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Volume 7B Proposed Development (Offshore) Appendices

Appendix 6-2 Offshore Ornithology Distributional Responses Technical Report Annex 4 Review of Relevant Evidence

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OCEAN WINDS

Volume 7B Appendix 6-2 Annex 4 Review of Relevant Evidence

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Acronyms and Abbreviations

EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
INLA	Integrated Nested Laplace Approximations
MD-LOT	Marine Directorate - Licensing Operations Team
OWEZ	Egmond aan Zee Windpark
OWF	Offshore Wind Farm
RSPB	Royal Society for the Protection of Birds
SNCB	Statutory Nature Conservation Body
SPA	Special Protection Area

1 Introduction

1.1.1.1 The distributional responses assessment carried out for the Proposed Development (Offshore), located in the Moray Firth, Scotland, has primarily followed NatureScot (2023[1]) guidance, with any changes to this guidance having been discussed and agreed in advance with NatureScot. This approach has been referred to as the 'Guidance Approach' with any alternative approaches to assessment referred to as the 'Applicant Approach'.

1.1.1.2 The Applicant Approach, which is being proposed by Caledonia Offshore Wind Farm Limited (the Applicant), presents an assessment which is methodologically similar to the Guidance Approach, but with a selection of input parameters changed based on the Applicant's appraisal of available empirical evidence relating to behavioural responses of seabirds collected as part of post-construction monitoring studies. The Applicant's assessment approach is therefore undertaken in accordance with the recommendations contained within Section 3.2 of the Draft Sectoral Marine Plan Roadmap of Actions (Marine Directorate, 2022[2]).

1.1.1.3 The Proposed Development (Offshore) includes the Caledonia Offshore Wind Farm (OWF) (i.e., Array Area) and the Caledonia Offshore Export Cable Corridor seaward of Mean High Water Springs. The Proposed Development (Offshore) will be developed in two phases (see Volume 1, Chapter 5: Proposed Development Phasing), referred to as Caledonia North and Caledonia South. It is assumed that construction of the two application areas could be progressed in either order (e.g., Caledonia North constructed in the first phase, then Caledonia South in the second phase, or vice-versa) or at the same time. This has been assessed within a single Environmental Impact Assessment Report (EIAR) covering the Proposed Development (Offshore) as well as Caledonia North and Caledonia South alone.

1.1.1.4 This technical note provides an overview of the most recent evidence to support the 'Applicant Approach' to the distributional responses assessment carried out for the Proposed Development (Offshore) (see Volume 7B, Appendix 6-2: Offshore Ornithology Distributional Responses Technical Report). This includes consideration of the following species/groups:

- Section 2: Kittiwake;
- Section 3: Auks – Guillemot, Razorbill and Puffin; and
- Section 4: Gannet.

2 Kittiwake

2.1 Position Overview

2.1.1.1 As detailed within the Offshore Scoping Report (Volume 7, Appendix 2) submitted to Marine Directorate - Licensing Operations Team (MD-LOT)[i] in relation to the Proposed Development (Offshore), the Applicant originally proposed to scope out kittiwake for inclusion in quantitative assessments of operational phase displacement. The Applicant's position conforms to the advice given in the Joint SNCB Interim Displacement Advice Note (SNCB, 2022[3]). However, this species has been included in the distributional responses assessment as a request was made for its inclusion in both the breeding and non-breeding seasons by NatureScot and the Royal Society for the Protection of Birds (RSPB) during consultation (25 May 2023).

2.1.1.2 Table 2-1 presents the matrix-based method displacement and mortality rates used in the NatureScot Guidance Approach for kittiwake, noting the Applicant's position is that in accordance with the Joint SNCB Interim Displacement Advice Note (SNCB, 2022[3]) assessment is not required and there is no strong empirical evidence to the contrary.

Table 2-1: Displacement and mortality rates used in the matrix-based method for kittiwake as per the NatureScot Guidance Approach and the Applicant's Position.

Approach	Displacement Rate	Mortality Rate – Breeding Season	Mortality Rate – Non-breeding Season
NatureScot Guidance Approach	30%	1% and 3%	1% and 3%
Applicant's Position	Not Assessed in accordance with the Joint SNCB Interim Displacement Advice Note (SNCB, 2022[3])		

2.2 Displacement Rate

2.2.1 SNCB's Guidance

2.2.1.1 The current UK Statutory Nature Conservation Bodies (SNCB) guidance on the requirements for displacement assessment (SNCB, 2022[3]), does not consider kittiwake to be a priority species for displacement assessment. This is on the basis that kittiwake falls below the SNCB recommended threshold for assessment relating to both 'disturbance susceptibility' and

[i] In 2023, Marine Scotland was renamed Marine Directorate, and thus the marine licensing and consents team is now referred to as Marine Directorate - Licensing Operations Team (MD-LOT).

'habitat specialisation' with respect to species which should be included for distributional response assessments. The following advice is provided (SNCB, 2017[4]; updated 2022[3]):

"It is recognised that, regardless of these scores, it is unlikely that cormorant and gull species will need to be routinely assessed for displacement, as a number of empirical studies have demonstrated these species can also be attracted as well as display no noticeable reaction to the presence of OWFs (e.g., Leopold *et al*., 2013[5]; Vanermen *et al*., 2014[6]; Petersen *et al*., 2006[7]; Mendel *et al*., 2014[8])".

2.2.1.2 The 'disturbance susceptibility' scores were derived from reviews of displacement and disturbance studies initially by Furness *et al.* (2013[9]), extended by Bradbury *et al.* (2014[10]) and updated by Wade *et al.* (2016[11]) and therefore at the time of issue in 2017 the Joint SNCB Interim Displacement Advice Note was based on the best available scientific evidence. The interim displacement advice note replaced an earlier Natural England and JNCC joint advice note from 2012 (Natural England and JNCC, 2012[12]) and a Displacement Workshop (6-7 May 2015) which was intended to address critical areas of clarification and SNCB positioning on the approach to assessing displacement impacts.

2.2.1.3 A comprehensive review was also undertaken by Dierschke *et al*. (2016[13]) on seabird avoidance and attraction to offshore wind farms which reached a similar conclusion on kittiwake disturbance susceptibility. A mean score of 2.7 was given to kittiwake classified as "*species which are hardly affected by offshore wind farms or with attraction and avoidance approximately equal over all studies*". The mean score was derived from the behavioural responses of kittiwake from 11 OWFs which were variable; with one account of strong attraction (increase of >80%), one account of weak attraction (increase of >50%), five accounts of no windfarm effect, one account of weak avoidance, one account of strong avoidance (decrease of >80%) and two accounts of macro avoidance behaviour.

2.2.1.4 The two accounts of macro avoidance at Horns Rev 1 and 2 were based on just 11 tracks (Skov *et al*., 2012[14]) and in previous studies on distributional responses at the two sites no significant effects where reported and kittiwake were observed roosting on the jacket foundations (e.g., Skov *et al*., 2008[15]). The account of strong avoidance was from studies at Thornton Bank which suggest a displacement rate of 70%, however at the neighbouring Bligh Bank site displacement was not observed for kittiwake (Vanermen *et al*., 2016[16]). Further uncertainty as to the distributional response being a wind farm effect is drawn from only one model showing a statistically significant effect, the buffer area showing a significant attraction effect and 1% of the kittiwakes recorded in the studies observed roosting on turbines at Thorton Bank (Vanermen *et al*., 2019[17]). Therefore, the high distributional response reported by one statistical model may not be genuine nor can it be attributed with high confidence to the presence of the wind farm. The concluding remark from the authors was "*due to inconsistency between the significance levels of the MMI and full model OWF coefficients, the results for black-legged kittiwake should yet be regarded as inconclusive*" (Vanermen *et al*., 2019[17]).

2.2.1.5 Therefore, in accordance with the recommendations in the Joint SNCB Interim Displacement Advice Note (SNCB, 2017[4]) OWFs in UK waters, have not been required to assess displacement effects on kittiwake as part of the Environmental Impact Assessment (EIA) process. This advice has continued for all assessments in UK waters with the exception of Scotland.

2.2.1.6 The current requirement for Scottish OWFs to assess displacement effects for kittiwake appears to have originated from the opinion of Scottish Ministers given for the EIA for the proposed Seagreen Phase 1 Offshore Project (MD-LOT, 2017a[18]). It was the Scottish Ministers' opinion that a displacement assessment should be included for kittiwake using a 30% displacement rate for the breeding season only and a qualitative assessment for the non-breeding season. NatureScot, formerly Scottish Natural Heritage, advised "*that there was no need to include kittiwake, the data available from post construction monitoring indicate no significant avoidance behaviour by this species*". However, advice was sought from MSS as the RSPB recommended a 50% displacement rate for kittiwake should be included in the assessment. MSS advised that displacement should be included in the kittiwake assessment as macro avoidance/displacement had been observed at some wind farms and a 30% displacement rate was recommended (MD-LOT, 2017a[18]).

2.2.2 Scoping Advice for Scottish OWF and Applicant's Position Statements

2.2.2.1 On reflection the advice for the Seagreen Phase 1 Offshore Project (MD-LOT, 2017a[18]) was unusual given the position advocated by SNCB not to consider displacement for kittiwake based on review of the available scientific evidence at the time (SNCB, 2017[4]; Dierschke *et al*., 2016[13]) and the 30% rate not empirically derived from any published study. This advice was then replicated for subsequent OWF projects in Scotland without inclusion of clear supporting evidence; Inch Cape (MD-LOT, 2017b[19]), Neart na Gaoithe, (MD-LOT, 2017c[20]), Moray West followed the scoping opinion for Seagreen OWF (Moray Offshore Windfarm (West), 2018[21]), and Pentland Floating OWF was provided with the same advice (MD-LOT, 2021[22]).

2.2.2.2 The current ScotWind and INTOG Rounds of east coast Scotland offshore wind applications; Green Volt, Berwick Bank, Salamander and Ossian, have all received the same scoping opinion regarding the assessment of kittiwake displacement. However, the Applicant's position in all cases has been that this approach is highly precautionary considering the lack of empirical evidence to support a 30% displacement rate (Berwick Bank, 2022[23]; Green Volt, 2023[24];, Salamander, 2024[25]; Ossian, 2024[26]).

2.2.3 NatureScot's Advice on Marine Renewables Development

2.2.3.1 Marine ornithology was recently collated in a series of published guidance notes in January 2023, which "*sets out NatureScot's recommendations for good practice in the impact assessments for Scottish casework*". Advice presented in Table 1 of Guidance Note 8 (NatureScot, 2023[1]) recommends a displacement rate of 30% for the impact assessments for kittiwake. This advice on kittiwake displacement is therefore no longer aligned with the advice given in the Joint SNCB Interim Displacement Advice Note (2022[3]). Although the guidance note refers to exceptions to advice in instances where strong empirical evidence suggests conclusions of the original sensitivity scores may be incorrect and that displacement rates may be updated when new evidence is available. The rationale for the proposed displacement rate used to inform the selection of the recommended displacement rate is unclear in Guidance Note 8. Therefore, any new studies that have been published since the issue of the Joint SNCB Interim Displacement Advice Note (SNCB, 2017[4]; updated in 2022[3]) have been reviewed in the section below to determine whether new evidence is available to support the advised 30% rate for kittiwake displacement assessment.

2.2.4 Studies on Kittiwake Distributional Responses to OWF 2017 Onwards

2.2.4.1 Since the review of seabird distributional response to OWFs undertaken by Dierschke *et al*. (2016[13]) there have been four studies on displacement assessment for kittiwake (APEM, 2017[27]; Percival and Ford, 2017[28]; Peschko *et al*., 2020[29]; Trinder *et al*., 2024[30]), a series of tracking studies of kittiwakes from the east coast of Scotland (Pollock *et al*., 2023[31]; O'Hanlon *et al*., 2024[32]; Johnston *et al*., 2024) and an updated review on post-construction displacement and attraction of marine birds (Lamb *et al*., 2024[33]).

Distributional responses at OWFs:

- A study that included kittiwake distributional response from the operational Westermost Rough OWF (located in the North Sea off the Yorkshire coast, England) found no evidence to suggest kittiwake were avoiding the OWF (APEM, 2017[34]). If the OWF was a negative determinant of kittiwake densities and distribution, low densities would be expected to occur within or near the wind farm. However, no significant effect of distance on density was found and kittiwake densities where moderately high within the wind farm (6.36 birds/km^2).

It should be noted that the data was collected across three digital aerial surveys in July 2017, and therefore may only represent breeding season behavioural responses to the OWF, or even a specific part of the breeding season.

- An analysis of pre-, post- and construction phase survey data at the Westermost Rough OWF was also undertaken to investigate distributional responses of seabirds (Percival and Ford, 2017[28]). No statistically significant differences were detected within the wind farm compared to the pre-construction phase and although there were clearly large differences in the kittiwake distribution and abundance between years, these variations extended into the habitat around the wind OWF. In summary, there was no clear evidence that this was attributable to the presence of the wind farm (Percival and Ford, 2017[28]).
- A study of the distributional response of kittiwake at four OWFs in the German North Sea was undertaken by Peschko *et al*. (2020[29]). The analysis included 14 years of pre-construction data and three years of operational phase data. The analysis suggested the distributional response from the combined OWFs to be statistically significant out to 20km from the OWF. The displacement effect was calculated to be a decrease in kittiwake densities of 45% within the OWF + 3km buffer. However, there are multiple concerns that give valid reasons for caution to whether the reported displacement effect is genuine. Firstly, the reported effect is only detected from data that covers the second week of May to mid-July referred to in the study as the 'breeding season'. The analysis of the data that covered the period from late February to early May referred to in the study as the 'Spring' did not show any statistically significant displacement effects. The reasoning for this split in the data is unclear as the non-migratory breeding season for kittiwakes is usually defined as 01/05 to 31/07 and March and April are still considered the breeding season as kittiwake attend the colony during this period establishing territories and building nests and therefore would be foraging from the colony in a similar manner as during May to July. Secondly, none of the natural covariates had an effect on kittiwake densities in the breeding season. This would reduce the confidence of the predicted densities across the study area and whether apparent changes in densities between project phases are genuine. This is also reflected in the large CIs presented around the reported displacement effect of -45%, of -65% to -15%. Indeed, the density distribution within the study area is not similar between the before and after project phases suggesting other factors are driving distributional changes other than the presence of the OWFs in the 'breeding season'. Thirdly, survey effort was much higher within the OWF area and buffer areas than the wider study area used as a control, although the study does not account for this. Fourthly, the displacement effect is from the combined response of all four OWFs in the study and therefore it is unclear whether the distributional response applies equally at each OWF in the study. These concerns raise reasonable doubt as to whether the results are

reproducible if the data underwent independent re-analysis. Furthermore, it could be argued that since this data was collected at an OWF considerably beyond UK waters, the outputs of the study are perhaps of lower relevance to the Proposed Development (Offshore) assessment than equivalent studies carried out closer to the Moray Firth.

- Post-construction monitoring studies at the Beatrice OWF, located immediately to the west of the Caledonia OWF, were undertaken for the 2019 and 2021 breeding season (May to July/August). Two independent analyses were conducted; the first used spatial models to compare the before (pre-construction) and after (post-construction) distributions and the second used a bespoke within windfarm and 500m buffer turbine avoidance method. Results from spatial modelling of the pre- and post-construction survey data indicated that there was a significant redistribution effect for this species, with significant increases in parts of the windfarm in year one of monitoring (MacArthur Green, 2021[35]; 20[ii]23[36]) The turbine avoidance analysis, suggested some evidence of avoidance closer to the turbines and at higher turbine RPM values. There was no indication of any change in abundance across the survey area, including the wind farm in year two of the monitoring (MacArthur Green, 2023[36]). The turbine avoidance analysis in year two showed no indication of any significant responses, either avoidance or attraction (MacArthur Green, 2023[36]). The results of the monitoring reports where published in a peer-reviewed journal concluding that the study found no evidence of displacement or avoidance of turbines by kittiwakes (Trinder *et al*., 2024[30]).

2.2.5 Tracking Studies

2.2.5.1 Tracking data from seabird tagging studies can provide valuable information on how species respond in relation to their proximity to OWFs.

- A study that tagged kittiwakes from Buchan Ness to Collieston Coast Special Protection Area (SPA) in the breeding season (late June to Early August) showed that 75% of the birds spent time within the footprint of an operational OWF within foraging range (O'Hanlon *et al*., 2024[32]). The time spent within an operational OWF varied considerably between birds ranging up to 18% of their time. The study demonstrated there were substantial differences in the way individuals responded to environmental conditions with uncertainty as to the drivers of habitat selection and foraging behaviour and therefore no clear evidence that OWFs were avoided at a population level. The study was repeated during the 2023 breeding season (Johnston *et al.,* 2024) and showed relatively similar results.

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- Data from the same study (O'Hanlon *et al*., 2024[32]) was used to investigate behavioural response to OWFs within foraging range of the colony (Pollock *et al*., 2023[31]). The results indicated that interactions with OWFs as suggested by O'Hanlon *et al*. (2024[32]) are more complex than a simple behavioural response of avoidance or attraction. The analysis demonstrated variable response behaviours at different distances from the OWF with on average attraction to the OWF although this was not shown to be statistically significant.

2.2.6 Project Area Specific Evidence

2.2.6.1 Similar results with respect to the turbine avoidance analysis reported at Beatrice OWF (Trinder *et al*., 2024[30]) have been reported in a preliminary format at the operational Moray East OWF (McGregor, *pers. comm.*), with the full analysis of a single breeding season of pre-construction and a single breeding season of post-construction surveys currently in progress.

2.2.6.2 In addition, in the MRSea Modelling Report for the Proposed Development (Offshore) (see Volume 7B, Appendix 6-1, Annex 16) kittiwake distribution in relation to the 34 Moray East OWF turbines within the Digital Aerial Survey area was analysed. The relationship between kittiwake distribution and turbine location within the Caledonia survey area suggested that kittiwakes were attracted to the operational turbines. Further analysis using Random Forests modelling suggested a lack of displacement across all seasons and OWF design scenarios at the Caledonia OWF. These results would suggest that kittiwake displacement would not occur as a result of OWF construction over the Project site in a similar manner reported at the adjacent Beatrice and Moray East OWFs.

3 Auks – Guillemot, Razorbill and Puffin

3.1 Position Overview

3.1.1.1 Guillemot, razorbill and puffin were included in the distributional responses assessment based on their abundance in the Caledonia OWF (plus a 4km buffer), highlighted by the 24 months (May 2021 to April 2023) of baseline data (Volume 7B, Appendix 6-1: Offshore Ornithology Baseline Characterisation Report).

3.1.1.2 Guillemot and razorbill have been identified as being moderately sensitive to displacement by Furness *et al*. (2013[9]) and Bradbury *et al*. (2014[10]), whereas puffin is classified as moderate to low sensitivity. The following sections provide a summary of relevant evidence for these species.

3.1.1.3 It should be noted that empirical evidence of puffin behavioural responses to OWF developments is limited in contrast to guillemot and razorbill. Given the similar ecology of three auk species, conclusions drawn for guillemot and razorbill are considered to be applicable for puffin.

3.1.1.4 Table 3-1 presents the matrix-based method displacement and mortality rates used in the Guidance Approach and the Applicant Approach.

Table 3-1: Displacement and mortality rates used in the matrix-based method for guillemot, razorbill and puffin as per the NatureScot Guidance Approach and the Applicant Approach.

Approach	Displacement Rate	Mortality Rate – Breeding Season	Mortality Rate – Non-breeding Season
Guidance Approach (guillemot, razorbill and puffin)	60%	3% and 5%	1% and 3%
Applicant Approach (guillemot and razorbill)	Up to 50%	Up to 1%	Up to 1%
Applicant Approach (puffin)	Up to 50%	Up to 1%	Up to 1%

3.2 Displacement Rate

3.2.1 SNCB Guidance

3.2.1.1 As per the NatureScot Guidance Note 8 (2023[1]), a displacement rate of 60% is advised for use when assessing distributional responses of guillemot and razorbill (Table 3-1). Based on information contained within the guidance note, the literature that has been used to inform the selection of the recommended displacement rate is not known.

3.2.1.2 Current UK SNCB (2022[3]) guidance recommends a displacement rate of 30 – 70% for auk species based on their disturbance susceptibility score. The susceptibility scores and subsequent rates are described as:

"*A general guide to appropriate displacement levels on a species-by-species basis, rather than to prescriptively read across to particular levels of displacement. That said, for those species lacking in empirical data on likely displacement levels resulting from OWF construction, there is potential utility in using the scores in order to maintain consistency of approach across different developments (where appropriate)*" (SNCB, 2022[3]).

3.2.1.3 As detailed in Section 3.2.2, the Applicant considers there is enough appropriate evidence available, especially given the post-construction monitoring results from other projects within the wider Moray Firth, to further refine the generalised displacement rates suggested for the Proposed Development (Offshore).

3.2.2 Studies on Auk Distributional Responses to OWF

3.2.2.1 Dierschke *et al*. (2016[13]) reviewed the behavioural responses reported as part of post-consent monitoring studies for 20 OWFs in the UK and Europe, of which analysis of behavioural responses for guillemot and razorbill were available for 11 and eight OWFs respectively. For puffin, no analysis of displacement effects were available for the OWFs included. This review summarised evidence of auk displacement derived from these studies and compared changes in baseline seabird abundance to post-construction scenarios. It is important to note that the mean displacement rates reported by Dierschke *et al*. (2016[13]) were predominantly derived from data collected during the non-breeding season.

3.2.2.2 Across the OWFs, guillemot and razorbills average behavioural response was categorised as weakly avoiding offshore wind farms (Dierschke *et al*., 2016[13]). A key point to note, however, is that for all five studies presented within Dierschke *et al*. (2016[13]) classified as having a strong avoidance effect on auks, recorded abundance was low with a high number of zero count surveys. Studies with high zero counts and a low abundance make displacement rate prediction highly problematic and inaccurate given natural spatial and temporal variation in this highly mobile group of species (APEM, 2022[37]). Reanalysis of these studies using Integrated Nested Laplace Approximations (INLA), an analysis method which is recommended for datasets including zero count inflation bias, resulted in predicted displacement being classified as non-significant (Zuur, 2018[38]; Leopold, 2018[39]). This suggests that the overall strength of potential displacement effects on these species due to operational OWFs may have been overestimated by Dierschke *et al*. (2016[13]).

3.2.2.3 Since publication of Dierschke *et al*. (2016[13]), there have been several additional OWF sites to have reported displacement effect studies on auks (e.g., APEM, 2017; Webb *et al*., 2017[40]; Peschko *et al*., 2020[29]; MacArthur Green, 2021[35]; 2023[36]) or updates from their monitoring programs (Vanermen *et al*., 2019[17]).

3.2.2.4 A study investigating auk and kittiwake displacement from the operational Westermost Rough OWF found no evidence to suggest auks were displaced, though high variability in overall mean densities of both guillemot and razorbill were recorded for the entire OWF and the surrounding buffer zone. It was noted there were variations in mean densities of these species across the buffer zone, however these differences were found to be non-significant (APEM, 2017).

3.2.2.5 A study by Peschko *et al*. (2020[29]) has been published collating data from OWFs located in the German North Sea. The results indicated guillemot displacement rates are reduced by approximately 20% during the breeding season compared to the non-breeding season, with displacement rates for guillemot predicted to be 44% in the breeding season and 63% in the non-breeding season.

3.2.2.6 A key consideration which needs to be accounted for when determining an appropriate displacement and mortality rate for assessment is the expected change in behavioural response over the operational time of the OWF (for which a typical expected lifespan is at least 25 years). In general, post-consent monitoring to date has occurred over short periods of times only following completion of the construction phase (two to five years at most). Even in the short-term following construction of OWF developments, gradual increases in area usage over time have been noted at Thanet OWF (located in the North Sea off the Kent coast, England) (Royal HaskoningDHV, 2013[41]), Luchterduinen OWF (Netherlands) and the Belgian OWF concession zone (Leopold and Verdaat, 2018[42]; Degraer *et al*., 2021[43]), suggesting gradual habituation to the OWFs. Similarly, Vanermen *et al*. (2021[44]) reported that within the Belgian OWF array the recorded peak density of razorbills was 4.59 birds/km^2, compared to 2.36 birds/km^2 outside the array. Densities of guillemot inside and outside of the array were reported to be similar, with 1.18 birds/km^2 inside compared to 1.03 birds/km^2 outside, and yet still slightly greater within the array (Vanermen *et al*., 2021[44]). This suggests the potential for slight attraction effect/no response to be occurring with respect to the two auk species in this region.

3.2.2.7 A recent review of all post-consent monitoring studied undertaken at the point of publication within the North Sea and UK Western Waters was submitted by Hornsea Four OWF. This review, undertaken by APEM (2022[37]), provides a comprehensive analysis of empirical data from multiple OWFs. The results of the post-consent studies were found to vary considerably across the sites. A single OWF was found to have positive displacement effects, eight OWFs had no significant effects or weak displacement effects, three had inferred displacement effects (not statistically tested) and eight with negative displacement effects (APEM, 2022[37]), though as previously noted some of these predicted effects were influenced by zero inflation bias. Overall, this comprehensive review recommended that a displacement rate of up to 50% for the OWF site plus a 2km buffer is most evidence based for distributional response assessments, whilst remaining precautionary.

3.2.3 Project Area Specific Evidence

3.2.3.1 The results of the post-construction monitoring of the Moray East OWF indicated little to no evidence of avoidance behaviour for guillemot and razorbill (McGregor, *pers. comm.*). For guillemot, one signal of avoidance in one distance range (<300m) for sitting birds was detected. These findings align with the broad-scale analysis, which also did not reveal any discernible trends (e.g., MacArthur Green, 2021[35]; 2023[36]; Trinder *et al*., 2024[30]). For razorbill, it should be noted the small sample size of this species observed.

3.2.3.2 Guillemot and razorbill were in higher abundance within the Beatrice OWF, located immediately to the west of the Proposed Development (Offshore), during post-construction surveys compared to pre-construction surveys as per the Year 1 post-construction monitoring report (MacArthur Green, 2021[35]). The results indicated that there was a significant increase in overall auk abundance following post-construction, but the spatial component of this relationship was found to be non-significant. No regions of the study area were found to have significant reductions in abundance, although it was noted that significant increases were observed within the southern half of the study area. Overall, it was concluded that the displacement rates of 30% to 70% currently applied to displacement assessments for auks are considerably over-estimated, at least in the breeding season for similar OWFs (MacArthur Green, 2021[35]). These findings were corroborated by the Year 2 post-construction monitoring report, with evidence to suggest no indication of avoidance of the OWF or individual turbines and in some cases higher densities of auks in proximity to turbines (MacArthur Green, 2023[36]).

3.2.3.3 It was concluded that overall, no displacement effect on auks was detected from the two years of post-construction monitoring for the Beatrice OWF (Trinder *et al*., 2024[30]).

3.2.4 Conclusions

3.2.4.1 Empirical evidence of displacement effects is predominantly shown in the non-breeding season and the limited evidence of displacement from the breeding season indicates a lower displacement effect. Therefore, the use of a single displacement rate of 50% across all seasons within the array area plus a 2km buffer would ensure an evidence based precautionary rate is applied for the distributional responses assessment.

3.3 Mortality Rate

3.3.1 SNCB Guidance

3.3.1.1 As per the NatureScot guidance, a morality rate of 3% and 5% is advised for use when assessing distributional responses of guillemot and razorbill during the breeding season, and 1% to 3% during the non-breeding season (Table 3-1). Derivation of such recommended is cited as being based on modelling outputs from SeabORD (Searle *et al*., 2018[45]).

3.3.1.2 Current UK SNCB (2022[3]) guidance acknowledges the difficulty in translating species energetic fitness consequences associated with disturbance and displacement into quantifiable rates, hence why a 'Matrix Approach' to assessment is recommended, combined with expert opinion to inform appropriate species mortality rates.

3.3.1.3 In accordance with this approach, the Applicant has reviewed current available evidence relating to seabird consequent mortality to inform an expert judgement on appropriate mortality rates, as detailed in Section 3.3.2.

3.3.2 Current Available Evidence

3.3.2.1 As per APEM (2022[37]), two further studies have been published with updates to predict the consequences following displacement of seabird including auks from OWFs (Searle *et al*., 2014[46]; 2018[45]; van Kooten *et al*., 2019[47]), since the SNCB guidance on displacement was published (SNCB, 2022[3]). The comprehensive study undertaken by APEM (2022[37]) investigating auk displacement mortality rates concludes that a displacement mortality rate of 1% is more representative of the available evidence while remaining sufficiently precautionary for use by OWF assessments.

3.3.2.2 Searle *et al*. (2014[46]; 2018[45]) assessed the effects of displacement and barrier effects on breeding seabirds using time and energy budget models created to estimate displacement effects on breeding seabird populations including auks during chick rearing. Overall, the models indicated that there is a potential that displacement will impact future survival prospects of an auk as a result of changes in time and energy budgets. However, it was concluded that during the breeding and non-breeding season displacement effects are unlikely to exceed an increase in mortality of 0.5%.

3.3.2.3 Van Kooten *et al*. (2019[47]) conducted a study to determine the cost of birds avoiding areas based on energy-budget models for two scenarios, using habitat utilization maps. Two displacement rates were tested, 50% based on Dierschke *et al*. (2016[13]) and 100% to understand the impacts of complete displacement. Two mortality rates were also applied, the first derived from Individual Based Model, using an energy budget approach to quantify this effect, while the second was based on a precautionary 10% mortality rate. Overall, the results indicated that an additional 1% mortality for displaced auks is a more appropriate evidenced based rate, in comparison to the overly precautionary 10% mortality rate.

3.3.2.4 The potential population level consequences of seabird displacement were also explored as part of a review undertaken by Norfolk Vanguard (MacArthur Green, 2019[48]). It was concluded that auk displacement from OWFs is likely to be incomplete and may reduce with habituation. Furthermore, long term there is a potential for increased food availability for auks as a result of enhanced habitat for fish populations around offshore wind farms. Considering these factors along with the very low natural annual morality rates of 6% and 10% for adult guillemot and razorbill respectively (Horswill and Robinson, 2015[49]), it is reasonable to assume the impacts of displacement from OWFs are unlikely to represent levels of mortality anywhere close to 6% and 10% of annual mortality that occurs due to the combination of many natural factors plus existing human activities (MacArthur Green, 2019[48]).

3.3.2.5 Additionally, there is anecdotal evidence available to suggest low additional mortality rates from guillemot breeding on Helgoland in the German North Sea where OWFs have been in operation since 2014 and auk displacement rates have been reported to be between 44-63% (during the non-breeding season) (Peschko *et al*., 2020[29]). Colony counts since operation began, indicate further supporting evidence that mortality rates greater than 1% are not apparent, as the breeding guillemot population has remained relatively stable between 2000 and 2018 (Dierschke *et al*., 2011[50]; 2018[51]).

3.3.2.6 Given the available evidence from existing OWF studies and post-construction monitoring, a mortality rate of up to 1% for auks within distributional response assessments is considered appropriate and inclusive of a high degree of precaution. As such, this has been proposed as the Applicant Approach for the Caledonia OWF (plus a 2km buffer) (Table 3-1).

4 Gannet

4.1 Position Overview

4.1.1.1 Gannet were included in the distributional responses assessment based on their abundance in the Caledonia OWF (plus a 4km buffer), highlighted by the 24 months (May 2021 to April 2023) of baseline data (Volume 7B, Appendix 6-1: Offshore Ornithology Baseline Characterisation Report). Additionally, this species has been identified to be sensitive to displacement by Furness *et al*. (2013[9]) and Bradbury *et al*. (2014[10]).

4.1.1.2 Table 4-1 presents the matrix-based method displacement and mortality rates used in the Guidance Approach and the Applicant Approach.

Table 4-1: Displacement and mortality rates used in the matrix-based method for gannet as per the NatureScot Guidance Approach and the Applicant Approach.

Approach	Displacement Rate	Mortality Rate – Breeding Season	Mortality Rate – Non-breeding Season
Guidance Approach	70%	1% and 3%	1% and 3%
Applicant Approach	70%	1%	1%

4.2 Displacement Rate

4.2.1 SNCB Guidance

4.2.1.1 As per the NatureScot Guidance Note 8 (NatureScot, 2023[1]) a displacement rate of 70% is advised for use when assessing distributional responses of gannet (Table 4-1). Based on information contained within the guidance note, their recommend rate appears to be based on the studies undertaken by Fox and Petersen (2006[52]), Krijgsveld *et al*. (2011[53]) and Vanermen *et al*. (2014[6]). As per Fox and Petersen (2006[52]), gannet were noted to avoid the OWF (and 2km and 4km buffers) post-construction. Krijgsveld *et al*. (2011[53]) established that 64% of gannets avoided entering the Egmond aan Zee Windpark (OWEZ) (macro-avoidance). Vanermen *et al*. (2014[6]) found gannet avoided the presence of Bligh Bank OWF (85% decrease in abundance).

4.2.1.2 As per the NatureScot guidance, a displacement rate of 70% is advised for use when assessing distributional responses of gannet (Table 4-1). Given the available evidence above, the Applicant Approach agrees with the use of a 70% displacement rate recommended.

4.2.1.3 According to current UK SNCB (2022[3]) guidance, any species recorded within the OWF development site (and buffer zones) that also scores 3 or more under '*Disturbance Susceptibility*' or '*Habitat Specialization*' should be assessed for displacement, unless there is strong empirical evidence to suggest otherwise. Gannet, which scored 2, are an exception to this given the available evidence suggesting this species are sensitive to displacement and barrier effects (e.g., Krijgsveld *et al*., 2011[53]; Vanermen *et al*., 2013[54]).

4.2.2 Studies on Gannet Distributional Responses to OWF

4.2.2.1 Dierschke *et al*. (2016[13]) reviewed the behavioural responses reported as part of post-consent monitoring studies for 20 OWFs in the UK and Europe, of which analysis of behavioural responses for gannet were available for 10 OWFs. Overall, gannet were categorised as "*species strongly or (nearly) completely avoiding offshore wind farms*".

4.2.2.2 Further evidence indicating that gannet are highly avoidant of OWFs has been reported during several post-construction monitoring studies (e.g., APEM, 2013[55]; Dierschke *et al*., 2016[13]; Leopold *et al*., 2013[5]; Vanermen *et al*., 2013[54]; 2016[16]; Garthe *et al*., 2017a[56]; 2017b[57]; Skov *et al*., 2018[58]). Skov *et al*. (2018[58]) observed 80% macro avoidance during a study at Thanet OWF. Leopold *et al.* (2013) reported the majority of gannet recorded avoided the Princes Amalia Wind Farm and OWEZ. This species also did not appear to forage within the OWFs but were observed actively foraging outside of the windfarms (Leopold *et al*., 2013). Furthermore, gannet densities at the Thornton Bank and Bligh Bank OWFs decreased by 99% and 82% respectively and by 60% and 26% within the buffer zones, respectively (Vanermen *et al*., 2016[16]).

4.2.3 Project Area Specific Evidence

4.2.3.1 Similar to the evidence outlined above, the findings of the Beatrice OWF post-construction monitoring studies indicated gannet avoid OWFs (MacArthur Green, 2021[35]; 2023[36]). It is noted that only 12 gannet were recorded within the OWF during 2021 and as such it was not possible to consider turbine avoidance. Additionally, it was highlighted that the consequences of displacement are likely to be minimal for gannet due to their diverse diet, their large foraging range and the low-energy flight costs in this species (see Section 4.3 below for further details).

4.2.4 Conclusions

4.2.4.1 Given the available evidence that has been reviewed, the Applicant agrees with the use of the advised SNCB's 70% displacement rate.

4.3 Mortality Rate

4.3.1.1 As per the NatureScot guidance a morality rate of 1% and 3% is advised for use when assessing distributional responses of gannet during the breeding season and non-breeding season (Table 4-1). However, based on the evidence presented the Applicant has concluded that 1% mortality is sufficiently precautionary, with no evidence found to support the use of the higher rate of 3%.

4.3.1.2 According to Woodward *et al*. (2019[59]) gannet have a mean maximum foraging range plus 1 standard deviation of 509.4km, with a maximum known foraging range of 709km. Furthermore, this species feeds on a wide range of prey species including mackerel (*Scomber scombrus*), sandeels (*Ammodytes* sp.), immature herring (*Clupea harrengus*) and sprat (*Sprattus sprattus*) (Forrester *et al*., 2007[60]; Hamer *et al*., 2007[61]). As such, were this species to be displaced from the Proposed Development (Offshore), it is considered that gannet would be able to find alternative prey source and suitable foraging areas without expending excessive additional energy.

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