



Technical Appendix 11.1: Overview of Offshore Ornithology EIA and HRA Documents

MachairWind Offshore Ornithology

ScottishPower Renewables (SPR)

320 St Vincent St Glasgow G2 5AD

Prepared by:

SLR Consulting Limited

St. Vincent Place, Glasgow, G1 2EU

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1.0 Introduction

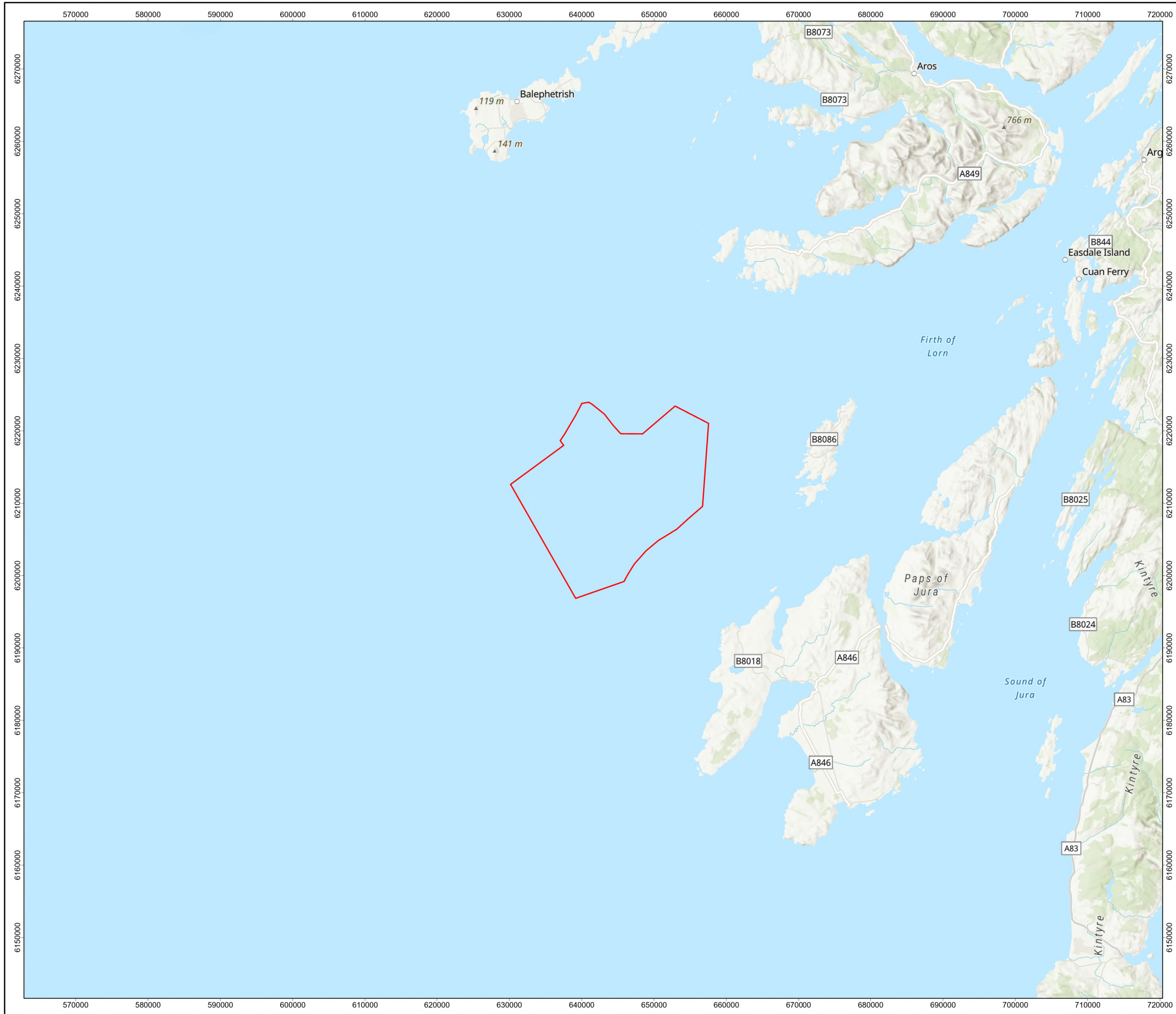
1.1 Project summary

1. MachairWind Limited ('the Applicant') is proposing the development of the MachairWind Windfarm ('the Project'), an Offshore Windfarm, located off the west coast of Scotland approximately 15 kilometres (km) to the northwest of Islay and approximately 12.4 km west of Colonsay at the closest points (**Figure 1**).
2. The Offshore Project will comprise up to 144 wind turbine generators (WTGs) with fixed-bottom foundations. The area within which the WTGs and associated infrastructure will be located is the Windfarm Development Area (WDA) which covers an area of 448 km².

1.2 Purpose of this report

3. This **Technical Appendix 11.1: Overview of Offshore Ornithology EIA and HRA Documents** provides an overview of the offshore ornithology Environmental Impact Assessment (EIA) and Habitats Regulation Appraisal (HRA) technical documents submitted in support of the EIA in **Chapter 11 Offshore Ornithology** of the Environmental Impact Assessment Report (EIAR), and the HRA, in the Report to Inform the Appropriate Assessment (RIAA), for the Project. This overview is provided to aid navigation around the technical information. The offshore ornithology assessment has been structured as a series of interlinked technical appendices and a screening report supporting the RIAA and EIAR, with each addressing a specific component of the EIA and HRA processes, namely:
 - **Windfarm Development Area Habitats Regulations Appraisal Screening Report;**
 - **Technical Appendix 11.2: Baseline Site Characterisation;**
 - **Technical Appendix 11.3: Collision Risk Modelling;**
 - **Technical Appendix 11.4: Displacement;**
 - **Technical Appendix 11.5: Cumulative and In-Combination Mortality Calculations;**
 - **Technical Appendix 11.6: Apportioning for HRA;** and,
 - **Technical Appendix 11.7: Population Viability Analysis (PVA).**
4. Summaries of each technical appendix are provided in **Section 1.4**. These summaries outline the purpose, methodological approach and key outputs of each technical appendix and explain how the results feed into the assessments presented in **Chapter 11 Offshore Ornithology** of the EIAR and RIAA. These summaries are intended to provide a concise overview of the technical workflow, from baseline data collection through to impact quantification and population-level consequence assessment.





Windfarm Development Area (WDA)

N

0 5 10 20 Kilometres



1	21/04/2026	MMM	MMM	NG/SO	NG/SO
REV	DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

DRAWING NUMBER: MCW-DWF-ENV-MAP-RHS-000203

DATUM	ETRS89	PROJECTION	UTM Zone 29N
SCALE	1:500,000	PAGE SIZE	A3

PROJECT TITLE: MachairWind

DRAWING TITLE: **MachairWind
Windfarm Development Area**

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1.3 Structure of application and assessment materials

5. The Application includes two assessment documents (the RIAA and **Chapter 11 Offshore Ornithology** of the EIAR), a screening report and set of seven technical appendices with 20 annexes to the appendices. **Table 1** outlines these documents.

Table 1: List of Appendices and associated annexes.

Document	Annexes associated with document
Windfarm Development Area Habitats Regulations Appraisal Screening Report	None
Report to Inform Appropriate Assessment (RIAA)	None
Chapter 11 Offshore Ornithology of the EIAR	None
Technical appendices	
Technical Appendix 11.1: Overview of Offshore Ornithology EIA and HRA Documents	None
Technical Appendix 11.2: Baseline Site Characterisation	Annex 11.2A: Project DAS Final Report (All Project Surveys)
	Annex 11.2B: Third-Party DAS survey 5 (01 plus 04 March 2021)
	Annex 11.2C: Third-Party DAS survey 6 (21 March 2021)
	Annex 11.2D: Third-Party DAS survey 15 (15 December 2021)
	Annex 11.2E: Raw Counts
	Annex 11.2F: Density estimates per survey of birds sat on the water
	Annex 11.2G: Density estimates per survey of birds in flight
	Annex 11.2H: Density estimates per survey of sitting and flying birds
	Annex 11.2I: Abundance estimates per survey of birds sat on the water
	Annex 11.2J: Abundance estimates per survey of birds in flight
	Annex 11.2K: Abundance estimates per survey of sitting and flying birds
	Annex 11.2L: Rarely Recorded Species Information
	Annex 11.2M: Regional Breeding Adult Population Estimates
	Annex 11.2N: Number of birds present in transect segments



Document	Annexes associated with document
	Annex 11.2O: Manx Shearwater Tracking Work on Lunga in 2025
	Annex 11.2P: Evaluation of seabird attraction to lighting on offshore windfarms
Technical Appendix 11.3 Collision Risk Modelling	Annex 11.3A: Bootstrapped density inputs to sCRM
	Annex 11.3B: Deterministic CRM inputs and outputs
	Annex 11.3C: Collision Risk Modelling of Greenland white-fronted goose
	Annex 11.3D: Migratory Collision Risk Modelling
Technical Appendix 11.4: Displacement	None
Technical Appendix 11.5: Cumulative and In-Combination Mortality Calculations	None
Technical Appendix 11.6: Apportioning for HRA	None
Technical Appendix 11.7: Population Viability Analysis (PVA)	None

1.4 Appendices' summaries

1.4.1 Technical Appendix 11.2: Baseline Site Characterisation – purpose and key points of the report

6. **Technical Appendix 11.2: Baseline Site Characterisation** provides a detailed description of marine ornithology interests within and surrounding the WDA, prior to construction and operation of the Project. The information presented establishes the baseline conditions against which potential effects are assessed within the EIAR and the RIAA. The baseline dataset is used to inform collision risk modelling and displacement assessments, including derivation of density and abundance metrics for relevant biological seasons.
7. Baseline characterisation was informed by 30 digital aerial survey (DAS) samples undertaken between March 2021 and September 2023, comprising 27 Project-specific surveys and three Third-Party surveys agreed with NatureScot. Surveys covered the WDA (448 km²) and buffers extending to 4 km beyond the boundary (total 852.78 km²). Design-based analytical methods were used to estimate density (birds/km²) and abundance of birds recorded in flight and sat on the surface of the sea.
8. Site characterisation was undertaken across three spatial scales: the WDA (to inform collision risk modelling), the WDA plus 2 km buffer (to inform displacement assessments for non-diver species), and the WDA plus 4 km buffer (to characterise baseline ornithology interests and to inform displacement assessments for divers).
9. Surveys were conducted using a transect-based design with >10% coverage per survey within the WDA plus 4 km buffer. Birds were identified to the lowest possible taxonomic level and classified by behaviour. Species group records (e.g. "auk species") were apportioned to species level prior to density and abundance estimation, and availability bias corrections were applied to diving species including guillemot, razorbill and puffin.



10. Marine bird species with more than 10 birds recorded in the WDA plus 4 km buffer during the survey programme included: Arctic tern, common gull, common tern, European storm-petrel, fulmar, gannet, great black-backed gull, great northern diver, great skua, guillemot, herring gull, kittiwake, Manx shearwater, puffin and razorbill. Species accounts are provided for these 15 species, presenting conservation status, raw observations, raw counts, and design-based density and abundance estimates for each biological season.
11. Density and abundance estimates were calculated on a per-survey basis using design-based methods and subsequently extrapolated to the relevant boundary area. Seasonal presentation of results followed NatureScot breeding and non-breeding definitions and Biologically Defined Minimum Population Scales (BDMPS), enabling interpretation of temporal variation in site use across breeding, migration and winter periods.

1.4.2 Technical Appendix 11.3: Collision Risk Modelling – purpose and key points of the report

12. **Technical Appendix 11.3: Collision Risk Modelling** provides details of the methods used to estimate collision mortality for marine bird species predicted to be at risk of collision with wind turbine generators within the WDA. Stochastic collision risk modelling (sCRM) was undertaken for six species: kittiwake, great black-backed gull, herring gull, Arctic tern, common tern and gannet.
13. Section 2.0. provides details on the modelling approach, model options applied, input parameters (e.g. bird densities, flight heights, avoidance rates and turbine specifications) and seasonal definitions. Monthly, seasonal and annual collision estimates are presented in Section 3.0, with a summary of collision estimates used to inform the EIAR and RIAA provided in Section 4.0.
14. Collision estimates were calculated using densities of birds in flight within the WDA derived from 29 months of DAS data (April 2021 to September 2023; bootstrapped density estimates are presented in **Annex 11.3A: Bootstrapped density inputs to sCRM**), together with species-specific biometric parameters and avoidance rates advised by NatureScot. A stochastic implementation of the Band (2012) model was undertaken using the *stochLAB* R package (Option 2, generic flight height distribution), as recommended in NatureScot Guidance Note 7. Turbine parameters assessed included a Most Likely Scenario (97 turbines) and Worst Case Scenario (144 turbines). Deterministic collision risk modelling (CRM) outputs were also generated and are presented in **Annex 11.3B: Deterministic CRM inputs and outputs**, although EIA and HRA are informed by sCRM outputs.
15. A bootstrap approach was applied to flying bird densities, with 1,000 resampled density estimates per calendar month used as inputs to the sCRM. Generic flight height distributions were applied. Avoidance rates used in the sCRM were 0.9929 (kittiwake and gannet), 0.9940 (great black-backed gull and herring gull) and 0.9908 (Arctic tern and common tern). A 70% macro-avoidance correction was applied to gannet densities in non-breeding season months, as advised by NatureScot.
16. Under the sCRM WCS, the species with the highest predicted annual collision mortality was kittiwake, with an estimated mean of 172.07 birds per annum. Gannet had a substantially lower annual collision estimate of 14.22 birds per annum. Great black-backed gull and herring gull had low annual collision estimates of 6.45 and 8.01 birds per annum, respectively. Arctic tern and common tern had very low annual collision estimates of 0.613 and 0.369 birds per annum, respectively. Full monthly, seasonal (NatureScot and BDMPS) and annual collision estimates for all six species are provided in Section 3.0 and Section 4.0.



17. Further modelling was conducted to assess collision risks for migratory non-seabird species passing through the WDA. **Annex 11.3C: Collision Risk Modelling of Greenland white-fronted goose** presents the methods and results of migratory collision risk modelling (mCRM) undertaken to estimate potential collision mortality for Greenland white-fronted geese migrating through the MachairWind WDA. Special attention was given to Greenland white-fronted goose as there are notable Special Protection Areas (SPAs) during the non-breeding season for this species on Islay. The report outlines the modelling framework, including population inputs, migration flightpath proportions, bird biometrics, avoidance rates, turbine specifications and the application of both the Most Likely (97 turbines) and Worst Case (144 turbines) design scenarios. The mCRM uses species-specific migration pathways and applies precautionary assumptions such as 100% of birds flying at rotor height and the lower mCRM avoidance rate of 99.9%, which inflates predicted collisions relative to recommended values. Collision estimates are calculated for both the total British and Irish population and the Islay sub-population, with model outputs summarised for pre-breeding, post-breeding and annual periods. Results show extremely low predicted seasonal and annual collision mortality across all scenarios, with annual totals for the British and Irish population between 0.08 and 0.11 birds per year and for the Islay population between 0.03 and 0.50 birds per year, depending on assumptions about what proportion of the Islay population may pass through the WDA (e.g. up to 100%). Overall, the assessment concludes that even under highly precautionary assumptions, collision risks to migrating Greenland white-fronted geese are negligible, with no detectable population-level effects anticipated.
18. **Annex 11.3D: Migratory Collision Risk Modelling** provides details of the methods used to estimate collision mortality for all other migratory non-seabird species predicted to pass through the WDA during operation. This Annex outlines the modelling approach, the mCRM framework, model options applied, turbine specifications, bird biometrics, behavioural parameters and species-specific migration seasons. The assessment uses predicted migration pathways from the Marine Scotland mCRM tool together with species-level inputs such as body length, wingspan, flight speed, avoidance rates and seasonal migration windows. Collision estimates under both the Most Likely Scenario (97 turbines) and Worst Case Scenario (144 turbines) are presented, with results summarised by pre-breeding, post-breeding and other seasonal periods. Across all species assessed model outputs show extremely low predicted monthly, seasonal and annual collision mortality, with even the highest values representing very small proportions of each UK population. Species such as mallard, snipe and wigeon show the highest absolute collision estimates, yet these equate to only 0.0031%, 0.0002% and 0.0025% of their UK populations, respectively. Overall, the assessment concludes that predicted migratory collision risks are negligible and are not expected to generate any detectable population-level effects.

1.4.3 Technical Appendix 11.4: Displacement – purpose and key points of the report

19. Displacement mortality was assessed using an upper and a lower displacement scenario for nine species: great northern diver, kittiwake, Arctic tern, common tern, guillemot, razorbill, puffin, fulmar and gannet.
20. Mean Seasonal Peak (MSP) abundance was calculated using 30 DAS samples (March 2021 to September 2023). MSP was defined as the mean of peak seasonal abundances across two complete survey years. MSP values used in the matrices included: great northern diver (16.2 birds, non-breeding season, WDA + 4 km); kittiwake (1,221 breeding; 5,654.4 non-breeding; 3,488.6 spring migration; 5,654.4 autumn migration); Arctic tern (91.4 breeding; 91.4 spring migration; 35.2 autumn migration); common tern (62.8 breeding; 0.0 spring migration; 62.8 autumn migration); guillemot (27,095.4 breeding; 28,531.5 non-breeding);



razorbill (2,636.1 breeding; 6,951.4 non-breeding); puffin (971.7 breeding; 1,192.4 non-breeding); fulmar (82.8 breeding; 150.6 non-breeding); and gannet (422.7 breeding; 139.4 non-breeding).

21. The displacement matrix approach was used to estimate mortality for all nine species. The matrices apply species-specific displacement rates and mortality rates advised by NatureScot.
22. Under the upper displacement scenarios agreed with NatureScot, the highest predicted displacement mortality occurred for guillemot, with 812.9 birds in the breeding season and 513.6 birds in the non-breeding season. Puffin had higher predicted displacement mortality of 29.1 birds in the breeding season and 21.5 birds in the non-breeding season. Razorbill displacement mortality was 79.1 birds in the breeding season, 125.1 birds in the non-breeding season and spring migration period and 55.7 in autumn migration period. Kittiwake displacement mortality was predicted to be 50.9 birds in the non-breeding season and autumn migration, 31.4 birds in spring migration, and 11 birds in the breeding season. Gannet displacement mortality was 8.9 birds in the breeding season, 2.9 birds in the non-breeding season and spring migration period and 3.2 in the autumn migration period. Fulmar displacement mortality was lower (approximately 0-1 birds in any season), and Arctic tern and common tern displacement mortality was predicted to be fewer than two birds per season under the upper scenarios. Great northern diver displacement mortality was less than one bird in the non-breeding season under the upper scenario.
23. SeabORD modelling was not undertaken for this assessment, following advice from NatureScot (Expert Topic Group Meeting 4, 2 December 2025). Consequently, displacement mortality estimates used in the EIA and HRA assessments are derived solely from the matrix approach.

1.4.4 Technical Appendix 11.5: Cumulative and In-Combination Mortality Calculations– purpose and key points of the report

24. **Technical Appendix 11.5: Cumulative and In-Combination Mortality Calculations** collates predicted collision and displacement mortalities for the Project and other offshore windfarms within foraging range (breeding season) and the relevant Western BDMPS regions (non-breeding season, with the exception of guillemot and herring gull). These collated totals are used to inform the cumulative effects assessment for the EIA and the in-combination assessment for the HRA, as presented in **Chapter 11 Offshore Ornithology** of the EIAR and the RIAA, respectively.
25. The report describes the methods used to identify relevant offshore windfarms and collate mortality data (Section 2.0). It distinguishes between the EIA cumulative assessment, undertaken at the regional population scale (Section 2.4), and the HRA in-combination assessment, undertaken at the SPA population scale (Section 2.5).
26. For the cumulative assessment, collision and displacement mortalities from offshore windfarms within the species-appropriate Western BDMPS regions were added to WDA-alone estimates. For the in-combination assessment, WDA-alone mortality was first apportioned to SPAs using the NatureScot apportioning method (**Technical Appendix 11.6: Apportioning for HRA**) and then combined with SPA-specific mortality from other offshore windfarms.
27. Section 3.0 presents cumulative mortality at a regional population scale for each species. Section 4.0 presents in-combination mortality apportioned to SPAs.



1.4.5 Technical Appendix 11.6: Apportioning for HRA – purpose and key points of the report

28. **Technical Appendix 11.6: Apportioning for HRA** sets out the methods used to apportion WDA-alone collision and displacement mortality to SPA populations with connectivity to the WDA, for the purposes of the HRA only.
29. Breeding and non-breeding season collision and displacement mortality estimates from the WDA-alone were apportioned to SPA populations using species- and season-specific weightings calculated. Apportioned WDA-alone mortality was subsequently combined with in-combination mortality from other offshore windfarms (**Technical Appendix 11.5: Cumulative and In-Combination Mortality Calculations**) to inform the calculation of change in annual adult mortality rate and to determine the requirement for Population Viability Analysis (PVA).
30. The apportioning methodology is described in Section 2.0. Section 4.0 presents species-specific results for Arctic tern, common tern, kittiwake, great black-backed gull, guillemot, razorbill, puffin, fulmar and gannet, including breeding and/or non-breeding season apportioning weights for each SPA, apportioned seasonal and annual mortality, change in baseline mortality rate and identification of SPA populations requiring a PVA.
31. Breeding season apportioning weights were calculated following the NatureScot apportioning method. Mortality was apportioned to both SPA and non-SPA colonies within species-specific foraging range.
32. Non-breeding season mortality was apportioned to SPAs within the relevant western BDMPS region. Apportioning weights were calculated as the proportional contribution of adult birds from each SPA to the BDMPS population for autumn, spring and winter. Guillemot and herring gull are non-migratory and so, following NatureScot advice, foraging range was used to define the SPAs to which non-breeding season mortality was apportioned.
33. In line with NatureScot advice, a PVA was undertaken where either: (i) WDA-alone mortality resulted in an increase of at least 0.02% in annual adult baseline mortality; or (ii) in-combination mortality resulted in an increase of at least 0.02% in annual adult baseline mortality and WDA-alone annual mortality was at least 0.2 birds per annum. The species and SPAs for which WDA-alone and/or in-combination mortality exceeded these thresholds are indicated in this report.

1.4.6 Technical Appendix 11.7: Population Viability Analysis (PVA) – purpose and key points of the report

34. **Technical Appendix 11.7: Population Viability Analysis (PVA)** describes the methods, model structure, parameterisation and outputs of the PVAs undertaken to assess the population consequences of predicted collision and displacement mortality from the WDA-alone and in-combination (HRA) and cumulatively (EIA). This report also presents the assessment of whether a PVA was required for the WDA-alone and cumulative (EIA) predicted mortalities.
35. PVAs were conducted where thresholds advised by NatureScot were exceeded. For the HRA, PVAs were run at the SPA population scale using adult mortality only. For the EIA, PVAs were run at the regional population scale and incorporated mortality across all age classes. The report therefore covers both assessment frameworks within a single modelling approach, with differences in population units and mortality inputs clearly defined.



36. Section 4.0 describes the PVA model structure and parameterisation, including demographic rates and incorporation of additional offshore wind mortality as a change in annual survival rate. Separate subsections explain how mortality inputs were derived for SPA populations (from apportioned annual adult mortality) and regional populations (from total WDA-alone and cumulative mortality).
37. Section 5.0 presents the species- and population-specific PVA inputs and outputs. For each SPA or regional population for which a PVA was required, the appendix includes a table of model inputs and demographic parameters, a table of output metrics, and a figure illustrating projected population trajectories under baseline and impacted scenarios.



