Partners in UK offshore wind

MORGAN OFFSHORE WIND PROJECT: GENERATION ASSETS

Environmental Statement

Volume 4, Annex 5.2: Offshore ornithology displacement technical report

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Image of an offshore wind farm

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Glossary

Term	Meaning
Season	Bird behaviour and abundance is recognised to differ across a calendar year, with particular months recognised as being part of different seasons. The biologically defined minimum population scales (BDMPS) seasons used in this report are based on those in Furness (2015), hereafter referred to as seasons.
Ornithology	Ornithology is a branch of zoology that concerns the study of birds.
Statutory Nature Conservation Bodies (SNCBs)	Joint Nature Conservation Committee (JNCC), Natural Resources Wales, Department of Agriculture, Environment and Rural Affairs/Northern Ireland Environment Agency, Natural England and NatureScot, agencies which provide advice in relation to nature conservation to government.

Acronyms

Term	Meaning
BDMPS	Biologically Defined Minimum Population Scales
DCO	Development Consent Order
EIA	Environmental Impact Assessment
EWG	Expert Working Group
HRA	Habitats Regulations Assessment
IBMs	Individual-Based Models
JNCC	Joint Nature Conservation Committee
MRSea	Marine Renewables Strategic environmental assessment
NRW	Natural Resources Wales
PEIR	Preliminary Environmental Information Report
RSPB	Royal Society for the Protection of Birds
SNCB	Statutory Nature Conservation Body's
TWT	The Wildlife Trust
VOR	Valued Ornithological Receptor

Units

Unit	Description
%	Percent
km	Kilometres
km^2	Square kilometres (area)
nm	Nautical miles

1 Offshore ornithology displacement technical report

1.1 Introduction

1.1.1 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); 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 Morgan Array Area including a buffer around it. In a review of studies from 20 operational offshore wind farms in Europe, Dierschke *et al*. (2016) assessed the extent of displacement or attraction of a number of seabird species. Whilst diver species and gannet *Morus bassanus* showed consistent and strong avoidance behaviour of operational wind farms, fulmar *Fulmarus glacialis*, common scoter *Melanitta nigra*, Manx shearwater *Puffinus puffinus*, razorbill *Alca torda*, guillemot *Uria aalge*, little gull *Hydrocoloeus minutus* and Sandwich tern *Thalasseus sandvicensis* showed less consistent displacement.

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 The Statutory Nature Conservation Bodies (SNCBs) have produced guidelines to assess seabird displacement associated with offshore wind farms (The Joint Nature Conservation Committee (JNCC) *et al.,* 2022). The guidelines promote the use of a displacement matrix approach (i.e. representing proportions of seabirds potentially displaced/dying as a result of an offshore wind farm development). JNCC *et al.* (2022) details 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 km from the wind farm footprint for most species, with

displacement up to 4 km considered for divers and seaducks (and in some cases up to 10 km) due to being the most sensitive species groups to disturbance from sound, boat and helicopter traffic).

1.1.1.6 The displacement assessment for the Morgan Offshore Wind Project: Generation Assets (hereafter referred to as the Morgan Generation Assets) makes use of the displacement matrix approach, which was agreed during consultation with the Offshore Ornithology Expert Working Group (EWG) on 13 July 2022 as part of the Evidence Plan process (Evidence Plan sent to stakeholders on 26 May 2022, responses received on 24 June 2022 from Natural England and JNCC, and 7 July from Natural Resources Wales (NRW)).

1.1.2 Aim of the report

1.1.2.1 This report presents the method and results of the matrix table approach to seabird displacement assessment resulting from the Morgan Generation Assets during the construction, operations and maintenance, and decommissioning phases. This report considers the most abundant seabird species recorded during the digital aerial surveys carried out between April 2021 and March 2023 to characterise the baseline for the assessment. The full methods and results of the digital aerial surveys are presented in Volume 4, Annex 5.1: Offshore ornithology baseline characterisation technical report of the Environmental Statement.

1.1.3 Morgan offshore ornithology study area

1.1.3.1 The Morgan Array Area is located in the east Irish Sea, approximately 22.3 km (12 nm) from the Isle of Man and 37.2 km (20.1 nm) from the northwest coast of England. The Morgan Array Area is 280 km^2 in size. Displacement analyses have utilised population estimates from the Morgan Array Area plus a 2 km buffer. These population estimates have been derived from aerial surveys undertaken across the Morgan Offshore Ornithology Survey Area (as defined in Volume 4, Annex 5.1: Offshore ornithology baseline characterisation technical report of the Environmental Statement). This technical report also utilises abundance data from the Morgan Offshore Ornithology Study Area (also defined in Volume 4, Annex 5.1: Offshore ornithology baseline characterisation technical report of the Environmental Statement) to identify if displacement analyses are required for the Valued Ornithological Receptors (VORs) identified in Volume 4, Annex 5.1: Offshore ornithology baseline characterisation technical report of the Environmental Statement. These areas are illustrated in Figure 1.1.

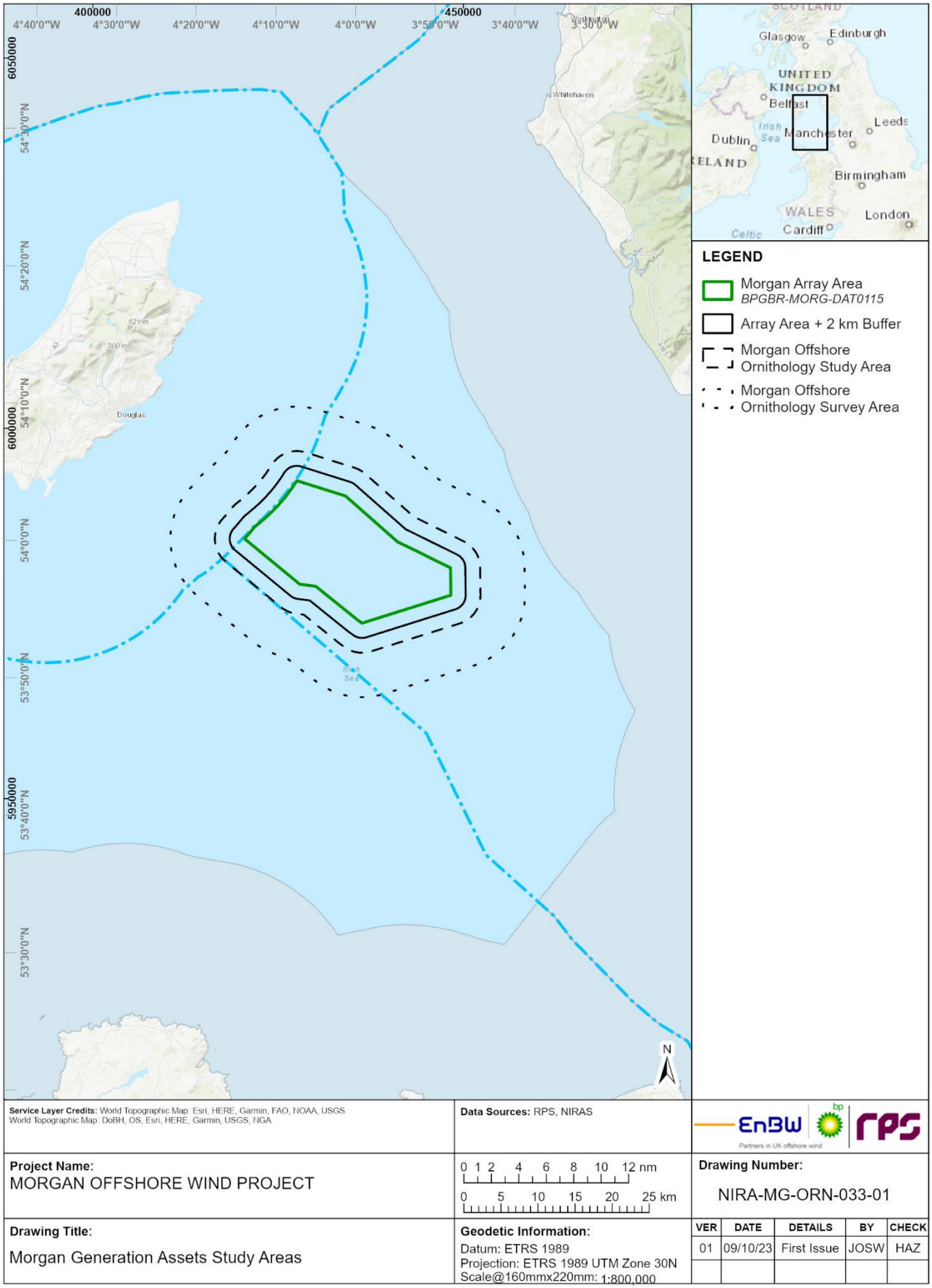

Figure 1.1: Morgan offshore ornithology study area used for displacement analyses and the Morgan Array Area.

1.2 Consultation

1.2.1 Overview

1.2.1.1 A summary of the key matters raised during consultation activities undertaken to date specific to offshore ornithology is presented in Table 1.1 below, together with how these comments have been considered in the production of this technical report.

1.2.2 Evidence Plan process

1.2.2.1 The purpose of the Evidence Plan process is to agree the information the Morgan Generation Assets needs to supply to the Secretary of State, as part of a Development Consent Order (DCO) application for the Morgan Generation Assets. The Evidence Plan seeks to ensure compliance with Habitats Regulations Assessment (HRA). The development and monitoring of the Evidence Plan and its subsequent progress is being undertaken by the Steering Group. The Steering Group will comprise of the Planning Inspectorate, the Applicant, NRW, Natural England, JNCC and the MMO as the key regulatory and SNCBs. To inform the Environmental Impact Assessment (EIA) and HRA process during the pre-application stage of the Morgan Generation Assets, EWGs were also set up to discuss and agree topic specific issues with the relevant stakeholders. Consultation was undertaken via the Offshore Ornithology EWG, with meetings held in February 2022, July 2022, November 2022, February 2023, June 2023, October 2023 and December 2023.

1.2.2.2 The responses provided and changes suggested by the stakeholders through the EWG are summarised in Table 1.1, together with changes implemented in this technical report.

1.2.3 Section 42 consultation

1.2.3.1 A number of comments were received during the S42 consultation following submission of the Preliminary Environmental Information Report (PEIR) chapter. All the responses provided, and changes suggested by the stakeholders are presented in the Consultation report (Document Reference E3) together with changes implemented in the technical reports underpinning the Environmental Statement.

1.2.3.2 A summary of the key responses with changes implemented in this technical report of the Environmental Statement are presented in Table 1.1.

Table 1.1: Consultation responses relevant to the technical appendix.

Date	Consultee and type of response	Topics and comment raised	Response to comment raised and/or where considered in this chapter
June 2022	**Scoping Opinion** The Planning Inspectorate	It is noted that the approach to obtaining density and spatial abundance estimates will be discussed within the Evidence Plan process. The Inspectorate advises that given the fundamental importance of this discussion to the outcomes of the EIA process, the Applicant should seek to agree the modelling parameters used and the methodology applied with the relevant consultees, giving careful consideration to the sharing of information through the Evidence Plan process.	The approach incorporates all parameters recommended by SNCBs. Approach is detailed in Volume 4, Annex 5.1 Offshore ornithology baseline characterisation report of the Environmental Statement.
		The Inspectorate advises that the breeding, non-breeding, and migratory seasons (where applicable) are defined for each relevant bird species assessed. Effort should be made to agree the definitions of each season with the relevant consultees including where the use of seasonal peaks is part of the modelling methodology.	Seasons are based on Furness (2015) definitions and approach has been agreed with SNCBs through the evidence plan process. Seasonality is provided in section 1.3.2
July 2022	Offshore Ornithology Expert Working Group 2: Natural England, JNCC, NRW, Royal Society for the Protection of Birds (RSPB), The Wildlife Trust (TWT)	Agreed on the approach to displacement as set out in the offshore ornithology displacement assessment technical paper (provided as part of the EWG process, see the Technical enaggement plan report (document reference E4)), taking into account clarifications to be provided by SNCBs.	It was agreed that kittiwake would be included in displacement along with the combined estimate of birds on the water and in flight for Manx shearwater.

Date	Consultee and type of response	Topics and comment raised	Response to comment raised and/or where considered in this chapter
July – August 2022	JNCC and Natural England – displacement technical paper provided and agreed as part of the Offshore Ornithology Expert Working Group 2.	Advise that whole displacement matrices are presented for black-legged kittiwake Rissa tridactyla and Manx shearwater Puffinus puffinus using a range of mortality rates from 1 to 10%.	Displacement matrices (using a range of mortality rates) for both Manx shearwater and black-legged kittiwake are presented in section 1.4 of this technical report.
		Advise that a combined estimate of the number of birds on the water (corrected for survey coverage) and of the number of birds in flight (corrected for survey coverage) are used for an assessment of Manx shearwater displacement.	The assessment of Manx shearwater presented in this report is based on the combined estimate of birds on the water and birds in flight.
		Advise that a displacement assessment is also carried out for the construction and decommissioning phases. This should assume that 50% of the annual displacement impact resulting from the operations phase will occur during construction, and decommissioning, phases.	The displacement assessments in Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement. have been carried out for the construction, operations, and decommissioning phases assuming that 50% of the annual displacement impact resulting from the operations phase will occur during construction and decommissioning phases.
		Advise that assessments of displacement should use the information on uncertainty and variability in the input parameters (e.g. bird densities, mortality and displacement rates) to allow consideration of the range of values predicted impacts may fall within, and to allow an assessment of confidence in the conclusions made regarding adverse effects on site integrity and significance of impacts for populations.	The displacement analysis undertaken in this Technical Report and the assessments presented in Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement are considered to account for the full range of uncertainty and variability in the input parameters (i.e. mean-peak populations and a range of displacement and mortality rates) following joint SNCB guidance (JNCC *et al.,* 2022)

Date	Consultee and type of response	Topics and comment raised	Response to comment raised and/or where considered in this chapter
		Advise that black-legged kittiwake is screened into the displacement assessment as recent evidence suggests that they can be sensitive to displacement from offshore wind farms.	Displacement assessment has been conducted for black-legged kittiwake in Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement..
		Advise that model-or design-based estimates of abundance and density of divers and scoters are presented to determine whether or not a displacement assessment should be carried out for red-throated diver and seaducks.	Density estimates of all species encountered during the digital aerial surveys are presented in Volume 4, annex 5.1: Offshore ornithology baseline characterisation report of the Environmental Statement.
	JNCC and Natural England – collision technical paper provided and agreed as part of the Offshore Ornithology Expert Working Group 2.	Advise the use of a migration-free breeding season.	Seasons were defined in this technical report according to the breeding, non-breeding and migratory periods using seasonal divisions proposed for Biologically Defined Minimum Population Scales (BDMPS) by Furness (2015).
December 2022	**Offshore Ornithology Expert Working Group 3 –** Natural England, JNCC and RSPB.	Suggested that the displacement rates that should be used for Manx Shearwater are 70% displacement and 10% mortality.	Displacement rates of 30-70% and mortality rates of 1-10% have been presented for Manx shearwater in this technical report.
		JNCC requested full displacement matrices be presented.	Full displacement matrices are presented in this technical report.
June 2023	**S42 – Consultation Log** Natural England	Vol.4, Ann. 10.2 We welcome the use of highlighted cells to indicate displacement and mortality rates used in the project alone displacement assessment. However, we consider it would be useful if the tables also indicated where 1% of baseline mortality was exceeded (if visible on the matrix). Consider amending.	The 1% threshold of baseline mortality will be referenced in relevant assessments in Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.

Date	Consultee and type of response	Topics and comment raised	Response to comment raised and/or where considered in this chapter
		Vol.2, Ch.10, Table 10.62, Table 10.87 According to Furness (2015) there are three seasons for northern gannet; pre-breeding, breeding and post-breeding, as shown in Table 10.62 (construction phase), but only two seasons are shown in Table 10.87 (operation and maintenance phase). We note that the decommissioning phase has not been assessed explicitly. Consider cumulative disturbance and displacement with respect to the decommissioning phase.	The seasonal definitions from Furness (2015), specifically the number of seasons, has been applied as discussed in section 1.3.2 of this technical report.
		Vol.4, Ann.10.2, 1.2.2 Natural England note that we did not advise that black-legged kittiwake was screened into the displacement assessment. Natural England currently consider the evidence base insufficient, but suggestive of a broad range of responses incorporating both displacement and attraction for this species. Natural England will not comment on kittiwake displacement, or consider combined collision and displacement impacts for that species.	Kittiwake has been included in this technical report at the request of JNCC.
	S42 – Consultation Log NRW	204. Offshore Ornithology. Detailed comments. Assessment of Significant Effects/Impacts at EIA scale (section 10.8 of Chapter 10, Annexes 10.2-10.4). Disturbance and displacement. NRW (A) welcome that quantitative assessments of displacement have been undertaken for all phases for guillemot, razorbill, puffin, gannet and Manx shearwater for EIA scale within section 10.8.1 of Chapter 10 and in Annex 10.2. NRW (A) also note that assessment has been made of kittiwake displacement. However, currently NRW (A) do not recommend that displacement is assessed for kittiwake as we currently consider the evidence base to be insufficient and hence, NRW (A) have not provided advice/comment on this.	Kittiwake has been included in this technical report at the request of JNCC.

Date	Consultee and type of response	Topics and comment raised	Response to comment raised and/or where considered in this chapter
		205. Offshore Ornithology. Detailed comments. Assessment of Significant Effects/Impacts at EIA scale (section 10.8 of Chapter 10, Annexes 10.2-10.4). Disturbance and displacement. The table headings for the tables in Appendix A of Annex 10.2 (Tables A.1-A.6) suggest that the mean seasonal peak abundance estimates used in the matrices for displacement assessments are based on the modelled (i.e. Marine Renewables Strategic environmental assessment (MRSea)) abundance estimates. However, clarification is required as to whether this is the case, as we note that in Appendix B, Table B4 of Annex 10.1 for gannet for example, Table B4 suggests that there are no model-based (MRSea) abundances for any months except August and September of the 12 months of data presented for the Morgan generation assets site plus 2km buffer, but there are abundances given for all the months without MRSea estimates (i.e. Apr-Jul, Oct-Mar) in Table A.4 of Annex 10.2, which suggests that the design-based estimates for these months have been included. Therefore, clarification is required as to whether the monthly abundance estimates presented in Tables A.1-A.6 of Annex 10.2 are actually a mix of design based and model-based (MRSea) estimates or are all model-based (MRSea) or all design-based for the species where MRSea has been run.	Additional clarification added to assessment (see section 1.3.3). Where available abundance metrics from MRSea modelling have been used with design-based estimates used where MRSea estimates are unavailable as discussed in section 1.3.3 of this technical report.
		206. Offshore Ornithology. Detailed comments. Assessment of Significant Effects/Impacts at EIA scale (section 10.8 of Chapter 10, Annexes 10.2-10.4). Disturbance and displacement. Based on the above (paragraph 205), it appears that for the species where MRSea estimates have been generated for some of the surveys, the quantitative impact assessments (e.g. of displacement and collision risk) have been based on a mix of MRSea estimates for months where these are available and design-based estimates where MRSea estimates are not available. Whilst this approach seems sensible and uses the best available data, this hierarchy of approach needs to be clearly stated in the documents.	Additional clarification added to assessment (see section 1.3.3). Where available abundance metrics from MRSea modelling have been used with design-based estimates used where MRSea estimates are unavailable as discussed in section 1.3.3 of this technical report.
		207. Offshore Ornithology. Detailed comments. Assessment of Significant Effects/Impacts at EIA scale (section 10.8 of Chapter 10, Annexes 10.2-10.4). Disturbance and displacement. NRW (A) agree with the displacement and mortality rates used for the operational phase for auks (guillemot, razorbill and puffin) and gannet and also welcome that displacement during the construction and decommissioning phases has been considered to be 50% of the operational phase.	Noted, approach has been followed in this technical report with a range of displacement and mortality rates presented in section 1.4.

Date	Consultee and type of response	Topics and comment raised	Response to comment raised and/or where considered in this chapter
		208. Offshore Ornithology. Detailed comments. Assessment of Significant Effects/Impacts at EIA scale (section 10.8 of Chapter 10, Annexes 10.2-10.4). Disturbance and displacement. However, as discussed during offshore ornithology EWG 3, as there is currently no evidence for any particular range of displacement rates (1-10%, 30-70% or any other) for Manx shearwater from offshore wind farms, NRW (A) welcome that the whole matrices for all phases are presented in Tables 1.103-1.111 and 1.113-1.121 of Annex 10.2. NRW (A) do note that Manx shearwaters have been shown to avoid the windfarm at North Hoyle in Liverpool Bay (see Table 3 of Dierschke et al. [2016]). The predicted impacts across the whole matrices presented in the PEIR can be used to further inform discussions through the EWG on the appropriate range of displacement rates to use in the final submission for Manx shearwater (as was agreed during EWG 3).	Complete matrices are included in section 1.4 of this technical report.
	S42 consultation RSPB	Confirmed that RSPB would provide their input via the EWG and that the main breeding seabird species of interest to the RSPB includes Manx Shearwater (*Puffinus puffinus*), Northern Gannet (*Morus bassanus*), Black-legged Kittiwake (*Rissa tridactyla*), Common Guillemot (*Uria algae*) and Razorbill (*Alca torda*) along with non-breeding Red-throated Diver (*Gavia stellata*) and Common Scoter (*Melanitta nigra*). Commented on breeding Lesser Black-backed Gull (*Larus fuscus*), despite the low frequency of occurrence during the reported survey work. This is because, with the exception of the Ribble and Alt Estuary SPA colony, the main Irish Sea breeding colonies (at Bowland Fells SPA and Morecambe Bay and Duddon Estuary SPA) require restoration to a favourable conservation status and the implications of this needs careful consideration via the Expert Working Groups.	Noted. Discussions with RSPB have been ongoing throughout the pre-application process through the EWGs.
	S42 consultation North West Wildlife Trust	Confirmed that the North West Wildlife Trust (NWWT) echo RSPBs comments on the PEIR. Given the number of OWF being developed in the Irish Sea, NWWT expect a full cumulative impact assessment to be undertaken, including consideration of transboundary impacts. Concerns are raised over the possible disturbance, displacement and barrier effects on sensitive receptors, particular black-legged kittiwake and northern gannet.	Cumulative effects and transboundary impacts in relation to offshore ornithology are considered within Volume 2, Chapter 5: Offshore ornithology of the Environmental Statement.

1.3 Methodology

1.3.1 Species for consideration

1.3.1.1 The full process applied to identify VORs that may be affected by impacts associated with the Morgan Generation Assets is documented in Volume 4, Annex 5.1: Offshore ornithology baseline characterisation technical report of the Environmental Statement. 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 1.2) (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 Morgan Offshore Ornithology Study Area (as defined in Volume 4, Annex 5.1: Offshore ornithology baseline characterisation technical report of the Environmental Statement) (Figure 1.1) is considered to be of importance, when compared against a relevant population scale thresholds (regional, national or international) as described in Volume 4, Annex 5.1 Offshore ornithology baseline characterisation report of the Environmental Statement.

1.3.1.2 Table 1.2 identifies those VORs for which displacement analysis is required based on the above criteria.

Table 1.2: Identification of VORs for which analysis of displacement for the Morgan Generation Assets is required.

VOR	Vulnerability to displacement impacts	Uncertainty level associated with vulnerability rating	Importance of population at the Morgan Generation Assets	Displacement analysis required (Yes/No)
Kittiwake *Rissa tridactyla*	Low	Very Low	Regional	No – low vulnerability, very low associated uncertainty, species recorded in regionally important numbers at the Morgan Generation Assets.
Little gull *Hydrocoloeus minutus*	Very Low	N/A	Regional	No – very low vulnerability, species recorded in only a few surveys
Great black-backed gull *Larus marinus*	Low	Very Low	Regional	No – low vulnerability, very low associated uncertainty, species recorded in regionally important numbers at the Morgan Generation Assets.
Herring gull *Larus argentatus*	Low	Very Low	Regional	No – low vulnerability, very low associated uncertainty, species recorded in regionally important numbers at the Morgan Generation Assets.

VOR	Vulnerability to displacement impacts	Uncertainty level associated with vulnerability rating	Importance of population at the Morgan Generation Assets	Displacement analysis required (Yes/No)
Lesser black-backed gull *Larus fuscus*	Low	Very Low	Local	No – low vulnerability, very low associated uncertainty
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	Local	No – low vulnerability, species not recorded in relevant study area during baseline surveys
Arctic tern *Sterna paradisaea*	Low	Moderate	Local	No – low vulnerability and species occurrence at the Morgan Generation Assets limited
Great skua *Stercorarius skua*	Very Low	High	Local	No – low vulnerability and species occurrence at the Morgan Generation Assets limited
Arctic skua *Stercorarius parasiticus*	Very Low	Very High	Local	No – low vulnerability, species not recorded in relevant study area during baseline surveys
Guillemot *Uria aalge*	High	Very Low	Regional	Yes – high vulnerability, species recorded in regionally important numbers at the Morgan Generation Assets
Razorbill *Alca torda*	High	Very Low	Regional	Yes – high vulnerability, species recorded in regionally important numbers at the Morgan Generation Assets
Puffin *Fratercula arctica*	Moderate	Moderate	Local	No – species occurrence at the Morgan Generation Assets limited
European storm petrel *Hydrobates pelagicus*	Very Low	Very High	Negligible	No – very low vulnerability and species not recorded during baseline surveys

VOR	Vulnerability to displacement impacts	Uncertainty level associated with vulnerability rating	Importance of population at the Morgan Generation Assets	Displacement analysis required (Yes/No)
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	Yes – although vulnerability is very low, the associated uncertainty is high
Manx shearwater *Puffinus puffinus*	Very Low	Very High	Local	Yes – although vulnerability is very low, the associated uncertainty is very high
Gannet *Morus bassanus*	High	Very Low	Local	Yes – high vulnerability, recorded in majority of baseline surveys

1.3.1.3 The following species were selected for displacement analysis:

- Guillemot (high vulnerability, regional population importance)
- Razorbill (high vulnerability, regional population importance)
- Fulmar (although vulnerability is very low, associated uncertainty level is high)
- Manx shearwater (although vulnerability is very low, associated uncertainty level is very high with species recorded during baseline surveys)
- Gannet (high vulnerability and although only of local population importance species recorded in the majority of surveys).

1.3.1.4 Following advice from the Offshore Ornithology EWG, kittiwake has also been included within the assessment. Kittiwake has been included due to evidence suggesting that the species can be sensitive to displacement from offshore wind farms (Peschko *et al*., 2020; Vanermen *et al*., 2016).

1.3.2 Seasonality

1.3.2.1 Seasonal extents used within the displacement assessment were defined according to the breeding, non-breeding and migratory periods (autumn and spring migration) based on Furness (2015) (Table 1.3) as per Offshore Ornithology EWG advice (based on the second EWG meeting and Evidence Plan sent to SNCBs on 27 May 2022, advice received on 24 June from Natural England and JNCC, and on 7 July 2022 from NRW).

1.3.2.2 If a month fell within two seasons (e.g. March for gannet is included in both the pre-breeding and breeding seasons in Furness (2015)), priority was given to the breeding season. In cases where a peak abundance was estimated during a month spanning two seasons, such as 100 birds observed in March for northern gannets, the peak of 100 birds was attributed to the breeding period. This approach was applied based on advice from JNCC during EWG meeting 2 (held on 13 July 2022), which discouraged the use of the migration-free breeding period in the displacement assessments.

Consequently, some months were present in more than one season. To avoid underestimating the impact during the breeding season therefore, a precautionary approach was taken to prioritizing it due to the significant importance of this time and any potential impacts during this period having a profound impact on the regional population. If two months fell across two periods (e.g. March and April for kittiwake overlapping the pre-breeding and breeding season) then the first month was assigned to the pre-breeding and the second assigned to the breeding. This approach was taken as birds are still undergoing migration in March (Furness, 2015) and would likely overestimate impacts if all birds were considered to be breeding during the migration period.

Table 1.3: Seasonal definitions as the basis for assessment, from Furness (2015).

Species	Pre-breeding season/spring migration	Breeding season	Post breeding season/autumn migration	Non-breeding/winter season
Kittiwake	January to March	April to August	September to December	n/a
Guillemot	n/a	March to July	n/a	August to February
Razorbill	January to March	April to July	August to October	November to December
Fulmar	December to March	April to August	September to October	November
Manx shearwater	March	April to August	September to October	n/a
Gannet	December to February	March to September	October to November	n/a

1.3.2.3 In the non-breeding season, seabirds are not constrained by colony location and can, depending on individual species, range widely within UK seas and beyond. The zone of influence for seabird species where an assessment in the non-breeding season and migratory periods is deemed to be required is based on the 'UK Western Waters' populations defined by Furness (2015).

1.3.3 Abundance estimates

1.3.3.1 Project-specific data for the Morgan Generation Assets has been collected during two years of digital aerial surveys carried out between April 2021 and March 2023 encompassing the Morgan Array Area plus a 10 km buffer (the Morgan Offshore Ornithology Survey Area as defined in Volume 4, Annex 5.1: Offshore ornithology baseline characterisation technical report of the Environmental Statement) (Figure 1.1). Further information on the aerial surveys undertaken for the Morgan Generation Assets and the methodologies used to derive population estimates is provided in the Volume 4, Annex 5.1: Offshore ornithology baseline characterisation technical report of the Environmental Statement.

1.3.3.2 For those species identified in section 1.3.1, a 2 km buffer is considered appropriate to inform assessment of displacement. No species for which a 4 km displacement buffer (or 10 km 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 the Morgan Generation Assets.

1.3.3.3 Model-based estimates using the Marine Renewables Strategic environmental assessment (MRSea) package were produced to predict numbers across the survey area alongside 95% confidence intervals 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.

1.3.3.4 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. Seasonal mean-peak population estimates of each species were calculated using the defined seasons identified in Table 1.3 to provide the number of seabirds at risk of displacement impacts. The use of a mean-peak population allows for consideration of inter-annual variability (JNCC *et al.,* 2022). Peak abundances in each season for each species considered within the displacement assessment are outlined in bold within Appendix A.

Table 1.4: Mean peak abundances for use in the assessment for each bio-season. Population estimates from model-based abundance estimation presented with design-based equivalents shown in brackets.

Species	Pre-breeding season/spring migration	Breeding season	Post breeding season/autumn migration	Non-breeding/winter season
Kittiwake	791 (601)	505 (502)	1,151 (1,083)	n/a
Guillemot	n/a	4,010 (3,720)	n/a	3,824 (3,349)
Razorbill	328 (289)	35 (35)	254 (159)	1,170 (1,128)
Fulmar	102	19	0	23
Manx shearwater	0 (0)	1,254 (547)	384 (911)	n/a
Gannet	35 (35)	154 (109)	65 (65)	n/a

1.3.4 Displacement and mortality rates

1.3.4.1 Displacement matrices are presented in section 1.4 for each species and associated seasons. Potential displacement impacts for each species are presented here based on a wide range of potential displacement (0 to 100%) and mortality rates (0 to 100%) following recent SNCB guidance (JNCC *et al*., 2022). In addition, the displacement and mortality rates identified following the guidance in JNCC *et al.* (2022) are highlighted. Displacement rates are identified using the vulnerability of each species to displacement from structures provided in Wade *et al.* (2016) which represents the most recent appraisal of species vulnerability to impacts associated with offshore wind farms. Mortality rates of 1 to 10% are highlighted in the matrices following SNCB advice to previous projects. The displacement and mortality rates defined based on guidance in JNCC *et al.* (2022) are summarised in Table 1.5.

Table 1.5: Displacement and mortality rates for use in the assessment during operations and maintenance phase.

Species	Displacement rates	Mortality rates	Source
Kittiwake	30 to 70%	1 to 10%	Peschko *et al.* (2020); Vanermen *et al.* (2016)
Guillemot	30 to 70%	1 to10%	JNCC *et al.* (2022)
Razorbill	30 to 70%	1 to 10%	JNCC *et al.* (2022)
Fulmar	1 to 10%	1 to 10%	JNCC *et al.* (2022)
Manx shearwater	30 to 70%	1 to 10%	JNCC *et al.* (2022)
Gannet	60 to 80%	1 to 10%	JNCC *et al.* (2022) East Anglia ONE North, Hornsea Four and Norfolk Vanguard; based on reference to Cook *et al.* (2018), Skov *et al.* (2018), Leopold *et al.* (2011) and Furness & Wade (2012).

1.3.4.2 The displacement and mortality rates identified in Table 1.5 are applicable to displacement that occurs in the operational phase. Displacement may also occur during the during the construction phase due to the presence of wind turbines, vessel traffic and construction and piling activities occurring within the site. These activities may displace individuals that would normally reside within and around the Morgan Generation Assets.

1.3.4.3 As actual rates of displacement during the construction phase are difficult to determine, and as recommended by the Offshore Ornithology EWG, the following methodology is proposed. Given that construction is limited both spatially and temporally and that any potential effects are unlikely to reach the same level as during the operation, the level to be used is half that of the operations and maintenance phase assessments. Table 1.6 shows the displacement and mortality rates used during the construction phase assessment. These rates are also highlighted in the matrices for each species in section 1.4.

1.3.4.4 Decommissioning activities within the Morgan Array Area are equal to or less than those carried out during the construction phase within the Morgan Array Area. Therefore, for the purpose of this assessment it is assumed that the impacts are likely to be similar.

Table 1.6: Displacement and mortality rates for use in the assessment during construction and decommissioning phase.

Species	Displacement rates	Mortality rates
Kittiwake	15 to 35%	1 to 10%
Guillemot	15 to 35%	1 to 10%
Razorbill	15 to 35%	1 to 10%
Fulmar	0.5 to 5%	1 to 10%
Manx shearwater	15 to 35%	1 to 10%
Gannet	30 to 40%	1 to 10%

1.4 Results

1.4.1 Overview

1.4.1.1 Displacement matrices for all species and associated seasons are presented in the following sections using the model-based abundance estimates in months where available and design-based estimates where model-based estimates could not be calculated. Displacement matrices using design-based abundance estimates only are presented in Appendix B. In each matrix the range of displacement and mortality rates applicable to the operations and maintenance phase of the Morgan Generation Assets are highlighted using cells filled with yellow. The range of displacement and mortality rates applicable to the construction phase of the Morgan Generation Assets are highlighted using purple borders.

1.4.2 Kittiwake

1.4.2.1 Displacement matrices for kittiwake in the pre-breeding, breeding and post-breeding seasons are presented in Table 1.7, Table 1.8 and Table 1.9, respectively.

Table 1.7: Predicted kittiwake mortality for the Morgan Array Area plus 2 km buffer during the pre-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Kittiwake (pre-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	1	2	4	8	16	24	32	40	47	55	63	71	79
	15	1	2	6	12	24	36	47	59	71	83	95	107	119
	20	2	3	8	16	32	47	63	79	95	111	127	142	158
	25	2	4	10	20	40	59	79	99	119	138	158	178	198
	30	2	5	12	24	47	71	95	119	142	166	190	214	237
	35	3	6	14	28	55	83	111	138	166	194	221	249	277
	40	3	6	16	32	63	95	127	158	190	221	253	285	316
	50	4	8	20	40	79	119	158	198	237	277	316	356	395
	60	5	9	24	47	95	142	190	237	285	332	380	427	475
	70	6	11	28	55	111	166	221	277	332	388	443	498	554
	80	6	13	32	63	127	190	253	316	380	443	506	569	633
	90	7	14	36	71	142	214	285	356	427	498	569	641	712
	100	8	16	40	79	158	237	316	395	475	554	633	712	791

Table 1.8: Predicted kittiwake mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Kittiwake (breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	1	1	3	5	10	15	20	25	30	35	40	45	51
	15	1	2	4	8	15	23	30	38	45	53	61	68	76
	20	1	2	5	10	20	30	40	51	61	71	81	91	101
	25	1	3	6	13	25	38	51	63	76	88	101	114	126
	30	2	3	8	15	30	45	61	76	91	106	121	136	152
	35	2	4	9	18	35	53	71	88	106	124	141	159	177
	40	2	4	10	20	40	61	81	101	121	141	162	182	202
	50	3	5	13	25	51	76	101	126	152	177	202	227	253
	60	3	6	15	30	61	91	121	152	182	212	242	273	303
	70	4	7	18	35	71	106	141	177	212	248	283	318	354
	80	4	8	20	40	81	121	162	202	242	283	323	364	404
	90	5	9	23	45	91	136	182	227	273	318	364	409	455
	100	5	10	25	51	101	152	202	253	303	354	404	455	505

Table 1.9: Predicted kittiwake mortality for the Morgan Array Area plus 2 km buffer during the post-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Kittiwake (post-breeding)	Mortality rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%) 10	1	2	6	12	23	35	46	58	69	81	92	104	115
15	2	3	9	17	35	52	69	86	104	121	138	155	173
20	2	5	12	23	46	69	92	115	138	161	184	207	230
25	3	6	14	29	58	86	115	144	173	201	230	259	288
30	3	7	17	35	69	104	138	173	207	242	276	311	345
35	4	8	20	40	81	121	161	201	242	282	322	362	403
40	5	9	23	46	92	138	184	230	276	322	368	414	460
50	6	12	29	58	115	173	230	288	345	403	460	518	575
60	7	14	35	69	138	207	276	345	414	483	552	621	690
70	8	16	40	81	161	242	322	403	483	564	644	725	805
80	9	18	46	92	184	276	368	460	552	644	736	828	920
90	10	21	52	104	207	311	414	518	621	725	828	932	1035
100	12	23	58	115	230	345	460	575	690	805	920	1035	1151

1.4.3 Guillemot

1.4.3.1 Displacement matrices for guillemot in the breeding and non-breeding seasons are presented in Table 1.10 and Table 1.11, respectively.

Table 1.10: Mean predicted guillemot mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Guillemot (breeding)	Mortality rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%) 10	4	8	20	40	80	120	160	201	241	281	321	361	401
15	6	12	30	60	120	180	241	301	361	421	481	541	602
20	8	16	40	80	160	241	321	401	481	561	642	722	802
25	10	20	50	100	201	301	401	501	602	702	802	902	1003
30	12	24	60	120	241	361	481	602	722	842	962	1083	1203
35	14	28	70	140	281	421	561	702	842	982	1123	1263	1404
40	16	32	80	160	321	481	642	802	962	1123	1283	1444	1604
50	20	40	100	201	401	602	802	1003	1203	1404	1604	1805	2005
60	24	48	120	241	481	722	962	1203	1444	1684	1925	2165	2406
70	28	56	140	281	561	842	1123	1404	1684	1965	2246	2526	2807
80	32	64	160	321	642	962	1283	1604	1925	2246	2566	2887	3208
90	36	72	180	361	722	1083	1444	1805	2165	2526	2887	3248	3609
100	40	80	201	401	802	1203	1604	2005	2406	2807	3208	3609	4010

Table 1.11: Mean predicted guillemot mortality for the Morgan Array Area plus 2 km buffer during the non-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Guillemot (non-breeding)	Mortality rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%) 10	4	8	19	38	76	115	153	191	229	268	306	344	382
15	6	11	29	57	115	172	229	287	344	401	459	516	574
20	8	15	38	76	153	229	306	382	459	535	612	688	765
25	10	19	48	96	191	287	382	478	574	669	765	860	956
30	11	23	57	115	229	344	459	574	688	803	918	1032	1147
35	13	27	67	134	268	401	535	669	803	937	1071	1204	1338
40	15	31	76	153	306	459	612	765	918	1071	1224	1377	1529
50	19	38	96	191	382	574	765	956	1147	1338	1529	1721	1912
60	23	46	115	229	459	688	918	1147	1377	1606	1835	2065	2294
70	27	54	134	268	535	803	1071	1338	1606	1874	2141	2409	2677
80	31	61	153	306	612	918	1224	1529	1835	2141	2447	2753	3059
90	34	69	172	344	688	1032	1377	1721	2065	2409	2753	3097	3441
100	38	76	191	382	765	1147	1529	1912	2294	2677	3059	3441	3824

1.4.4 Razorbill

1.4.4.1 Displacement matrices for razorbill in the pre-breeding, breeding, post-breeding and non-breeding seasons are presented in Table 1.12, Table 1.13, Table 1.14 and Table 1.15, respectively.

Table 1.12: Mean predicted razorbill mortality for the Morgan Array plus 2 km buffer during the pre-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Razorbill (pre-breeding)	Mortality rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%) 10	0	1	2	3	7	10	13	16	20	23	26	30	33
15	0	1	2	5	10	15	20	25	30	34	39	44	49
20	1	1	3	7	13	20	26	33	39	46	52	59	66
25	1	2	4	8	16	25	33	41	49	57	66	74	82
30	1	2	5	10	20	30	39	49	59	69	79	89	98
35	1	2	6	11	23	34	46	57	69	80	92	103	115
40	1	3	7	13	26	39	52	66	79	92	105	118	131
50	2	3	8	16	33	49	66	82	98	115	131	148	164
60	2	4	10	20	39	59	79	98	118	138	157	177	197
70	2	5	11	23	46	69	92	115	138	161	184	207	229
80	3	5	13	26	52	79	105	131	157	184	210	236	262
90	3	6	15	30	59	89	118	148	177	207	236	266	295
100	3	7	16	33	66	98	131	164	197	229	262	295	328

Table 1.13: Mean predicted razorbill mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Razorbill (breeding)	Mortality rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%) 10	0	0	0	0	1	1	1	2	2	2	3	3	3
15	0	0	0	1	1	2	2	3	3	4	4	5	5
20	0	0	0	1	1	2	3	3	4	5	6	6	7
25	0	0	0	1	2	3	3	4	5	6	7	8	9
30	0	0	1	1	2	3	4	5	6	7	8	9	10
35	0	0	1	1	2	4	5	6	7	9	10	11	12
40	0	0	1	1	3	4	6	7	8	10	11	13	14
50	0	0	1	2	3	5	7	9	10	12	14	16	17
60	0	0	1	2	4	6	8	10	13	15	17	19	21
70	0	0	1	2	5	7	10	12	15	17	19	22	24
80	0	1	1	3	6	8	11	14	17	19	22	25	28
90	0	1	2	3	6	9	13	16	19	22	25	28	31
100	0	1	2	3	7	10	14	17	21	24	28	31	35

Table 1.14: Mean predicted razorbill mortality for the Morgan Array Area plus 2 km buffer during the post-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Razorbill (post-breeding)	Mortality rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%) 10	0	1	1	3	5	8	10	13	15	18	20	23	25
15	0	1	2	4	8	11	15	19	23	27	30	34	38
20	1	1	3	5	10	15	20	25	30	35	41	46	51
25	1	1	3	6	13	19	25	32	38	44	51	57	63
30	1	2	4	8	15	23	30	38	46	53	61	68	76
35	1	2	4	9	18	27	35	44	53	62	71	80	89
40	1	2	5	10	20	30	41	51	61	71	81	91	101
50	1	3	6	13	25	38	51	63	76	89	101	114	127
60	2	3	8	15	30	46	61	76	91	106	122	137	152
70	2	4	9	18	35	53	71	89	106	124	142	160	177
80	2	4	10	20	41	61	81	101	122	142	162	183	203
90	2	5	11	23	46	68	91	114	137	160	183	205	228
100	3	5	13	25	51	76	101	127	152	177	203	228	254

Table 1.15: Mean predicted razorbill mortality for the Morgan Array Area plus 2 km buffer during the non-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Razorbill (non-breeding)	Mortality rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%) 10	1	2	6	12	23	35	47	59	70	82	94	105	117
15	2	4	9	18	35	53	70	88	105	123	140	158	176
20	2	5	12	23	47	70	94	117	140	164	187	211	234
25	3	6	15	29	59	88	117	146	176	205	234	263	293
30	4	7	18	35	70	105	140	176	211	246	281	316	351
35	4	8	20	41	82	123	164	205	246	287	328	369	410
40	5	9	23	47	94	140	187	234	281	328	374	421	468
50	6	12	29	59	117	176	234	293	351	410	468	527	585
60	7	14	35	70	140	211	281	351	421	491	562	632	702
70	8	16	41	82	164	246	328	410	491	573	655	737	819
80	9	19	47	94	187	281	374	468	562	655	749	842	936
90	11	21	53	105	211	316	421	527	632	737	842	948	1053
100	12	23	59	117	234	351	468	585	702	819	936	1053	1170

1.4.5 Fulmar

1.4.5.1 Displacement matrices for fulmar in the pre-breeding, breeding, post-breeding and non-breeding seasons are presented in Table 1.16, Table 1.17, Table 1.18 and Table 1.19, respectively.

Table 1.16: Predicted fulmar mortality for the Morgan Array plus 2 km buffer during the pre-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Fulmar (pre-breeding)	Mortality rate (%)												
Displacement rate (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
0.5	0	0	0	0	0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	1	1	1	1	1	1
5	0	0	0	1	1	2	2	3	3	4	4	5	5
10	0	0	1	1	2	3	4	5	6	7	8	9	10
20	0	0	1	2	4	6	8	10	12	14	16	18	20
30	0	1	2	3	6	9	12	15	18	21	24	28	31
40	0	1	2	4	8	12	16	20	24	29	33	37	41
50	1	1	3	5	10	15	20	25	31	36	41	46	51
60	1	1	3	6	12	18	24	31	37	43	49	55	61
70	1	1	4	7	14	21	29	36	43	50	57	64	71
80	1	2	4	8	16	24	33	41	49	57	65	73	82
90	1	2	5	9	18	28	37	46	55	64	73	83	92
100	1	2	5	10	20	31	41	51	61	71	82	92	102

Table 1.17: Predicted fulmar mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Fulmar (pre-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	1	1	1	1	1
	10	0	0	0	0	0	1	1	1	1	1	2	2	2
	20	0	0	0	0	1	1	2	2	2	3	3	3	4
	30	0	0	0	1	1	2	2	3	3	4	5	5	6
	40	0	0	0	1	2	2	3	4	5	5	6	7	8
	50	0	0	0	1	2	3	4	5	6	7	8	9	10
	60	0	0	1	1	2	3	5	6	7	8	9	10	12
	70	0	0	1	1	3	4	5	7	8	10	11	12	14
	80	0	0	1	2	3	5	6	8	9	11	12	14	16
	90	0	0	1	2	3	5	7	9	10	12	14	16	17
	100	0	0	1	2	4	6	8	10	12	14	16	17	19

Table 1.18: Predicted fulmar mortality for the Morgan Array Area plus 2 km buffer during the post-breeding season. All entries are zero

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Fulmar (post-breeding)	Mortality rate (%)												
Displacement rate (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1.19: Predicted fulmar mortality for the Morgan Array Area plus 2 km buffer during the non-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Fulmar (non-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	1	1	1	1	1	1
	10	0	0	0	0	0	1	1	1	1	2	2	2	2
	20	0	0	0	0	1	1	2	2	3	3	4	4	5
	30	0	0	0	1	1	2	3	4	4	5	6	6	7
	40	0	0	0	1	2	3	4	5	6	7	7	8	9
	50	0	0	1	1	2	4	5	6	7	8	9	11	12
	60	0	0	1	1	3	4	6	7	8	10	11	13	14
	70	0	0	1	2	3	5	7	8	10	11	13	15	16
	80	0	0	1	2	4	6	7	9	11	13	15	17	19
	90	0	0	1	2	4	6	8	11	13	15	17	19	21
	100	0	0	1	2	5	7	9	12	14	16	19	21	23

1.4.6 Manx shearwater

1.4.6.1 Displacement matrices for Manx shearwater in the pre-breeding, breeding and post-breeding seasons are presented in Table 1.20, Table 1.21, Table 1.22, respectively.

Table 1.20: Predicted Manx shearwater mortality for the Morgan Array Area plus 2 km buffer during the pre-breeding season. All entries are zero.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Manx shearwater (pre-breeding)	Mortality rate (%)												
Displacement rate (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1.21: Predicted Manx shearwater mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Manx shearwater (breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	0.5	1	3	6	13	25	38	50	63	75	88	100	113	125
	1	2	4	9	19	38	56	75	94	113	132	150	169	188
	5	3	5	13	25	50	75	100	125	150	176	201	226	251
	10	3	6	16	31	63	94	125	157	188	219	251	282	313
	20	4	8	19	38	75	113	150	188	226	263	301	339	376
	30	4	9	22	44	88	132	176	219	263	307	351	395	439
	40	5	10	25	50	100	150	201	251	301	351	401	451	502
	50	6	13	31	63	125	188	251	313	376	439	502	564	627
	60	8	15	38	75	150	226	301	376	451	527	602	677	752
	70	9	18	44	88	176	263	351	439	527	614	702	790	878
	80	10	20	50	100	201	301	401	502	602	702	803	903	1003
	90	11	23	56	113	226	339	451	564	677	790	903	1016	1129
	100	13	25	63	125	251	376	502	627	752	878	1003	1129	1254

Table 1.22: Predicted Manx shearwater mortality for the Morgan Array Area plus 2 km buffer during the post-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Manx shearwater (post-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	1	2	5	9	18	27	36	46	55	64	73	82	91
	15	1	3	7	14	27	41	55	68	82	96	109	123	137
	20	2	4	9	18	36	55	73	91	109	128	146	164	182
	25	2	5	11	23	46	68	91	114	137	159	182	205	228
	30	3	5	14	27	55	82	109	137	164	191	219	246	273
	35	3	6	16	32	64	96	128	159	191	223	255	287	319
	40	4	7	18	36	73	109	146	182	219	255	292	328	364
	50	5	9	23	46	91	137	182	228	273	319	364	410	456
	60	5	11	27	55	109	164	219	273	328	383	437	492	547
	70	6	13	32	64	128	191	255	319	383	446	510	574	638
	80	7	15	36	73	146	219	292	364	437	510	583	656	729
	90	8	16	41	82	164	246	328	410	492	574	656	738	820
	100	9	18	46	91	182	273	364	456	547	638	729	820	911

1.4.7 Gannet

1.4.7.1 Displacement matrices for gannet in the pre-breeding, breeding and post-breeding seasons are presented in Table 1.23, Table 1.24 and Table 1.25, respectively.

Table 1.23: Predicted gannet mortality for the Morgan Array Area plus 2 km buffer during the pre-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Gannet (pre-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	0	0	1	1	1	2	2	2	3	3	4
	20	0	0	0	1	1	2	3	4	4	5	6	6	7
	30	0	0	1	1	2	3	4	5	6	7	8	9	11
	40	0	0	1	1	3	4	6	7	8	10	11	13	14
	50	0	0	1	2	4	5	7	9	11	12	14	16	18
	60	0	0	1	2	4	6	8	11	13	15	17	19	21
	70	0	0	1	2	5	7	10	12	15	17	20	22	25
	80	0	1	1	3	6	8	11	14	17	20	22	25	28
	90	0	1	2	3	6	9	13	16	19	22	25	28	32
	100	0	1	2	4	7	11	14	18	21	25	28	32	35

Table 1.24: Predicted gannet mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Gannet (breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	1	2	3	5	6	8	9	11	12	14	15
	20	0	1	2	3	6	9	12	15	18	22	25	28	31
	30	0	1	2	5	9	14	18	23	28	32	37	42	46
	40	1	1	3	6	12	18	25	31	37	43	49	55	62
	50	1	2	4	8	15	23	31	38	46	54	62	69	77
	60	1	2	5	9	18	28	37	46	55	65	74	83	92
	70	1	2	5	11	22	32	43	54	65	75	86	97	108
	80	1	2	6	12	25	37	49	62	74	86	98	111	123
	90	1	3	7	14	28	42	55	69	83	97	111	125	138
	100	2	3	8	15	31	46	62	77	92	108	123	138	154

Table 1.25: Predicted gannet mortality for the Morgan Array Area plus 2 km buffer during the post-breeding season.

Purple borders = displacement and mortality rate range for construction phase.

Yellow shading = displacement and mortality rate range for operations and maintenance phase.

Gannet (post-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	0	1	1	2	3	3	4	5	5	6	7
	20	0	0	1	1	3	4	5	7	8	9	10	12	13
	30	0	0	1	2	4	6	8	10	12	14	16	18	20
	40	0	1	1	3	5	8	10	13	16	18	21	23	26
	50	0	1	2	3	7	10	13	16	20	23	26	29	33
	60	0	1	2	4	8	12	16	20	23	27	31	35	39
	70	0	1	2	5	9	14	18	23	27	32	36	41	46
	80	1	1	3	5	10	16	21	26	31	36	42	47	52
	90	1	1	3	6	12	18	23	29	35	41	47	53	59
	100	1	1	3	7	13	20	26	33	39	46	52	59	65

1.5 Summary

1.5.1.1 Table 1.26 provides a summary of the results of the displacement analyses undertaken for each species in section 1.4.

Table 1.26: Summary of displacement analyses undertaken for the Morgan Generation Assets.

Species	Project phase	Season	Seasonal mean-peak population	Displacement rates (%)	Mortality rates (%)	Displacement mortality
Kittiwake	Construction	Breeding	505	15	1	1
				35	10	18
		Post-breeding	1,151	15	1	2
				35	10	40
		Pre-breeding	791	15	1	1
				35	10	28
	Operation	Breeding	505	30	1	2
				70	10	35
		Post-breeding	1,151	30	1	3
				70	10	81
		Pre-breeding	791	30	1	2
				70	10	55

Species	Project phase	Season	Seasonal mean-peak population	Displacement rates (%)	Mortality rates (%)	Displacement mortality
Guillemot	Construction	Breeding	4,010	15	1	6
				35	10	140
		Non-breeding	3,824	15	1	6
				35	10	134
	Operation	Breeding	4,010	30	1	12
				70	10	281
		Non-breeding	3,824	30	1	11
				70	10	268
Razorbill	Construction	Pre-breeding	328	15	1	0
				35	10	11
		Breeding	35	15	1	0
				35	10	1
		Post-breeding	254	15	1	0
				35	10	9
		Non-breeding	1,170	15	1	2
				35	10	41
	Operation	Pre-breeding	328	30	1	1
				70	10	23
		Breeding	35	30	1	0
				70	10	2
		Post-breeding	254	30	1	1
				70	10	18
		Non-breeding	1,170	30	1	4
				70	10	82
Fulmar	Construction	Pre-breeding	102	0.5	1	0
				5	10	1
		Breeding	19	0.5	1	0
				5	10	0
		Post-breeding	0	0.5	1	0
				5	10	0
		Non-breeding	23	0.5	1	0
				5	10	0
	Operation	Pre-breeding	102	1	1	0
				10	10	1

Species	Project phase	Season	Seasonal mean-peak population	Displacement rates (%)	Mortality rates (%)	Displacement mortality
		Breeding	19	1	1	0
				10	10	0
		Post-breeding	0	1	1	0
				10	10	0
		Non-breeding	23	1	1	0
				10	10	0
Manx shearwater	Construction	Pre-breeding	0	15	1	0
				35	10	0
		Breeding	1,254	15	1	2
				35	10	38
		Post-breeding	384	15	1	1
				35	10	32
	Operation	Pre-breeding	0	30	1	0
				70	10	0
		Breeding	1,254	30	1	4
				70	10	88
		Post-breeding	384	30	1	3
				70	10	64
Gannet	Construction	Pre-breeding	35	30	1	0
				40	10	1
		Breeding	154	30	1	0
				40	10	6
		Post-breeding	65	30	1	0
				40	10	3
	Operation	Pre-breeding	35	60	1	0
				80	10	3
		Breeding	154	60	1	1
				80	10	12
		Post-breeding	65	60	1	0
				80	10	5

1.6 References

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Appendix A: Bird Data for Displacement Assessment

Table A.1: Kittiwake abundance estimates (all behaviours) within the Morgan Array Area plus 2 km buffer.

Year	Abundance metric	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Model-based abundance estimates													
Year 1	Mean	**409**	-	-	-	108	0	525	193	**1,621**	602	282	**915**
	Upper confidence	547	-	-	-	409	0	909	299	2,072	846	456	1,255
	Lower confidence	309	-	-	-	37	0	305	127	1,285	426	173	671
Year 2	Mean	**601**	-	-	-	-	258	-	**680**	467	181	234	**667**
	Upper confidence	848	-	-	-	-	394	-	986	728	259	313	1,070
	Lower confidence	422	-	-	-	-	176	-	483	302	128	173	410
Design-based abundance estimates													
Year 1	Mean	431	119	63	23	0	0	375	129	1,504	580	225	692
	Upper confidence	580	193	113	46	0	0	661	189	1,853	759	335	912
	Lower confidence	281	51	23	0	0	0	108	70	1,162	435	137	501
Year 2	Mean	573	63	84	31	63	250	39	391	662	246	190	509
	Upper confidence	737	124	134	64	102	410	72	573	1,056	337	271	667

Year	Abundance metric	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	Lower confidence	387	15	30	7	22	123	7	248	319	149	114	344

Table A.2: Guillemot abundance estimates (all behaviours) within the Morgan Array Area plus 2 km buffer.

Year	Abundance metric	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Model-based abundance estimates													
Year 1	Mean	**4,471**	1,070	616	262	325	820	2,097	167	**3,036**	1,656	2,113	**3,549**
	Upper confidence	5,188	1,351	835	380	665	1,158	2,628	247	3,996	2,102	2,573	4,188
	Lower confidence	3,887	844	457	182	177	593	1,643	116	2,344	1,304	1,750	3,015
Year 2	Mean	2,248	436	1,385	942	4,337	**4,611**	751	1,162	1,358	1,852	1,233	3,135
	Upper confidence	2,779	600	1,808	1,146	5,976	5,910	1,005	1,670	1,804	2,145	1,515	3,671
	Lower confidence	1,826	313	1,050	775	3,167	3,627	567	809	1,038	1,603	1,003	2,669
Design-based abundance estimates													
Year 1	Mean	4,400	885	566	381	219	461	2,269	196	2,360	1,888	2,046	3,475
	Upper confidence	4,967	1,120	770	562	361	644	2,855	292	2,854	2,251	2,536	4,022
	Lower confidence	3,834	642	356	233	63	285	1,721	105	1,940	1,548	1,590	2,931
Year 2	Mean	1,771	348	902	903	4,337	1,678	423	963	875	1,824	813	3,040
	Upper confidence	1,431	108	689	654	3,082	1,149	200	690	495	1,523	607	3,435
	Lower confidence	2,122	618	1,121	1,116	5,515	2,264	649	1,248	1,246	2,203	1,006	2,604

Table A.3: Razorbill abundance estimates (all behaviours) within the Morgan Array Area plus 2 km buffer.

Year	Abundance metric	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Model-based abundance estimates													
Year 1	Mean	-	-	-	0	0	-	-	-	**1,079**	**253**	-	192
	Upper confidence	-	-	-	0	0	-	-	-	1,842	485	-	307
	Lower confidence	-	-	-	0	0	-	-	-	627	137	-	118
Year 2	Mean	0	0	0	0	0	-	**468**	491	**1,261**	**403**	302	-
	Upper confidence	0	0	0	0	0	-	1,050	748	1,989	637	593	-
	Lower confidence	0	0	0	0	0	-	227	320	799	258	155	-
Design-based abundance estimates													
Year 1	Mean	10	21	70	0	0	10	39	166	1,317	261	190	143
	Upper confidence	30	49	129	0	0	30	82	484	2,080	471	416	255
	Lower confidence	0	0	19	0	0	0	9	0	496	75	0	46
Year 2	Mean	0	0	0	0	0	8	279	419	938	316	302	98
	Upper confidence	0	0	0	0	0	25	578	646	1,591	467	496	187
	Lower confidence	0	0	0	0	0	0	45	230	332	158	136	21

Table A.4: Fulmar abundance estimates (all behaviours) within the Morgan Array Area plus 2 km buffer.

Year	Abundance metric	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Design-based abundance estimates													
Year 1	Mean	**24**	0	0	0	0	0	0	0	0	**126**	8	8
	Upper confidence	46	0	0	0	0	0	0	0	0	283	24	23
	Lower confidence	0	0	0	0	0	0	0	0	0	7	0	0
Year 2	Mean	**15**	0	0	8	0	0	0	**47**	30	**78**	24	39
	Upper confidence	37	0	0	23	0	0	0	88	61	141	54	78
	Lower confidence	0	0	0	0	0	0	0	7	7	23	0	7

Table A.5: Manx shearwater abundance estimates (all behaviours) within the Morgan Array Area plus 2 km buffer.

Year	Abundance metric	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Model-based abundance estimates													
Year 1	Mean	58	-	159	162	**235**	**157**	0	0	0	0	0	0
	Upper confidence	261	-	505	546	912	520	0	0	0	0	0	0
	Lower confidence	16	-	51	69	79	61	0	0	0	0	0	0
Year 2	Mean	0	-	224	76	**2,273**	**1,666**	0	0	0	0	0	0
	Upper confidence	0	-	560	278	6,714	3,285	0	0	0	0	0	0
	Lower confidence	0	-	97	31	843	890	0	0	0	0	0	0
Design-based abundance estimates													
Year 1	Mean	101	16	260	140	40	39	0	0	0	0	0	0
	Upper confidence	181	38	384	229	73	86	0	0	0	0	0	0
	Lower confidence	30	0	151	62	8	0	0	0	0	0	0	0
Year 2	Mean	0	0	8	30	31	833	728	0	0	0	0	0
	Upper confidence	0	0	23	60	62	1,369	1,133	0	0	0	0	0
	Lower confidence	0	0	0	7	7	388	352	0	0	0	0	0

Table A.6: Gannet abundance estimates (all behaviours) within the Morgan Array Area plus 2 km buffer.

Year	Abundance metric	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Model-based abundance estimates													
Year 1	Mean	-	-	-	-	**191**	112	-	-	-	-	-	-
	Upper confidence	-	-	-	-	288	192	-	-	-	-	-	-
	Lower confidence	-	-	-	-	127	69	-	-	-	-	-	-
Year 2	Mean	-	-	-	-	-	**117**	-	-	-	-	-	-
	Upper confidence	-	-	-	-	-	237	-	-	-	-	-	-
	Lower confidence	-	-	-	-	-	64	-	-	-	-	-	-
Design-based abundance estimates													
Year 1	Mean	46	23	16	76	135	124	83	15	55	22	8	22
	Upper confidence	84	47	46	120	203	181	128	33	102	46	23	45
	Lower confidence	7	0	0	30	71	61	37	0	15	0	0	0
Year 2	Mean	54	7	38	23	84	69	45	47	15	0	0	24
	Upper confidence	91	23	83	47	137	113	91	82	32	0	0	47
	Lower confidence	15	0	0	0	37	34	15	15	0	0	0	0

Appendix B: Design-based abundance displacement matrices

Table B.1: Predicted kittiwake mortality for the Morgan Array Area plus 2 km buffer during the pre-breeding season.

Kittiwake (pre-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	1	1	3	6	12	18	24	30	36	42	48	54	60
	15	1	2	5	9	18	27	36	45	54	63	72	81	90
	20	1	2	6	12	24	36	48	60	72	84	96	108	120
	30	2	4	9	18	36	54	72	90	108	126	144	162	180
	35	2	4	11	21	42	63	84	105	126	147	168	189	210
	40	2	5	12	24	48	72	96	120	144	168	192	216	240
	50	3	6	15	30	60	90	120	150	180	210	240	270	300
	60	4	7	18	36	72	108	144	180	216	252	288	324	360
	70	4	8	21	42	84	126	168	210	252	294	336	379	421
	80	5	10	24	48	96	144	192	240	288	336	385	433	481
	90	5	11	27	54	108	162	216	270	324	379	433	487	541
	100	6	12	30	60	120	180	240	300	360	421	481	541	601

Table B.2: Predicted kittiwake mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Kittiwake (breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	1	1	3	5	10	15	20	25	30	35	40	45	50
	15	1	2	4	8	15	23	30	38	45	53	60	68	75
	20	1	2	5	10	20	30	40	50	60	70	80	90	100
	30	2	3	8	15	30	45	60	75	90	105	120	135	151
	35	2	4	9	18	35	53	70	88	105	123	140	158	176
	40	2	4	10	20	40	60	80	100	120	140	161	181	201
	50	3	5	13	25	50	75	100	125	151	176	201	226	251
	60	3	6	15	30	60	90	120	151	181	211	241	271	301
	70	4	7	18	35	70	105	140	176	211	246	281	316	351
	80	4	8	20	40	80	120	161	201	241	281	321	361	401
	90	5	9	23	45	90	135	181	226	271	316	361	406	452
	100	5	10	25	50	100	151	201	251	301	351	401	452	502

Table B.3: Predicted kittiwake mortality for the Morgan Array Area plus 2 km buffer during the post-breeding season.

Kittiwake (post-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	1	2	5	11	22	32	43	54	65	76	87	97	108
	15	2	3	8	16	32	49	65	81	97	114	130	146	162
	20	2	4	11	22	43	65	87	108	130	152	173	195	217
	30	3	6	16	32	65	97	130	162	195	227	260	292	325
	35	4	8	19	38	76	114	152	190	227	265	303	341	379
	40	4	9	22	43	87	130	173	217	260	303	347	390	433
	50	5	11	27	54	108	162	217	271	325	379	433	487	542
	60	6	13	32	65	130	195	260	325	390	455	520	585	650
	70	8	15	38	76	152	227	303	379	455	531	606	682	758
	80	9	17	43	87	173	260	347	433	520	606	693	780	866
	90	10	19	49	97	195	292	390	487	585	682	780	877	975
	100	11	22	54	108	217	325	433	542	650	758	866	975	1083

Table B.4: Predicted guillemot mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Guillemot (breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	4	7	19	37	74	112	149	186	223	260	298	335	372
	15	6	11	28	56	112	167	223	279	335	391	446	502	558
	20	7	15	37	74	149	223	298	372	446	521	595	670	744
	30	11	22	56	112	223	335	446	558	670	781	893	1004	1116
	35	13	26	65	130	260	391	521	651	781	911	1042	1172	1302
	40	15	30	74	149	298	446	595	744	893	1042	1191	1339	1488
	50	19	37	93	186	372	558	744	930	1116	1302	1488	1674	1860
	60	22	45	112	223	446	670	893	1116	1339	1563	1786	2009	2232
	70	26	52	130	260	521	781	1042	1302	1563	1823	2083	2344	2604
	80	30	60	149	298	595	893	1191	1488	1786	2083	2381	2679	2976
	90	33	67	167	335	670	1004	1339	1674	2009	2344	2679	3013	3348
	100	37	74	186	372	744	1116	1488	1860	2232	2604	2976	3348	3720

Table B.5: Predicted guillemot mortality for the Morgan Array Area plus 2 km buffer during the non-breeding season.

Guillemot (non-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	3	7	17	33	67	100	134	167	201	234	268	301	335
	15	5	10	25	50	100	151	201	251	301	352	402	452	502
	20	7	13	33	67	134	201	268	335	402	469	536	603	670
	30	10	20	50	100	201	301	402	502	603	703	804	904	1005
	35	12	23	59	117	234	352	469	586	703	820	938	1055	1172
	40	13	27	67	134	268	402	536	670	804	938	1072	1205	1339
	50	17	33	84	167	335	502	670	837	1005	1172	1339	1507	1674
	60	20	40	100	201	402	603	804	1005	1205	1406	1607	1808	2009
	70	23	47	117	234	469	703	938	1172	1406	1641	1875	2110	2344
	80	27	54	134	268	536	804	1072	1339	1607	1875	2143	2411	2679
	90	30	60	151	301	603	904	1205	1507	1808	2110	2411	2712	3014
	100	33	67	167	335	670	1005	1339	1674	2009	2344	2679	3014	3349

Table B.6: Predicted razorbill mortality for the Morgan Array Area plus 2 km buffer during the pre-breeding season.

Razorbill (pre-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	1	1	3	6	9	12	14	17	20	23	26	29
	15	0	1	2	4	9	13	17	22	26	30	35	39	43
	20	1	1	3	6	12	17	23	29	35	40	46	52	58
	30	1	2	4	9	17	26	35	43	52	61	69	78	87
	35	1	2	5	10	20	30	40	50	61	71	81	91	101
	40	1	2	6	12	23	35	46	58	69	81	92	104	115
	50	1	3	7	14	29	43	58	72	87	101	115	130	144
	60	2	3	9	17	35	52	69	87	104	121	138	156	173
	70	2	4	10	20	40	61	81	101	121	141	162	182	202
	80	2	5	12	23	46	69	92	115	138	162	185	208	231
	90	3	5	13	26	52	78	104	130	156	182	208	234	260
	100	3	6	14	29	58	87	115	144	173	202	231	260	289

Table B.7: Predicted razorbill mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Razorbill (breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	0	0	1	1	1	2	2	2	3	3	3
	15	0	0	0	1	1	2	2	3	3	4	4	5	5
	20	0	0	0	1	1	2	3	3	4	5	6	6	7
	30	0	0	1	1	2	3	4	5	6	7	8	9	10
	35	0	0	1	1	2	4	5	6	7	9	10	11	12
	40	0	0	1	1	3	4	6	7	8	10	11	13	14
	50	0	0	1	2	3	5	7	9	10	12	14	16	17
	60	0	0	1	2	4	6	8	10	13	15	17	19	21
	70	0	0	1	2	5	7	10	12	15	17	19	22	24
	80	0	1	1	3	6	8	11	14	17	19	22	25	28
	90	0	1	2	3	6	9	13	16	19	22	25	28	31
	100	0	1	2	3	7	10	14	17	21	24	28	31	35

Table B.8: Predicted razorbill mortality for the Morgan Array Area plus 2 km buffer during the post-breeding season.

Razorbill (post-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	1	2	3	5	6	8	10	11	13	14	16
	15	0	0	1	2	5	7	10	12	14	17	19	21	24
	20	0	1	2	3	6	10	13	16	19	22	25	29	32
	30	0	1	2	5	10	14	19	24	29	33	38	43	48
	35	1	1	3	6	11	17	22	28	33	39	45	50	56
	40	1	1	3	6	13	19	25	32	38	45	51	57	64
	50	1	2	4	8	16	24	32	40	48	56	64	72	80
	60	1	2	5	10	19	29	38	48	57	67	76	86	95
	70	1	2	6	11	22	33	45	56	67	78	89	100	111
	80	1	3	6	13	25	38	51	64	76	89	102	114	127
	90	1	3	7	14	29	43	57	72	86	100	114	129	143
	100	2	3	8	16	32	48	64	80	95	111	127	143	159

Table B.9: Predicted razorbill mortality for the Morgan Array Area plus 2 km buffer during the non-breeding season.

Razorbill (non-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	1	2	6	11	23	34	45	56	68	79	90	102	113
	15	2	3	8	17	34	51	68	85	102	118	135	152	169
	20	2	5	11	23	45	68	90	113	135	158	180	203	226
	30	3	7	17	34	68	102	135	169	203	237	271	305	338
	35	4	8	20	39	79	118	158	197	237	276	316	355	395
	40	5	9	23	45	90	135	180	226	271	316	361	406	451
	50	6	11	28	56	113	169	226	282	338	395	451	508	564
	60	7	14	34	68	135	203	271	338	406	474	541	609	677
	70	8	16	39	79	158	237	316	395	474	553	632	711	789
	80	9	18	45	90	180	271	361	451	541	632	722	812	902
	90	10	20	51	102	203	305	406	508	609	711	812	914	1015
	100	11	23	56	113	226	338	451	564	677	789	902	1015	1128

Table B.10: Predicted fulmar mortality for the Morgan Array Area plus 2 km buffer during the pre-breeding season.

Fulmar (pre-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	0.5	0	0	0	0	0	0	0	0	0	0	0	0	1
	1	0	0	0	0	0	0	0	1	1	1	1	1	1
	5	0	0	0	1	1	2	2	3	3	4	4	5	5
	10	0	0	1	1	2	3	4	5	6	7	8	9	10
	20	0	0	1	2	4	6	8	10	12	14	16	18	20
	30	0	1	2	3	6	9	12	15	18	21	24	28	31
	40	0	1	2	4	8	12	16	20	24	29	33	37	41
	50	1	1	3	5	10	15	20	25	31	36	41	46	51
	60	1	1	3	6	12	18	24	31	37	43	49	55	61
	70	1	1	4	7	14	21	29	36	43	50	57	64	71
	80	1	2	4	8	16	24	33	41	49	57	65	73	82
	90	1	2	5	9	18	28	37	46	55	64	73	83	92
	100	1	2	5	10	20	31	41	51	61	71	82	92	102

Table B.11: Predicted fulmar mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Fulmar (breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	1	1	1	1	1
	10	0	0	0	0	0	1	1	1	1	1	2	2	2
	20	0	0	0	0	1	1	2	2	2	3	3	3	4
	30	0	0	0	1	1	2	2	3	3	4	5	5	6
	40	0	0	0	1	2	2	3	4	5	5	6	7	8
	50	0	0	0	1	2	3	4	5	6	7	8	9	10
	60	0	0	1	1	2	3	5	6	7	8	9	10	12
	70	0	0	1	1	3	4	5	7	8	10	11	12	14
	80	0	0	1	2	3	5	6	8	9	11	12	14	16
	90	0	0	1	2	3	5	7	9	10	12	14	16	17
	100	0	0	1	2	4	6	8	10	12	14	16	17	19

Table B.12: Predicted fulmar mortality for the Morgan Array Area plus 2 km buffer during the post-breeding season.

Fulmar (post-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0	0	0	0	0	0	0
	60	0	0	0	0	0	0	0	0	0	0	0	0	0
	70	0	0	0	0	0	0	0	0	0	0	0	0	0
	80	0	0	0	0	0	0	0	0	0	0	0	0	0
	90	0	0	0	0	0	0	0	0	0	0	0	0	0
	100	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B.13: Predicted fulmar mortality for the Morgan Array Area plus 2 km buffer during the non-breeding season.

Fulmar (non-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	1	1	1	1	1	1
	10	0	0	0	0	0	1	1	1	1	2	2	2	2
	20	0	0	0	0	1	1	2	2	3	3	4	4	5
	30	0	0	0	1	1	2	3	4	4	5	6	6	7
	40	0	0	0	1	2	3	4	5	6	7	7	8	9
	50	0	0	1	1	2	4	5	6	7	8	9	11	12
	60	0	0	1	1	3	4	6	7	8	10	11	13	14
	70	0	0	1	2	3	5	7	8	10	11	13	15	16
	80	0	0	1	2	4	6	7	9	11	13	15	17	19
	90	0	0	1	2	4	6	8	11	13	15	17	19	21
	100	0	0	1	2	5	7	9	12	14	16	19	21	23

Table B.14: Predicted Manx shearwater mortality for the Morgan Array Area plus 2 km buffer during the pre-breeding season.

Manx shearwater (pre-breeding)	Mortality rate (%)												
	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B.15: Predicted Manx shearwater mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Manx shearwater (breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	1	1	3	5	11	16	22	27	33	38	44	49	55
	15	1	2	4	8	16	25	33	41	49	57	66	74	82
	20	1	2	5	11	22	33	44	55	66	77	87	98	109
	30	2	3	8	16	33	49	66	82	98	115	131	148	164
	35	2	4	10	19	38	57	77	96	115	134	153	172	191
	40	2	4	11	22	44	66	87	109	131	153	175	197	219
	50	3	5	14	27	55	82	109	137	164	191	219	246	273
	60	3	7	16	33	66	98	131	164	197	230	262	295	328
	70	4	8	19	38	77	115	153	191	230	268	306	344	383
	80	4	9	22	44	87	131	175	219	262	306	350	394	437
	90	5	10	25	49	98	148	197	246	295	344	394	443	492
	100	5	11	27	55	109	164	219	273	328	383	437	492	547

Table B.16: Predicted Manx shearwater mortality for the Morgan Array Area plus 2 km buffer during the post-breeding season.

Manx shearwater (post-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	1	2	4	8	12	15	19	23	27	31	35	38
	15	1	1	3	6	12	17	23	29	35	40	46	52	58
	20	1	2	4	8	15	23	31	38	46	54	61	69	77
	30	1	2	6	12	23	35	46	58	69	81	92	104	115
	35	1	3	7	13	27	40	54	67	81	94	107	121	134
	40	2	3	8	15	31	46	61	77	92	107	123	138	154
	50	2	4	10	19	38	58	77	96	115	134	154	173	192
	60	2	5	12	23	46	69	92	115	138	161	184	207	230
	70	3	5	13	27	54	81	107	134	161	188	215	242	269
	80	3	6	15	31	61	92	123	154	184	215	246	276	307
	90	3	7	17	35	69	104	138	173	207	242	276	311	345
	100	4	8	19	38	77	115	154	192	230	269	307	345	384

Table B.17: Predicted gannet mortality for the Morgan Array Area plus 2 km buffer during the pre-breeding season.

Gannet (pre-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	0	0	1	1	1	2	2	2	3	3	4
	20	0	0	0	1	1	2	3	4	4	5	6	6	7
	30	0	0	1	1	2	3	4	5	6	7	8	9	11
	40	0	0	1	1	3	4	6	7	8	10	11	13	14
	50	0	0	1	2	4	5	7	9	11	12	14	16	18
	60	0	0	1	2	4	6	8	11	13	15	17	19	21
	70	0	0	1	2	5	7	10	12	15	17	20	22	25
	80	0	1	1	3	6	8	11	14	17	20	22	25	28
	90	0	1	2	3	6	9	13	16	19	22	25	28	32
	100	0	1	2	4	7	11	14	18	21	25	28	32	35

Table B.18: Predicted gannet mortality for the Morgan Array Area plus 2 km buffer during the breeding season.

Gannet (breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	1	1	2	3	4	5	7	8	9	10	11
	20	0	0	1	2	4	7	9	11	13	15	17	20	22
	30	0	1	2	3	7	10	13	16	20	23	26	29	33
	40	0	1	2	4	9	13	17	22	26	31	35	39	44
	50	1	1	3	5	11	16	22	27	33	38	44	49	55
	60	1	1	3	7	13	20	26	33	39	46	52	59	66
	70	1	2	4	8	15	23	31	38	46	54	61	69	76
	80	1	2	4	9	17	26	35	44	52	61	70	79	87
	90	1	2	5	10	20	29	39	49	59	69	79	88	98
	100	1	2	5	11	22	33	44	55	66	76	87	98	109

Table B.19: Predicted gannet mortality for the Morgan Array Area plus 2 km buffer during post-breeding season.

Gannet (post-breeding)		Mortality rate (%)												
		1	2	5	10	20	30	40	50	60	70	80	90	100
Displacement rate (%)	10	0	0	0	1	1	2	3	3	4	5	5	6	7
	20	0	0	1	1	3	4	5	7	8	9	10	12	13
	30	0	0	1	2	4	6	8	10	12	14	16	18	20
	40	0	1	1	3	5	8	10	13	16	18	21	23	26
	50	0	1	2	3	7	10	13	16	20	23	26	29	33
	60	0	1	2	4	8	12	16	20	23	27	31	35	39
	70	0	1	2	5	9	14	18	23	27	32	36	41	46
	80	1	1	3	5	10	16	21	26	31	36	42	47	52
	90	1	1	3	6	12	18	23	29	35	41	47	53	59
	100	1	1	3	7	13	20	26	33	39	46	52	59	65