4	5	9	18	27	36	45	54	63	72	81	90
50	0	1	2	3	5	6	11	23	34	45	56	68	79	90	101	113
60	0	1	3	4	5	7	14	27	41	54	68	81	95	108	122	135
70	0	2	3	5	6	8	16	32	47	63	79	95	110	126	142	158
80	0	2	4	5	7	9	18	36	54	72	90	108	126	144	162	180
90	0	2	4	6	8	10	20	41	61	81	101	122	142	162	182	203
100	0	2	5	7	9	11	23	45	68	90	113	135	158	180	203	225

Table 34 Razorbill annual displacement matrix (based on an abundance of 515 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1	1	2	2	3	3	4	4	5	5
10	0	1	1	2	2	3	5	10	15	21	26	31	36	41	46	52
20	0	1	2	3	4	5	10	21	31	41	52	62	72	82	93	103
30	0	2	3	5	6	8	15	31	46	62	77	93	108	124	139	155
40	0	2	4	6	8	10	21	41	62	82	103	124	144	165	185	206
50	0	3	5	8	10	13	26	52	77	103	129	155	180	206	232	258
60	0	3	6	9	12	15	31	62	93	124	155	185	216	247	278	309
70	0	4	7	11	14	18	36	72	108	144	180	216	252	288	324	361
80	0	4	8	12	16	21	41	82	124	165	206	247	288	330	371	412
90	0	5	9	14	19	23	46	93	139	185	232	278	324	371	417	464
100	0	5	10	15	21	26	52	103	155	206	258	309	361	412	464	515

3.5 Puffin displacement matrices

Table 35 Puffin breeding displacement matrix (based on an abundance of 134 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
10	0	0	0	0	1	1	1	3	4	5	7	8	9	11	12	13
20	0	0	1	1	1	1	3	5	8	11	13	16	19	21	24	27
30	0	0	1	1	2	2	4	8	12	16	20	24	28	32	36	40
40	0	1	1	2	2	3	5	11	16	21	27	32	38	43	48	54
50	0	1	1	2	3	3	7	13	20	27	34	40	47	54	60	67
60	0	1	2	2	3	4	8	16	24	32	40	48	56	64	72	80
70	0	1	2	3	4	5	9	19	28	38	47	56	66	75	84	94
80	0	1	2	3	4	5	11	21	32	43	54	64	75	86	96	107
90	0	1	2	4	5	6	12	24	36	48	60	72	84	96	109	121
100	0	1	3	4	5	7	13	27	40	54	67	80	94	107	121	134

Table 36 Puffin breeding displacement matrix (based on an abundance of 250 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3
10	0	0	1	1	1	1	3	5	8	10	13	15	18	20	23	25
20	0	1	1	2	2	3	5	10	15	20	25	30	35	40	45	50
30	0	1	2	2	3	4	8	15	23	30	38	45	53	60	68	75
40	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
50	0	1	3	4	5	6	13	25	38	50	63	75	88	100	113	125
60	0	2	3	5	6	8	15	30	45	60	75	90	105	120	135	150
70	0	2	4	5	7	9	18	35	53	70	88	105	123	140	158	175
80	0	2	4	6	8	10	20	40	60	80	100	120	140	160	180	200
90	0	2	5	7	9	11	23	45	68	90	113	135	158	180	203	225
100	0	3	5	8	10	13	25	50	75	100	125	150	175	200	225	250

Table 37 Puffin non-breeding displacement matrix (based on an abundance of 20 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	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	0	0	0
30	0	0	0	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	0	0	0
50	0	0	0	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	0	0	0
70	0	0	0	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	0	0	0
90	0	0	0	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	0	0	20

Table 38 Puffin non-breeding displacement matrix (based on an abundance of 41 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	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	0	0	0
30	0	0	0	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	0	0	0
50	0	0	0	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	0	0	0
70	0	0	0	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	0	0	0
90	0	0	0	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	0	0	41

Table 39 Puffin annual displacement matrix (based on an abundance of 154 for Green Volt array area only).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2
10	0	0	0	0	1	1	2	3	5	6	8	9	11	12	14	15
20	0	0	1	1	1	2	3	6	9	12	15	18	22	25	28	31
30	0	0	1	1	2	2	5	9	14	18	23	28	32	37	42	46
40	0	1	1	2	2	3	6	12	18	25	31	37	43	49	55	62
50	0	1	2	2	3	4	8	15	23	31	39	46	54	62	69	77
60	0	1	2	3	4	5	9	18	28	37	46	55	65	74	83	92
70	0	1	2	3	4	5	11	22	32	43	54	65	75	86	97	108
80	0	1	2	4	5	6	12	25	37	49	62	74	86	99	111	123
90	0	1	3	4	6	7	14	28	42	55	69	83	97	111	125	139
100	0	2	3	5	6	8	15	31	46	62	77	92	108	123	139	154

Table 40 Puffin annual displacement matrix (based on an abundance of 291 for Green Volt array area plus 2 km buffer).

Displacement (%)	Mortality rates (%)															
	0	1	2	3	4	5	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1	1	1	1	2	2	2	3	3
10	0	0	1	1	1	1	3	6	9	12	15	17	20	23	26	29
20	0	1	1	2	2	3	6	12	17	23	29	35	41	47	52	58
30	0	1	2	3	3	4	9	17	26	35	44	52	61	70	79	87
40	0	1	2	3	5	6	12	23	35	47	58	70	81	93	105	116
50	0	1	3	4	6	7	15	29	44	58	73	87	102	116	131	146
60	0	2	3	5	7	9	17	35	52	70	87	105	122	140	157	175
70	0	2	4	6	8	10	20	41	61	81	102	122	143	163	183	204
80	0	2	5	7	9	12	23	47	70	93	116	140	163	186	210	233
90	0	3	5	8	10	13	26	52	79	105	131	157	183	210	236	262
100	0	3	6	9	12	15	29	58	87	116	146	175	204	233	262	291

4. References

Furness, R.W. (2015). Non-breeding season populations of seabirds in UK waters; Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Reports, Number 164.

Seabird Monitoring Programme (2022). https://app.bto.org/seabirds/public/data.jsp

Statutory Nature Conservation Bodies (updated, 2022). Joint SNCBs Interim Displacement Advice Note: Advice on how to present assessment information on the extent and potential consequences of seabird displacement from Offshore Wind Farm (OWF) developments. SNCBs (Natural Resources Wales (NRW), Department of Agriculture, Environment and Rural Affairs / Northern Ireland Environment Agency (DAERA/NIEA), Natural England (NE), Scottish Natural Heritage (SNH) and Joint Nature Conservation Committee (JNCC)).

GREEN VOLT

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