Morven South Offshore Wind Array Project

Environmental Impact Assessment Report

Volume 3, Annex 11.4: Offshore Ornithology Displacement Modelling Report (Matrix Approach)

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1 Introduction

1.1 Background

1.1.1.1 Seabirds can be impacted by offshore wind farm developments in a number of ways, including collision, displacement, barrier effects and disturbance, as well as indirect impacts such as changes to prey availability. Disturbance as the result of activities during the construction, operations and maintenance and decommissioning phases of an offshore wind farm has the potential to displace seabirds from an area of sea in which the activity is occurring. In relation to offshore wind farm development, displacement is defined as a reduction in the number of seabirds occurring within or immediately adjacent to an offshore wind farm (Furness *et al*., 2013).

1.1.1.2 Species differ greatly in their susceptibility to disturbance. Species sensitivity to disturbance in response to offshore wind farms has been quantified by Garthe and Hüppop (2004), Furness *et al*. (2013), Bradbury *et al*. (2014) and Wade *et al*. (2016). During the operations and maintenance phase, the presence of operational wind turbines has the potential to directly disturb seabirds leading to displacement from the Morven South Offshore Wind Array Project (hereafter 'Morven South') Boundary, including a buffer around it.

1.1.1.3 As the result of disturbance, displaced birds may move to areas already occupied by other birds and thus face higher intra/inter-specific competition due to a higher density of individuals competing for the same resource. Alternatively, displaced birds may be forced to move into areas of lower quality (e.g. areas of lower prey availability). Such disturbance and resulting displacement could ultimately affect their demographic fitness (i.e. survival rates and breeding productivity) as well as potentially impacting on other birds in areas that displaced birds move to. Changes in mortality levels of displaced birds have been established for waders (e.g. Burton *et al*., 2006).

1.1.1.4 There is however a lack of empirical evidence on the consequence of displacement of seabirds, in terms of both their survival and productivity. In waterbirds such as waders, geese and seaducks, simulations using Individual-Based Models (IBMs) have demonstrated changes to mortality as the result of changes in energy budgets of individuals (Pettifor *et al*., 2000; West *et al*., 2003; Kaiser *et al*., 2002). IBMs are rarely used to predict the fate of displaced seabirds due to offshore wind farms and impacts on fitness (Topping and Petersen, 2011).

1.1.1.5 Statutory Nature Conservation Bodies (SNCBs) have produced joint guidance to assess seabird displacement associated with offshore wind farms (Joint Nature Conservation Committee (JNCC) *et al*., 2022) with NatureScot also having produced guidance specific to assessments in Scottish waters (NatureScot, 2023a). The guidelines promote the use of a displacement matrix approach (i.e. representing proportions of seabirds potentially displaced or mortalities as a result of an offshore wind farm development). Both JNCC *et al*. (2022) and NatureScot (2023a) detail that any effects from disturbance and displacement are expected to be spatially limited to the offshore wind farm footprint and within close proximity (birds are impacted by displacement up to 2 kilometres (km) from the wind farm footprint for most species, with displacement up to 4km considered for divers and seaducks (and in some cases up to 10km) due to being the most sensitive species groups to disturbance from sound, boat and helicopter traffic).

1.1.1.6 The displacement assessment for Morven South makes use of the displacement matrix approach alongside the SeabORD application (Searle *et al*., 2018) as recommended by NatureScot in pre-application consultation (see Volume 1, Chapter 5: Consultation, of the Environmental Impact Assessment (EIA) Report). The methodology and outputs from SeabORD modelling are provided in Volume 3, Annex 11.5: Offshore Ornithology Displacement Modelling Report (SeabORD).

1.2 Aim of the report

1.2.1.1 This report presents the method and results of the matrix table approach to seabird displacement assessment resulting from Morven South during the construction, operations and maintenance, and

decommissioning phases. The analyses incorporate those species identified as Valued Ornithological Receptors (VORs) in Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report that are vulnerable to displacement effects.

2 Methodology

2.1 Species for consideration

2.1.1.1 The full process applied to identify VORs that may be affected by impacts associated with Morven South is documented in Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report. VORs that are potentially affected by displacement are those:

- Known to be vulnerable to displacement impacts (based on Wade *et al*., 2016; Bradbury *et al*., 2014) (Table 2.1) (i.e. a score of moderate or higher) with the uncertainty level associated with the vulnerability scores also taken into account;
- Where the population of the species observed at the Morven South Offshore Ornithology Study Area (as defined in Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report) is considered to be of importance, when compared against a relevant population scale thresholds (regional, national or international) as described in Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report;
- Where an SNCB recommends the consideration of a species in the assessment of displacement from offshore wind farms.

2.1.1.2 Table 2.1 identifies those VORs for which displacement analysis is required based on the above criteria.

Table 2.1: Identification of VORs for which analysis of displacement for Morven South is required

VOR	Vulnerability to displacement impacts	Uncertainty level associated with vulnerability rating	Importance of population at Morven North	Displacement analysis required (Yes/No)
Kittiwake (*Rissa tridactyla*)	Low	Very Low	Local	Yes – low vulnerability, very low associated uncertainty, species recorded in locally important numbers at Morven South. However, NatureScot recommend the inclusion of this species in displacement assessments.
Little gull (*Hydrocoloeus minutus*)	Very Low	N/A	Negligible	No – very low vulnerability, species not recorded in baseline surveys
Great black-backed gull (*Larus marinus*)	Low	Very Low	Local	No – low vulnerability, very low associated uncertainty, species recorded in locally important numbers at Morven South
Sandwich tern (*Thalasseus sandvicensis*)	Low	Low	Negligible	No – low vulnerability and species not recorded during baseline surveys
Little tern (*Sternula albifrons*)	Low	Moderate	Negligible	No – low vulnerability and species not recorded during baseline surveys
Roseate tern (*Sterna dougallii*)	Low	High	Negligible	No – low vulnerability and species not recorded during baseline surveys
Common tern (*Sterna hirundo*)	Low	Low	Negligible	No – low vulnerability, and species not recorded in relevant study area during baseline surveys

VOR	Vulnerability to displacement impacts	Uncertainty level associated with vulnerability rating	Importance of population at Morven North	Displacement analysis required (Yes/No)
Arctic tern (*Sterna paradisaea*)	Low	Moderate	National	No – low vulnerability and although species recorded in nationally important numbers, occurrence is considered to represent passage birds as there are no breeding colonies within foraging range
Great skua (*Stercorarius skua*)	Very Low	High	Local	No – low vulnerability and species occurrence at Morven South limited
Arctic skua (*Stercorarius parasiticus*)	Very Low	Very High	Negligible	No – low vulnerability, and species not recorded in relevant study area during baseline surveys
Common guillemot (*Uria aalge*)	High	Very Low	Regional	Yes – high vulnerability, species recorded in regionally important numbers at Morven South. NatureScot also recommend the inclusion of this species in displacement assessments.
Razorbill (*Alca torda*)	High	Very Low	Regional	Yes – high vulnerability, species recorded in regionally important numbers at Morven South. NatureScot also recommend the inclusion of this species in displacement assessments.
Puffin (*Fratercula arctica*)	Moderate	Moderate	Local	Yes – moderate vulnerability, recorded in the majority of baseline surveys. NatureScot also recommend the inclusion of this species in displacement assessments.

VOR	Vulnerability to displacement impacts	Uncertainty level associated with vulnerability rating	Importance of population at Morven North	Displacement analysis required (Yes/No)
European storm petrel (*Hydrobates pelagicus*)	Very Low	Very High	Negligible	No – very low vulnerability and species not recorded during baseline surveys
Leach's petrel (*Oceanodroma leucorhoa*)	Very Low	Very High	Negligible	No – very low vulnerability and species not recorded during baseline surveys
Fulmar (*Fulmarus glacialis*)	Very Low	High	Local	No– very low vulnerability although note uncertainty is high. Species also has a high habitat flexibility. Species only recorded in locally important numbers at Morven South. However, NatureScot have recommended the inclusion of this species in displacement assessments (11 July 2025).
Manx shearwater (*Puffinus puffinus*)	Very Low	Very High	Regional	No – vulnerability is very low, although the associated uncertainty is very high. Although population estimates surpassed importance thresholds, the species was only recorded in two baseline surveys
Gannet (*Morus bassanus*)	High	Very Low	Local	Yes – high vulnerability, recorded in majority of baseline surveys. NatureScot also recommend the inclusion of this species in displacement assessments.

2.1.1.3 The following species were selected for displacement analysis:

- Kittiwake (included on the advice of NatureScot);
- Guillemot (high vulnerability, regional population importance);
- Razorbill (high vulnerability, regional population importance);
- Puffin (moderate vulnerability, recorded in the majority of baseline surveys);
- Fulmar (included on the advice of NatureScot);
- Gannet (high vulnerability and although only of local population importance, species recorded in the majority of surveys).

2.2 Abundance estimates and seasonality

2.2.1.1 Digital aerial surveys of the Morven North Offshore Wind Array Project (hereafter 'Morven North') and Morven South were undertaken between January 2021 and September 2023. Further information on the aerial surveys undertaken for Morven South and the methodologies used to derive population estimates is provided in the Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report. During pre-application consultation with NatureScot (see Volume 1, Chapter 5: Consultation, of the Morven South EIA Report) it was advised that due to the planned application date for Morven South (Quarter 2, 2026), only data from October 2021 to September 2023 (representing the standard 24 months of baseline data) should be used for baseline characterisation to avoid data being older than the five year data cut-off at the point of application (NatureScot, 2023b). Whilst this temporal extent corresponds with the seasonal extents for gannet it foreshortens the non-breeding seasons defined for other species. Morven Offshore Wind Limited (MvOWL, hereafter referred to as "the Applicant") has therefore agreed with NatureScot through additional targeted consultation (April 2025) and consultation meetings (28 May 2025) that data prior to October 2021 can be used to allow for the consideration of two complete seasonal extents for each species (see Volume 1, Chapter 5: Consultation). This therefore leads to a dataset with a temporal extent of July 2021 to September 2023 providing two full seasonal extents for each species identified in Section 2.1.

2.2.1.2 Seasons have been defined based on NatureScot advice (breeding season) (NatureScot, 2020) with non-breeding seasons split, where necessary, based on the seasonal extents defined in Furness (2015) with priority given to the breeding season where overlaps exist (Table 2.2). Where the seasonal extents presented in NatureScot (2020) begin or end within a month, the middle of the month was used as the cut off for inclusion in either the breeding or relevant non-breeding season. Months were assigned to a season based on the day that the site-specific survey from which abundance estimates were calculated was flown. Timings of each survey can be found in Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report.

2.2.1.3 In the case of guillemot and razorbill, further advice has been sought from NatureScot regarding seasonality, and the inclusion of alternative seasons for use in displacement analyses for these species (see Volume 1, Chapter 5: Consultation). This advice, and full descriptions and justifications of changes to the seasonal extents used for these two species can be found in Appendix B. It was agreed that peak abundances of both guillemot and razorbill in the Morven South Boundary occurring late in the breeding season likely represents post-breeding dispersal of birds from breeding colonies. This aligns with the phenology provided in Furness (2015), which describes modal dispersal from breeding colonies as taking place in July and colonies being deserted by August. It also aligns with fledging data from the Isle of May from 2021 to 2023, where chicks fledge between late June and early August (see Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report).

2.2.1.4 In the case of guillemot, NatureScot advised during a consultation meeting undertaken on 28 May 2025 that July and August should be included in a post-breeding season, where the abundance estimates were higher than those recorded in surrounding months. In the case of Morven South, a post-breeding season comprising July and August 2022 and July 2023 has been defined. Justification for the inclusion of these months in the post-breeding season is provided in Appendix B.

2.2.1.5 In the case of razorbill, NatureScot has advised that the post-breeding season should be extended to include the months in which peak abundance was recorded during the digital aerial surveys; in this case, this means including July and August in the post-breeding season rather than the breeding season.

Table 2.2: Seasonal definitions as the basis for assessment, from NatureScot (2020) and Furness (2015) and after additional advice from NatureScot taking into account the date each baseline survey was flown

Species	Pre-breeding season/spring migration	Breeding season	Post breeding season/autumn migration	Non-breeding/winter season
Kittiwake	January to April 2022 and 2023	May to August 2022 and 2023	September to December 2021 and 2022	n/a
Gannet	December to March 2021/22 and 2022/23	April to September 2022 and 2023	October to November 2021 and 2022	n/a
Guillemot	n/a	April to June 2022 and 2023	July and August 2022 and July 2023	August 2021 to March 2022 and September 2022 to March 2023
Razorbill	January to March 2022 and 2023	April to June 2022 and April to July 2023	July to October 2021 and 2022	November to December 2021 and 2022
Puffin	n/a	April to August 2022 and 2023	n/a	September to March 2021/22 and 2022/23
Fulmar	December to March 2021/22 and 2022/23	April to September 2022 and 2023	October 2021 and 2022	November 2021 and 2022

2.2.1.6 Population estimates for each species for relevant months have been calculated using data relevant to Morven South plus an appropriate buffer as recommended in JNCC *et al*. (2022) and NatureScot (2023a). For those species identified in Section 2.1, a 2km buffer is considered appropriate to inform assessment of displacement. No species for which a 4km displacement buffer (or 10km buffer in some cases) around the wind farm would typically be applied (i.e. those with a Very High vulnerability to displacement (e.g. common scoter and red-throated diver) were selected for inclusion in the analyses presented in this Annex due to these species being absent during aerial surveys of Morven South.

2.2.1.7 Model-based estimates using the Marine Renewables Strategic environmental assessment (MRSea) package were produced to predict bird numbers across the survey area alongside 95% confidence intervals (CIs) to provide a level of uncertainty. Design based estimates for bird numbers and densities in each month were also generated and compared to the MRSea estimates. This provides additional validation of the MRSea outputs and provides estimates for months where low raw abundances prevented the use of the MRSea model, if required. A full description of the methodology applied for both of these abundance estimation approaches is provided in Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report.

2.2.1.8 The primary data that informs the basis for the assessment of displacement effects are seasonal mean-peak population estimates including seabirds both on the water and in flight within Morven

South plus a 2km buffer. The monthly data used to calculate these populations are presented in Appendix A. Seasonal mean-peak population estimates of each species were calculated using the defined seasons identified in Table 2.2 to provide the number of seabirds at risk of displacement impacts (Table 2.3). The use of a mean-peak population allows for consideration of inter-annual variability (JNCC *et al*., 2022).

Table 2.3: Mean peak abundances for use in the assessment for each bio-season from model-based abundance estimation

Species	Pre-breeding season/spring migration	Breeding season	Post breeding season/autumn migration	Non-breeding/winter season
Kittiwake	112	394	280	n/a
Gannet	43	366	89	n/a
Guillemot	n/a	835	8,980	2,498
Razorbill	89	57	2,935	403
Puffin	n/a	106	n/a	433
Fulmar	182	257	249	299

2.3 Displacement and mortality rates

2.3.1.1 Displacement matrices are presented in section 3 for each species and associated seasons. Potential displacement impacts for each species are presented based on a wide range of potential displacement (0 to 100%) and mortality rates (0 to 100%) following SNCB guidance (JNCC *et al*., 2022). In addition, the displacement and mortality rates identified following the guidance in NatureScot (2023a) and those considered by the Applicant based on the evidence presented in section 4 are highlighted. The displacement and mortality rates defined based on guidance in NatureScot (2023a) and for fulmar only, subsequent advice provided by NatureScot to the Applicant (11 July 2025) are summarised in Table 2.4.

Table 2.4: Displacement and mortality rates applied for each species

Species	Displacement rate (%)		Mortality rate (%)		
	NatureScot	Applicant	NatureScot		Applicant
			Breeding season	Non-breeding season	All seasons
Kittiwake	30	30	1 and 3	1 and 3	1
Guillemot	60	50	3 and 5	1 and 3	1
Razorbill	60	50	3 and 5	1 and 3	1
Puffin	60	50	3 and 5	1 and 3	1
Gannet	70	70	1 and 3	1 and 3	1
Fulmar	20	10	1 and 3	1 and 3	1

3 Results

3.1.1.1 Displacement matrices for all species and associated seasons are presented in the following species-specific sections. In all matrices cells that are filled with yellow represent the displacement mortality when the displacement and mortality rates recommended by the Applicant are applied. Cells with purple borders represent the displacement mortality when the displacement and mortality rates recommended by NatureScot are applied.

3.2 Kittiwake

3.2.1.1 Displacement matrices for kittiwake in the pre-breeding, breeding, and post-breeding seasons are presented in Table 3.1, Table 3.2, and Table 3.3, respectively.

Table 3.1: Predicted kittiwake mortality for Morven South plus 2km buffer during the pre-breeding season

Kittiwake (pre-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	1	1	2	3	4	6	7	8	9	10	11
	20	0	1	1	2	4	7	9	11	13	16	18	20	22
	30	0	1	2	3	7	10	13	17	20	24	27	30	34
	40	0	1	2	4	9	13	18	22	27	31	36	40	45
	50	1	2	3	6	11	17	22	28	34	39	45	51	56
	60	1	2	3	7	13	20	27	34	40	47	54	61	67
	70	1	2	4	8	16	24	31	39	47	55	63	71	79
	80	1	3	4	9	18	27	36	45	54	63	72	81	90
	90	1	3	5	10	20	30	40	51	61	71	81	91	101
	100	1	3	6	11	22	34	45	56	67	79	90	101	112

Table 3.2: Predicted kittiwake mortality for Morven South plus 2km buffer during the breeding season

Kittiwake (breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	1	2	4	8	12	16	20	24	28	31	35	39
	20	1	2	4	8	16	24	31	39	47	55	63	71	79
	30	1	4	6	12	24	35	47	59	71	83	94	106	118
	40	2	5	8	16	31	47	63	79	94	110	126	142	157
	50	2	6	10	20	39	59	79	98	118	138	157	177	197
	60	2	7	12	24	47	71	94	118	142	165	189	212	236
	70	3	8	14	28	55	83	110	138	165	193	220	248	275
	80	3	9	16	31	63	94	126	157	189	220	252	283	315
	90	4	11	18	35	71	106	142	177	212	248	283	319	354
	100	4	12	20	39	79	118	157	197	236	275	315	354	394

Table 3.3: Predicted kittiwake mortality for Morven South plus 2km buffer during the post-breeding season

Kittiwake (post-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	1	1	3	6	8	11	14	17	20	22	25	28
	20	1	2	3	6	11	17	22	28	34	39	45	50	56
	30	1	3	4	8	17	25	34	42	50	59	67	76	84
	40	1	3	6	11	22	34	45	56	67	78	90	101	112
	50	1	4	7	14	28	42	56	70	84	98	112	126	140
	60	2	5	8	17	34	50	67	84	101	118	134	151	168
	70	2	6	10	20	39	59	78	98	118	137	157	176	196
	80	2	7	11	22	45	67	90	112	134	157	179	202	224
	90	3	8	13	25	50	76	101	126	151	176	202	227	252
	100	3	8	14	28	56	84	112	140	168	196	224	252	280

3.3 Gannet

3.3.1.1 Displacement matrices for gannet in the pre-breeding, breeding, and post-breeding seasons are presented in Table 3.4, Table 3.5 and Table 3.6, respectively.

Table 3.4: Predicted gannet mortality for Morven South plus 2km buffer during the pre-breeding season

Gannet (pre-breeding)		Mortality rate (%)												
		1	**3**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Displacement rate (%)	**10**	0	0	0	0	1	1	2	2	3	3	3	4	4
	20	0	0	0	1	2	3	3	4	5	6	7	8	9
	30	0	0	1	1	3	4	5	6	8	9	10	12	13
	40	0	1	1	2	3	5	7	9	10	12	14	16	17
	50	0	1	1	2	4	6	9	11	13	15	17	19	22
	60	0	1	1	3	5	8	10	13	16	18	21	23	26
	70	0	1	2	3	6	9	12	15	18	21	24	27	30
	80	0	1	2	3	7	10	14	17	21	24	28	31	35
	90	0	1	2	4	8	12	16	19	23	27	31	35	39
	100	0	1	2	4	9	13	17	22	26	30	35	39	43

Table 3.5: Predicted gannet mortality for Morven South plus 2km buffer during the breeding season

Gannet (breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	1	2	4	7	11	15	18	22	26	29	33	37
	20	1	2	4	7	15	22	29	37	44	51	59	66	73
	30	1	3	5	11	22	33	44	55	66	77	88	99	110
	40	1	4	7	15	29	44	59	73	88	103	117	132	147
	50	2	5	9	18	37	55	73	92	110	128	147	165	183
	60	2	7	11	22	44	66	88	110	132	154	176	198	220
	70	3	8	13	26	51	77	103	128	154	179	205	231	256
	80	3	9	15	29	59	88	117	147	176	205	234	264	293
	90	3	10	16	33	66	99	132	165	198	231	264	297	330
	100	4	11	18	37	73	110	147	183	220	256	293	330	366

Table 3.6: Predicted gannet mortality for Morven South plus 2km buffer during the post-breeding season

Gannet (post-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	0	1	2	3	4	4	5	6	7	8	9
	20	0	1	1	2	4	5	7	9	11	13	14	16	18
	30	0	1	1	3	5	8	11	13	16	19	21	24	27
	40	0	1	2	4	7	11	14	18	21	25	29	32	36
	50	0	1	2	4	9	13	18	22	27	31	36	40	45
	60	1	2	3	5	11	16	21	27	32	38	43	48	54
	70	1	2	3	6	13	19	25	31	38	44	50	56	63
	80	1	2	4	7	14	21	29	36	43	50	57	64	72
	90	1	2	4	8	16	24	32	40	48	56	64	72	81
	100	1	3	4	9	18	27	36	45	54	63	72	81	89

3.4 Guillemot

3.4.1.1 Displacement matrices for guillemot in the breeding and non-breeding seasons are presented in Table 3.7 and Table 3.9 respectively. Displacement matrices for the additional post-breeding season introduced after advice from NatureScot are presented in Table 3.8.

Table 3.7: Predicted guillemot mortality for Morven South plus 2km buffer during the breeding season

Guillemot (breeding)		Mortality rate (%)												
		1	**3**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Displacement rate (%)	**10**	1	3	4	8	17	25	33	42	50	58	67	75	84
	20	2	5	8	17	33	50	67	84	100	117	134	150	167
	30	3	8	13	25	50	75	100	125	150	175	200	226	251
	40	3	10	17	33	67	100	134	167	200	234	267	301	334
	50	4	13	21	42	84	125	167	209	251	292	334	376	418
	60	5	15	25	50	100	150	200	251	301	351	401	451	501
	70	6	18	29	58	117	175	234	292	351	409	468	526	585
	80	7	20	33	67	134	200	267	334	401	468	535	601	668
	90	8	23	38	75	150	226	301	376	451	526	601	677	752
	100	8	25	42	84	167	251	334	418	501	585	668	752	835

Table 3.8: Predicted guillemot mortality for Morven South plus 2km buffer during the post-breeding season

Guillemot (post-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	9	27	45	90	180	269	359	449	539	629	718	808	898
	20	18	54	90	180	359	539	718	898	1,078	1,257	1,437	1,616	1,796
	30	27	81	135	269	539	808	1,078	1,347	1,616	1,886	2,155	2,425	2,694
	40	36	108	180	359	718	1,078	1,437	1,796	2,155	2,515	2,874	3,233	3,592
	50	45	135	225	449	898	1,347	1,796	2,245	2,694	3,143	3,592	4,041	4,490
	60	54	162	269	539	1,078	1,616	2,155	2,694	3,233	3,772	4,311	4,849	5,388
	70	63	189	314	629	1,257	1,886	2,515	3,143	3,772	4,400	5,029	5,658	6,286
	80	72	216	359	718	1,437	2,155	2,874	3,592	4,311	5,029	5,747	6,466	7,184
	90	81	242	404	808	1,616	2,425	3,233	4,041	4,849	5,658	6,466	7,274	8,082
	100	90	269	449	898	1,796	2,694	3,592	4,490	5,388	6,286	7,184	8,082	8,980

Table 3.9: Predicted guillemot mortality for Morven South plus 2km buffer during the non-breeding season

Guillemot (non-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	2	7	12	25	50	75	100	125	150	175	200	225	250
	20	5	15	25	50	100	150	200	250	300	350	400	450	500
	30	7	22	37	75	150	225	300	375	450	525	600	674	749
	40	10	30	50	100	200	300	400	500	600	699	799	899	999
	50	12	37	62	125	250	375	500	624	749	874	999	1,124	1,249
	60	15	45	75	150	300	450	600	749	899	1,049	1,199	1,349	1,499
	70	17	52	87	175	350	525	699	874	1,049	1,224	1,399	1,574	1,749
	80	20	60	100	200	400	600	799	999	1,199	1,399	1,599	1,799	1,998
	90	22	67	112	225	450	674	899	1,124	1,349	1,574	1,799	2,023	2,248
	100	25	75	125	250	500	749	999	1,249	1,499	1,749	1,998	2,248	2,498

3.5 Razorbill

3.5.1.1 Displacement matrices for razorbill in the pre-breeding, breeding, post-breeding, and non-breeding seasons are presented in Table 3.10, Table 3.11, Table 3.12, and, Table 3.13 respectively.

Table 3.10: Predicted razorbill mortality for Morven South plus 2km buffer during the pre-breeding season

Razorbill (post-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	0	1	2	3	4	4	5	6	7	8	9
	20	0	1	1	2	4	5	7	9	11	13	14	16	18
	30	0	1	1	3	5	8	11	13	16	19	21	24	27
	40	0	1	2	4	7	11	14	18	21	25	29	32	36
	50	0	1	2	4	9	13	18	22	27	31	36	40	45
	60	1	2	3	5	11	16	21	27	32	38	43	48	54
	70	1	2	3	6	13	19	25	31	38	44	50	56	63
	80	1	2	4	7	14	21	29	36	43	50	57	64	71
	90	1	2	4	8	16	24	32	40	48	56	64	72	80
	100	1	3	4	9	18	27	36	45	54	63	71	80	89

Table 3.11: Predicted razorbill mortality for Morven South plus 2km buffer during the breeding season

Razorbill (breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	0	1	1	2	2	3	3	4	5	5	6
	20	0	0	1	1	2	3	5	6	7	8	9	10	11
	30	0	1	1	2	3	5	7	8	10	12	14	15	17
	40	0	1	1	2	5	7	9	11	14	16	18	20	23
	50	0	1	1	3	6	8	11	14	17	20	23	25	28
	60	0	1	2	3	7	10	14	17	20	24	27	31	34

Razorbill (breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
	70	0	1	2	4	8	12	16	20	24	28	32	36	40
	80	0	1	2	5	9	14	18	23	27	32	36	41	45
	90	1	2	3	5	10	15	20	25	31	36	41	46	51
	100	1	2	3	6	11	17	23	28	34	40	45	51	57

Table 3.12: Predicted razorbill mortality for Morven South plus 2km buffer during the post-breeding season

Razorbill (post-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	3	9	15	29	59	88	117	147	176	205	235	264	294
	20	6	18	29	59	117	176	235	294	352	411	470	528	587
	30	9	26	44	88	176	264	352	440	528	616	704	792	881
	40	12	35	59	117	235	352	470	587	704	822	939	1,057	1,174
	50	15	44	73	147	294	440	587	734	881	1,027	1,174	1,321	1,468
	60	18	53	88	176	352	528	704	881	1,057	1,233	1,409	1,585	1,761
	70	21	62	103	205	411	616	822	1,027	1,233	1,438	1,644	1,849	2,055
	80	23	70	117	235	470	704	939	1,174	1,409	1,644	1,878	2,113	2,348
	90	26	79	132	264	528	792	1,057	1,321	1,585	1,849	2,113	2,377	2,642
	100	29	88	147	294	587	881	1,174	1,468	1,761	2,055	2,348	2,642	2,935

Table 3.13: Predicted razorbill mortality for Morven South plus 2km buffer during the non-breeding season

Razorbill (non-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	1	2	4	8	12	16	20	24	28	32	36	40
	20	1	2	4	8	16	24	32	40	48	56	65	73	81
	30	1	4	6	12	24	36	48	61	73	85	97	109	121
	40	2	5	8	16	32	48	65	81	97	113	129	145	161
	50	2	6	10	20	40	61	81	101	121	141	161	182	202
	60	2	7	12	24	48	73	97	121	145	169	194	218	242
	70	3	8	14	28	56	85	113	141	169	198	226	254	282
	80	3	10	16	32	65	97	129	161	194	226	258	290	323
	90	4	11	18	36	73	109	145	182	218	254	290	327	363
	100	4	12	20	40	81	121	161	202	242	282	323	363	403

3.6 Puffin

3.6.1.1 Displacement matrices for puffin in the breeding and non-breeding seasons are presented in Table 3.14 and Table 3.15, respectively.

Table 3.14: Predicted puffin mortality for Morven South plus 2km buffer during the breeding season

Puffin (breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	1	1	2	3	4	5	6	7	8	10	11
	20	0	1	1	2	4	6	8	11	13	15	17	19	21
	30	0	1	2	3	6	10	13	16	19	22	25	29	32
	40	0	1	2	4	8	13	17	21	25	30	34	38	42
	50	1	2	3	5	11	16	21	27	32	37	42	48	53
	60	1	2	3	6	13	19	25	32	38	45	51	57	64

Puffin (breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
	70	1	2	4	7	15	22	30	37	45	52	59	67	74
	80	1	3	4	8	17	25	34	42	51	59	68	76	85
	90	1	3	5	10	19	29	38	48	57	67	76	86	96
	100	1	3	5	11	21	32	42	53	64	74	85	96	106

Table 3.15: Predicted puffin mortality for Morven South plus 2km buffer during the non-breeding season

Puffin (non-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	1	2	4	9	13	17	22	26	30	35	39	43
	20	1	3	4	9	17	26	35	43	52	61	69	78	87
	30	1	4	6	13	26	39	52	65	78	91	104	117	130
	40	2	5	9	17	35	52	69	87	104	121	139	156	173
	50	2	6	11	22	43	65	87	108	130	152	173	195	217
	60	3	8	13	26	52	78	104	130	156	182	208	234	260
	70	3	9	15	30	61	91	121	152	182	212	243	273	303
	80	3	10	17	35	69	104	139	173	208	243	277	312	347
	90	4	12	19	39	78	117	156	195	234	273	312	351	390
	100	4	13	22	43	87	130	173	217	260	303	347	390	433

3.7 Fulmar

3.7.1.1 Displacement matrices for fulmar in the pre-breeding, breeding, post-breeding and non-breeding seasons are presented in Table 3.16, Table 3.17, Table 3.18 and Table 3.19, respectively.

Table 3.16: Predicted fulmar mortality for Morven South plus 2km buffer during the pre-breeding season

Fulmar (pre-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	1	0	0	0	0	0	1	1	1	1	1	1	2	2
	2	0	0	0	0	1	1	1	2	2	3	3	3	4
	5	0	0	0	1	2	3	4	5	5	6	7	8	9
	10	0	0	1	2	4	5	7	9	11	13	15	16	18
	20	0	1	2	4	7	11	15	18	22	26	29	33	36
	30	1	1	3	5	11	16	22	27	33	38	44	49	55
	40	1	1	4	7	15	22	29	36	44	51	58	66	73
	50	1	2	5	9	18	27	36	46	55	64	73	82	91
	60	1	2	5	11	22	33	44	55	66	77	87	98	109
	70	1	3	6	13	26	38	51	64	77	89	102	115	128
	80	1	3	7	15	29	44	58	73	87	102	117	131	146
	90	2	3	8	16	33	49	66	82	98	115	131	148	164
	100	2	4	9	18	36	55	73	91	109	128	146	164	182

Table 3.17: Predicted fulmar mortality for Morven South plus 2km buffer during the breeding season

Fulmar (breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	1	0	0	0	0	1	1	1	1	2	2	2	2	3
	2	0	0	0	1	1	2	2	3	3	4	4	5	5
	5	0	0	1	1	3	4	5	6	8	9	10	12	13
	10	0	1	1	3	5	8	10	13	15	18	21	23	26
	20	1	1	3	5	10	15	21	26	31	36	41	46	51
	30	1	2	4	8	15	23	31	39	46	54	62	69	77
	40	1	2	5	10	21	31	41	51	62	72	82	92	103
	50	1	3	6	13	26	39	51	64	77	90	103	116	128
	60	2	3	8	15	31	46	62	77	92	108	123	139	154
	70	2	4	9	18	36	54	72	90	108	126	144	162	180
	80	2	4	10	21	41	62	82	103	123	144	164	185	206
	90	2	5	12	23	46	69	92	116	139	162	185	208	231
	100	3	5	13	26	51	77	103	128	154	180	206	231	257

Table 3.18: Predicted fulmar mortality for Morven South plus 2km buffer during the post-breeding season

Fulmar (post-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	1	0	0	0	0	0	1	1	1	1	2	2	2	2
	2	0	0	0	0	1	1	2	2	3	3	4	4	5
	5	0	0	1	1	2	4	5	6	7	9	10	11	12
	10	0	0	1	2	5	7	10	12	15	17	20	22	25
	20	0	1	2	5	10	15	20	25	30	35	40	45	50
	30	1	1	4	7	15	22	30	37	45	52	60	67	75

Fulmar (post-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
	40	1	2	5	10	20	30	40	50	60	70	80	90	100
	50	1	2	6	12	25	37	50	62	75	87	100	112	124
	60	1	3	7	15	30	45	60	75	90	105	119	134	149
	70	2	3	9	17	35	52	70	87	105	122	139	157	174
	80	2	4	10	20	40	60	80	100	119	139	159	179	199
	90	2	4	11	22	45	67	90	112	134	157	179	202	224
	100	2	5	12	25	50	75	100	124	149	174	199	224	249

Table 3.19: Predicted fulmar mortality for Morven South plus 2km buffer during the non-breeding season

Fulmar (non-breeding)		Mortality rate (%)												
		1	3	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	1	0	0	0	0	1	1	1	1	2	2	2	3	3
	2	0	0	0	1	1	2	2	3	4	4	5	5	6
	5	0	0	1	1	3	4	6	7	9	10	12	13	15
	10	0	1	1	3	6	9	12	15	18	21	24	27	30
	20	1	1	3	6	12	18	24	30	36	42	48	54	60
	30	1	2	4	9	18	27	36	45	54	63	72	81	90
	40	1	2	6	12	24	36	48	60	72	84	96	108	120
	50	1	3	7	15	30	45	60	75	90	105	120	135	149
	60	2	4	9	18	36	54	72	90	108	126	143	161	179
	70	2	4	10	21	42	63	84	105	126	146	167	188	209
	80	2	5	12	24	48	72	96	120	143	167	191	215	239
	90	3	5	13	27	54	81	108	135	161	188	215	242	269
	100	3	6	15	30	60	90	120	149	179	209	239	269	299

4 Discussion

4.1 Evidence-based displacement and mortality rates

4.1.1.1 Since displacement sensitivity varies between species, the displacement rates and associated mortality rates used to assess the effects displacement from Morven South for the Applicant's position have been derived from previous studies, guidance documents and advice received by SNCBs.

4.1.1.2 There is limited empirical evidence on which mortality rate to use when assessing the impacts of displacement of offshore wind farms, however, the current SNCBs guidance, based on expert opinion, is to consider a mortality rate of up to 10% (JNCC *et al*., 2022). Van Kooten *et al*. (2019) studied the effects of displacement on seabirds using energy-budget models for two scenarios using habitat utilization maps and a fixed 10% mortality rate. The evidence from this study suggests that a 1% mortality rate for displaced birds is more appropriate than the potentially over-precautionary 10% mortality rate. Similarly, Searle *et al*. (2014; 2018) used time and energy budget models to investigate the effects of displacement and barrier effects on breeding populations of seabirds, including auks during the chick rearing period. The study reported changes in time and energy budgets which could impact future survival of auks, however the simulations concluded that the displacement effects were unlikely to result in a mortality rate increase of over 0.5%. Therefore, in line with the advice from the JNCC *et al*. (2022), a 1% to 10% mortality of displaced individuals is presented for all species in this assessment, although the Applicant considers that 1% mortality rate to be the more likely impact based on the studies discussed above.

4.1.2 Kittiwake

4.1.2.1 Kittiwake are considered to have a moderate habitat flexibility and low vulnerability to displacement (Wade *et al*., 2016). However, NatureScot recommend that displacement effects are considered for kittiwake (NatureScot, 2023a).

4.1.2.2 Studies regarding the displacement at Egmond aan Zee Offshore Wind Farm (Leopold *et al*., 2011), Bligh Bank Offshore Wind Farm and Thorntonbank Offshore Wind Farm (Vanermen, 2013). Horns Rev Offshore Wind Farm, Princess Amalia Windpark (Furness, 2013) reported no significant displacement of kittiwake. A study by Peschko (2020) used a long-term dataset covering 14 years before and 3 years after the construction of Offshore Wind Farms in the southern North Sea to assess the displacement of kittiwake. They found a 45% decrease in density during the breeding season.

4.1.2.3 NatureScot advise a 30% displacement rate and 1% to 3% mortality rate for kittiwake in both the breeding and non-breeding season (Nature Scot, 2023) and when following joint SNCB guidance (JNCC *et al*., 2022) a 10% to 30% displacement rate range would be used. To assess the effects of displacement from Morven South on the kittiwake population in the area, a displacement rate of 30% is recommended by the Applicant with this corresponding with the displacement rate recommended by NatureScot. The Applicant recommends the use of a 1% mortality rate which aligns with one of the mortality rates recommended by NatureScot (1% and 3%).

4.1.3 Guillemot, razorbill and puffin

4.1.3.1 To assess the effects of displacement from Morven South on the guillemot, razorbill and puffin populations in the area, a displacement rate of 50% is recommended by the Applicant. This is slightly lower than the rate recommended by NatureScot (60%). The Applicant recommends the use of a 1% mortality rate in all seasons whereas NatureScot recommend the use of 3% and 5% in the breeding season and 1% and 3% in non-breeding seasons.

4.1.3.2 Evidence shows that auk species have a moderate vulnerability to displacement from structures and vessel and helicopter traffic (Wade *et al*., 2016). Furthermore, displacement impacts from post-

consent monitoring studies (from 13 different European offshore windfarm sites) have been collated and reviewed by Dierschke *et al*., (2016), which found auk species to show 'weak displacement' overall, but results were highly variable. Similarly, a recent review submitted by Hornsea Four Offshore Wind Farm (APEM, 2022) summarises all current post consent-monitoring studies undertaken to date within the UK waters and provides an extensive study and analysis of the empirical data from offshore wind farms. This review found that auk displacement varies considerably across different sites, with displacement rates ranging from +112% to -75%. However, this review concluded that a displacement rate of 50% and mortality rate of 1% was appropriate for use in relation to displacement assessments being undertaken for the Hornsea Four offshore wind farm. The review suggests that in areas of high abundance, displacement is limited and postulates that this may be due to higher importance of the underlying habitat to birds meaning birds are more likely to tolerate the presence of structures in the area. For areas with low abundance, displacement rates were increased and the review postulates that this may be that birds are able to forage in other areas as competition between birds is reduced. Although greater than 50% displacement was observed at five developments in the study, all had very low auk abundance of auks within the study area. Where auk abundance was greater, <50% displacement was recorded. Therefore, considering the abundance of auks at Morven South, a 50% displacement rate is considered appropriate for Morven South.

4.1.3.3 A recent study on displacement at the Beatrice offshore wind farm utilising an approach investigating the distribution of seabirds in relation to turbine locations suggested that auk species did not avoid turbines (MacArthur Green, 2023). The abundance of both guillemot and razorbill increased significantly from the pre-construction period into the post-construction period. This would suggest that these species are not displaced by offshore wind farms and that the use of a 50% displacement rate, as suggested by APEM (2022) is highly precautionary.

4.1.3.4 Based on the review of the relevant literature, a displacement rate of 50% has been deemed appropriate for auk species. This rate is considered to be highly precautionary as a study of offshore wind farms in the German North Sea found reduced displacement rates (~20%) of guillemots during the breeding season compared to the non-breeding season (Peschko *et al*., 2020) and the most recent studies have shown no displacement of auks (MacArthur Green, 2023). This is an important consideration as the mean displacement rates derived from the Dierschke *et al*. (2016) review were primarily from data collected in the non-breeding season. Therefore, by applying a single displacement rate of 50% across all seasons ensures a precautionary rate is used for the assessment.

4.1.3.5 Furthermore, evidence suggests that although auk species are somewhat sensitive to displacement, the effects are short-term, and studies indicate auk habituation to offshore windfarms. For example, a study at Thanet Offshore Windfarm found auk species became habituated in the post-construction period. The density of guillemot and razorbill decreased in the construction and first year of post-construction when compared to the pre-construction period and whilst the densities in subsequent post-construction years were lower than recorded during the pre-construction period, these differences were not significant (Percival, 2013). Further evidence is emerging through additional post-construction monitoring of offshore windfarms, for instance, there are reports of auk numbers increasing and observations of foraging behaviour within wind farm areas (Leopold and Verdaat, 2018). This suggests the displacement rates of auk species within Morven South will reduce over time.

4.1.4 Gannet

4.1.4.1 To assess the effects of displacement from Morven South on the gannet population in the area, a displacement rate of 70% is recommended by the Applicant. This corresponds with the displacement rate recommended by NatureScot. The Applicant recommends the use of a 1% mortality rate which aligns with one of the mortality rates recommended by NatureScot (1% and 3%).

4.1.4.2 Whilst evidence suggests that gannet show a limited vulnerability to disturbance from ship and helicopter traffic (Wade *et al*., 2016), the species avoidance rates to offshore wind farms can be high. Natural England recently reviewed nine studies that reported on gannet avoidance rates using a

variation of survey methods (Pavat *et al*., 2023). The avoidance rates reported range from 61.7% to 100%. Another review by APEM (2022) looked at studies across 25 offshore wind farms, over different seasons, and reported displacement rates of 40% to 60% during the breeding season, and 60% to 80% during the non-breeding season. In light of literature the use of a displacement rate of 70% has been deemed appropriate.

4.1.4.3 Based on expert judgement a mortality rate of 1% is considered appropriate. This decision is supported by additional evidence that suggests that gannet have a large mean-maximum (315km) and maximum (709km) foraging range (Woodward *et al*., 2019) and feed on a diverse range of prey items and thus displaced birds will have access to suitable alternative foraging opportunities despite the potential reduced foraging activities within Morven South.

4.1.5 Fulmar

4.1.5.1 Evidence has been interpreted to show that fulmar show a very low vulnerability to displacement from structures and vessel and helicopter traffic, though the uncertainty level associated with the vulnerability rating was high (Wade *et al*., 2016). A recent meta-analysis of 39 studies by Lamb *et al*. (2024) highlights this uncertainty, the synthetic analysis showing that less frequently observed species like fulmar exhibit few significant displacement events, yet when effects are detected, they tend to be strongly negative. This would suggest displacement may be underestimated in these species.

4.1.5.2 To assess the effects of displacement from Morven South on the fulmar population in the area, a displacement rate of 10% is recommended by the Applicant. This is slightly lower than the rate recommended by NatureScot (20%) when recommending the inclusion of this species in displacement assessments (11 July 2025). The Applicant recommends the use of a 1% mortality rate which aligns with one of the mortality rates recommended by NatureScot (1% and 3%).

5 References

APEM (2022) Hornsea Project Four Auk Displacement and Mortality Evidence Review. Available: https://infrastructure.planninginspectorate.gov.uk/wpcontent/ipc/uploads/projects/EN010098/EN010098-001044-Hornsea%20Project%20Four%20-%20G1.47%20Auk%20Displacement%20and%20Mortality%20Evidence%20Review.pdf. (Accessed on: November 2025).

Bradbury, G., Trinder, M., Furness, B., Banks, A.N., Caldow, R.W. and Hume, D. (2014) Mapping seabird sensitivity to offshore wind farms. PloS one, 9(9), p.e106366.

Burton, N.H.K., Rehfisch, M.M., Clark, N.A. and Dodd, S.G. (2006) Impacts of sudden winter habitat loss on the body condition and survival of Redshank Tringa totanus. J. Appl. Ecol. 43: 464–473.

Dierschke, V., Furness, R.W. & Garthe, S. (2016) Seabirds and offshore wind farms in European waters: avoidance and attraction. Biological Conservation, 202, 59-68.

Furness, R.W., Wade, H.M. and Masden, E.A. (2013) Assessing vulnerability of marine bird populations to offshore wind farms. Journal of Environmental Management, 119, 56-66.

Furness, R.W. (2015) Non-breeding season populations of seabirds in United Kingdom (UK) waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Reports, No. 164.

Garthe, S and Hüppop, O. (2004) Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. Journal of Applied Ecology, 41, 724-734.

JNCC, Natural Resources Wales, Department of Agriculture, Environment and Rural Affairs/Northern Ireland Environment Agency, Natural England and Scottish Natural Heritage, (2022). Joint SNCB Interim Displacement Advice Note. [Online]. Available at: https://data.jncc.gov.uk/data/9aecb87c-80c5-4cfb-9102-39f0228dcc9a/joint-sncb-interim-displacement-advice-note-2022.pdf. (Accessed on: November 2025).

Kaiser, M., Elliott, A., Galanidi, M., Ivor, E., Rees, S., Caldow, R., Stillman, R., Sutherland, W. and Showler, D. (2002) Predicting the Displacement of Common Scoter Melanitta nigra from Benthic Feeding Areas Due to Offshore Windfarms (Report No. COWRIE-BEN-03-2002). Report by Bangor University. Report for Collaborative Offshore Wind Research into the Environment (COWRIE).

Lamb, J., Gulka, J., Adams, E., Cook, A. and Williams, K.A. (2024) A synthetic analysis of post-construction displacement and attraction of marine birds at offshore wind energy installations. Environmental Impact Assessment Review 108, 107611. https://doi.org/10.1016/j.eiar.2024.107611. (Accessed on: November 2025).

Leopold, M.F., Verdaat, H.J.P. (2019) Pilot field study: observations from a fixed platform on occurrence and behaviour of common guillemots and other seabirds in offshore wind farm Luchterduinen. [Online]. Available at: https://library.wur.nl/WebQuery/wurpubs/fulltext/460411. (Accessed on: November 2025).

MacArthur Green (2023) Beatrice Offshore Wind Farm: Year 2 Post-construction Ornithological Monitoring Report. Available: https://marine.gov.scot/sites/default/files/bowl_2021_post_construction_ornithology_monitoring_report_25_07_2023.pdf. (Accessed on: November 2025).

NatureScot (2020) Short Guidance Note: Seasonal Periods for Birds in the Scottish Marine Environment. [Online]. Available at: https://www.nature.scot/sites/default/files/2020-10/Guidance%20note%20-%20Seasonal%20definitions%20for%20birds%20in%20the%20Scottish%20Marine%20Environment.pdf (Accessed on: November 2025).

NatureScot (2023a) Guidance Note 8: Guidance to support Offshore Wind Applications: Marine Ornithology Advice for assessing the distributional responses, displacement and barrier effects of Marine birds. [Online]. Available at: https://www.nature.scot/doc/guidance-note-8-guidance-support-offshore-wind-applications-marine-ornithology-advice-assessing. (Accessed on: November 2025).

NatureScot (2023b) Guidance Note 2: Guidance to support Offshore Wind Applications: Advice for Marine Ornithology Baseline Characterisation Surveys and Reporting. [Online]. Available at: https://www.nature.scot/doc/guidance-note-2-guidance-support-offshore-wind-applications-advice-marine-ornithology-baseline. (Accessed on: November 2025).

Pavat, D., Harker, A.J., Humphries, G., Keogan, K., Webb, A. and Macleod K. (2023) Consideration of avoidance behaviour of northern gannet (Morus bassanus) in collision risk modelling for offshore wind farm impact assessments. [Online]. Available at: https://publications.naturalengland.org.uk/file/5127676298526720. (Accessed on: November 2025).

Percival, S. 2013. Thanet Offshore Wind Farm Ornithological Monitoring 2012–2013. Vattenfall & Royal Haskoning.

Peschko, V., Mendel, B., Mercker, M., Dierschke, J., & Garthe, S. (2021) Gannets (Morus bassanus) are strongly affected by operating offshore wind farms during the breeding season. Journal of Environmental Management, 279, 111509.

Pettifor, R.A., Caldow, R.W.G., Rowcliffe, J.M., Goss-Custard, J.D. and Black, J.M. (2000) Spatially explicit, indi-vidual-based, behavioural models of the annual cycle of two migratory goose populations. J. Appl. Ecol. 37:103–35.

Searle, K.R., Mobbs, D.C., Butler, A., Furness, R.W., Trinder, M.N. and Daunt. F. (2018). Finding out the fate of displaced birds (FCR/2015/19). Scottish Marine and Freshwater Science Vol 9 No 08.

Topping, C. and Petersen, I.K. (2011) Report on a red-throated diver agent-based model to assess the cu-mulative impact from offshore wind farms. Report commissioned by Vattenfall A/S. Aarhus University, DCE - Danish Centre for Environment and Energy.

Van Kooten, T., Soudijn, F., Tulp, I., Chen, C., Benden, D. and Leoplod, M. (2019) The consequences of seabird habitat loss from offshore wind turbines, version 2. Displacement and population level effects in 5 selected species. [Online]. Available at: https://library.wur.nl/WebQuery/wurpubs/fulltext/496173. (Accessed on: November 2025).

Vanermen N., Stienen E.W.M., Courtens W., Onkelinx T., Van de walle M. and Verstraete H. (2013) Bird monitoring at offshore wind farms in the Belgian part of the North Sea – Assessing seabird displacement effects. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2013 (INBO.R.2013.755887). Instituut voor Natuur- en Bosonderzoek, Brussel.

Wade, H.M., Masden E.M., Jackson, A.C. and Furness, R.W. (2016) Incorporating data uncertainty when esti-mating potential vulnerability of Scottish seabirds to marine renewable energy developments. Marine Policy, 70, 108-113.

West, A.D., Goss-Custard, J.D., McGrorty, S., Stillman, R.A., Durell, S.E.A. le V. dit, Stewart, B., Walker, P., Palmer, D.W. and Coates, P. (2003) The Burry shellfishery and oystercatchers: using a behaviour-based model to advise on shellfishery management policy. Marine Ecology Progress Series, 248: 279-292

Woodward, I., Thaxter, C.B., Owen, E. and Cook, A.S.C.P. (2019) Desk-based revision of seabird foraging ranges used for HRA screening. BTO Report 724 for The Crown Estate.

Appendix A Bird data for displacement assessment

Table A.1: Kittiwake abundance estimates (all behaviours) within Morven South plus 2km buffer

Year	Abundance metric	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Model-based abundance estimates													
Year 1	Mean	413	67	44	39	16	43	46	177	236	631	426	59
	Upper confidence	564	129	79	97	39	103	89	244	311	832	588	100
	Lower confidence	283	41	25	20	0	24	22	122	183	450	302	32
Year 2	Mean	18	6	45	147	23	26	44	47	156	48	10	35
	Upper confidence	45	38	108	196	86	49	97	76	247	102	168	91
	Lower confidence	0	2	26	99	11	13	24	25	108	27	1	20

Table A.2: Gannet abundance estimates (all behaviours) within Morven South plus 2km buffer

Year	Abundance metric	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Model-based abundance estimates													
Year 1	Mean	121	13	8	9	0	7	17	201	230	158	205	23
	Upper confidence	184	39	23	30	0	25	44	267	362	222	280	86
	Lower confidence	82	4	0	0	0	0	7	147	141	107	149	12
Year 2	Mean	58	13	34	0	7	77	119	217	50	449	502	48

Year	Abundance metric	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
	Upper confidence	124	34	70	0	23	141	194	286	103	545	604	174
	Lower confidence	35	4	16	0	0	49	84	157	28	355	404	30

Table A.3: Guillemot abundance estimates (all behaviours) within Morven South plus 2km buffer

Year	Abundance metric	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Model-based abundance estimates													
Year 1	Mean	1,021	10,676	829	2,115	2,146	374	1,034	3,438	980	3,897	3,025	17,152
	Upper confidence	1,210	11,518	983	2,375	2,519	496	1,217	3,710	1,284	4,192	3,281	18,165
	Lower confidence	842	9,758	672	1,879	1,869	287	879	3,128	759	3,590	2,754	15,987
Year 2	Mean	15,971	852	2,218	1,676	1,351	239	2,120	1,215	823	4,354	2,369	29,008
	Upper confidence	17,478	1,033	2,482	1,920	1,575	369	2,653	1,408	1,198	4,674	2,610	31,197
	Lower confidence	14,292	725	1,956	1,439	1,143	173	1,705	1,016	588	4,020	2,134	26,616

Table A.4: Razorbill abundance estimates (all behaviours) within Morven South plus 2km buffer

Year	Abundance metric	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Model-based abundance estimates													
Year 1	Mean	1,411	23	90	23	8	56	13	53	20	53	47	
	Upper confidence	1,753	120	156	58	39	204	39	120	137	125	152	
	Lower confidence	1,127	13	56	8	2	24	4	23	9	30	28	
Year 2	Mean	852	4,459	134	170	751	136	55	9	125	0	61	243
	Upper confidence	988	5,089	213	275	918	261	119	36	205	0	120	357
	Lower confidence	713	3,806	89	122	593	99	23	3	78	0	33	186

Table A.5: Puffin abundance estimates (all behaviours) within Morven South plus 2km buffer

Year	Abundance metric	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Model-based abundance estimates													
Year 1	Mean	206	4	18	9	0	0	32	9	26	24	18	128
	Upper confidence	281	25	42	44	0	0	80	27	103	55	79	193
	Lower confidence	152	0	0	2	0	0	0	0	10	10	7	88
Year 2	Mean	661	20	0	43	0	39	39	25	84	73	0	0
	Upper confidence	794	71	0	77	0	121	99	55	141	131	0	0

Year	Abundance metric	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
	Lower confidence	542	8	0	19	0	22	20	11	54	40	0	0

Table A.6: Fulmar abundance estimates (all behaviours) within Morven South plus 2km buffer

Year	Abundance metric	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Model-based abundance estimates													
Year 1	Mean	466	450	165	24	99	44	41	24	320	12	39	92
	Upper confidence	562	549	233	53	137	115	79	65	3,878	29	107	147
	Lower confidence	376	358	122	10	63	27	19	12	47	5	23	58
Year 2	Mean	32	148	139	200	88	172	14	158	11	22	141	194
	Upper confidence	98	212	216	269	146	241	44	220	112	60	198	273
	Lower confidence	19	98	103	150	57	121	0	115	4	9	100	138

Appendix B Calculation process for guillemot and razorbill mean-peak population estimates

5.1.1.1 The approach to defining the seasonal extents for guillemot and razorbill to enable the calculation of seasonal mean-peak population estimates is based on advice received from NatureScot during pre-application consultation. The advice which is also included in Volume 1, Chapter 5: Consultation, of the Morven South EIA Report is summarised here.

5.1.1.2 In January 2025, the Applicant requested advice from NatureScot in relation to the age of the data to be used to support the assessments required for Morven South. The Applicant had collected baseline data between January 2021 and September 2023 and with a proposed application date of Q2 2026 was aware that data towards the start of this period would be beyond the five year cut-off usually applied to baseline data. NatureScot advised that in order to the application being informed by data beyond the five year cut-off that the assessment should utilise data between October 2021 and September 2023, thus providing a dataset covering the required minimum of two years.

5.1.1.3 In March 2025, the Applicant requested further advice from NatureScot in relation to the use of data between October 2021 and September 2023. Whilst this time period corresponded with the seasonal extents for gannet it foreshortened the non-breeding seasons defined for other species. The Applicant proposed that data from before October 2021 be used to ensure two full seasons for each species could be used within displacement analyses. The Applicant has therefore agreed with NatureScot through additional targeted consultation (April 2025) and consultation meetings (28 May 2025) that data prior to October 2021 can be used to allow for the consideration of two complete seasonal extents for each species (see Volume 1, Chapter 5: Consultation). This therefore leads to a dataset with a temporal extent of July 2021 to September 2023 providing two full seasonal extents for each species identified in Section 2.1.

5.1.1.4 During pre-application consultation the Applicant had identified increased populations of guillemot and razorbill in months towards the end of the breeding season/start of the non-breeding season, when compared to surrounding months. In March 2025, the Applicant presented evidence that these increased populations were likely due to the post-breeding dispersal of the two species from nearby colonies and requested NatureScot's advice in relation to the treatment of these months in displacement analyses for the two species. In April 2025 and May 2025, NatureScot provided advice stating that July and August be incorporated into a new post-breeding season for guillemot and the existing post-breeding season for razorbill where it was evident that the populations were different to surrounding months.

5.1.1.5 Table B.1 identifies the seasons defined for guillemot and the justification behind the seasonal extents based on the advice provided by NatureScot. An explanation as to how this advice applies to individual months is provided in Table B.1. The data presented in Table B.1 can also be found in Appendix 4, Table 12.5 of Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report.

Table B.1: Seasonal extents defined for guillemot

Season	Extent	Justification
Breeding	April to June 2022 and 2023	As population estimates in July 2022 and 2023 are higher than in preceding breeding season months, July is included in the post-breeding season leaving April, May and June to form the breeding season. The years from which months are taken allows for complete seasons to be used accounting for the five-year data cut-off.
Post-breeding	July and August 2022 and July 2023	Population estimates recorded in these months are significantly higher than preceding breeding season months and subsequent non-breeding season months.
Non-breeding	August 2021 to March 2022 and September 2022 to March 2023	Population in August 2021 is lower than preceding breeding season month and therefore it is incorporated into the non-breeding season. Population in August 2022 is higher than subsequent non-breeding season months and therefore is incorporated into the post-breeding season. The years from which months are taken allows for complete seasons to be used. August and September 2023 cannot be used as they do not form part of a complete non-breeding season.

5.1.1.6 Table B. 2 identifies the seasons defined for razorbill and the justification behind the seasonal extents based on the advice provided by NatureScot. An explanation as to how this advice applies to individual months is provided in Table B. 2. The data presented in Table B. 2 can also be found in Appendix 4, Table 12.8 of Volume 3, Annex 11.1: Offshore Ornithology Baseline Characterisation Report.

Table B. 2: Seasonal extents defined for razorbill

Season	Extent	Justification
Breeding	April to June 2022 and April to July 2023	As the population estimates in July 2022 are higher than preceding breeding season months, July 2022 is included in the post-breeding season leaving April, May and June to form the breeding season. The population estimate in July 2023 is comparable to preceding breeding season months and therefore is included in the breeding season. The years from which months are taken allows for complete seasons to be used accounting for the five-year data cut-off.
Post-breeding	July to October 2021 and 2022	July included in post-breeding season based on NatureScot's advice, remaining post-breeding season extent based on seasonal extents provided in Furness (2015).
Non-breeding	November to December 2021 and 2022	Based on seasonal extents provided in Furness (2015)
Pre-breeding	January to March 2022 and 2023	Based on seasonal extents provided in Furness (2015).

Table B. 3: Calculation process used to calculate mean-peak population estimates for guillemot based on NatureScot's advice

Month	Population estimate (no. of birds)	Season	Justification
June 2021	3385	Not used	Not used. Data in 2022 and 2023 has been given priority in order to ensure data is within the five year cut-off. Data presented to show where population estimates began to decline indicating the start of the non-breeding season in 2021.
July 2021	3931	Not used	
August 2021	821	Non-breeding	Population estimate lower than July and considered to be unaffected by post-breeding dispersal, considered to be a non-breeding month following the seasonal definitions in NatureScot (2020).
September 2021	2209	Non-breeding	Included in the non-breeding season based on the seasonal definitions in NatureScot (2020).
October 2021	563	Non-breeding	
November 2021	2150	Non-breeding	
December 2021	717	Non-breeding	
January 2022	445	Non-breeding	
February 2022	1421	Non-breeding	
March 2022	890	Non-breeding	
April 2022	450	Breeding	Included in the breeding season based on the seasonal definitions in NatureScot (2020).
May 2022	741	Breeding	
June 2022	569	Breeding	
July 2022	6200	Post-breeding	Population estimate significantly higher than other breeding season months in this year, assigned to the post-breeding season following NatureScot pre-application advice.
August 2022	14567	Post-breeding	
September 2022	520	Non-breeding	

Month	Population estimate (no. of birds)	Season	Justification
October 2021	2399	Non-breeding	Included in the non-breeding season based on the seasonal definitions in NatureScot (2020).
November 2022	2787	Non-breeding	
December 2022	1529	Non-breeding	
January 2023	244	Non-breeding	
February 2023	1250	Non-breeding	
March 2023	203	Non-breeding	
April 2023	930	Breeding	Included in the breeding season based on the seasonal definitions in NatureScot (2020).
May 2023	423	Breeding	
June 2023	475	Breeding	
July 2023	3394	Post-breeding	Population estimate significantly higher than other breeding season months in this year, assigned to the post-breeding season following NatureScot pre-application advice.
August 2023	698	Not used	Population estimate lower than previous month in same year and therefore would be assigned to the non-breeding season however, two complete non-breeding seasons have already been identified, and this month does not form part of a complete non-breeding season. This population estimate is not used.
September 2023	161	Not used	This month does not form part of a complete non-breeding season. This population estimate is not used.

Table B. 4: Calculation process used to calculate mean-peak population estimates for razorbill

Month	Population estimate (no. of birds)	Season	Justification
June 2021	647	Not used	Not used. Data in 2022 and 2023 has been given priority in order to ensure data is within the five year cut-off. Data presented to provide a comparison between breeding seasons months and July 2021 to determine if July should be included in the post-breeding season.
July 2021	1411	Not used	Population estimate is higher than preceding breeding season month and therefore it is included in the post-breeding season based on NatureScot's pre-application advice.
August 2021	23	Post-breeding	Included in the post-breeding season based on the seasonal definitions in Furness (2015).
September 2021	90	Post-breeding	
October 2021	23	Post-breeding	
November 2021	8	Post-breeding	Included in the non-breeding season based on the seasonal definitions in Furness (2015).
December 2021	56	Non-breeding	
January 2022	13	Non-breeding	Included in the pre-breeding season based on the seasonal definitions in Furness (2015).
February 2022	53	Pre-breeding	
March 2022	20	Pre-breeding	
April 2022	53	Pre-breeding	Included in the breeding season based on the seasonal definitions in NatureScot (2020).
May 2022	47	Breeding	
June 2022	1	Breeding	
July 2022	852	Breeding	Population estimate is higher than preceding breeding season month and therefore it is included in the post-breeding season based on NatureScot's pre-application advice.
August 2022	4459	Post-breeding	Included in the post-breeding season based on the seasonal definitions in Furness (2015).
September 2022	134	Post-breeding	
October 2021	170	Post-breeding	
November 2022	751	Post-breeding	

Month	Population estimate (no. of birds)	Season	Justification
December 2022	136	Non-breeding	Included in the non-breeding season based on the seasonal definitions in Furness (2015).
January 2023	55	Non-breeding	Included in the pre-breeding season based on the seasonal definitions in Furness (2015).
February 2023	9	Pre-breeding	
March 2023	125	Pre-breeding	
April 2023	0	Pre-breeding	Included in the breeding season based on the seasonal definitions in NatureScot (2020).
May 2023	61	Breeding	
June 2023	22	Breeding	
July 2023	43	Breeding	Included in the breeding season based on the seasonal definitions in NatureScot (2020). Population is comparable to other breeding season months in this year.
August 2023	19	Breeding	This month does not form part of a complete post-breeding season. This population estimate is not used.
September 2023	0	Not used	