MachairWind Offshore Windfarm

Appendix I – Offshore Ornithology Methods Statement

ScottishPower Renewables | MachairWind Offshore Windfarm

SEPTEMBER 2024

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Revision 1

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GLOSSARY OF ACRONYMS

Term	Description
BDMPS	Biologically Defined Minimum Population Scale
BTO	British Trust for Ornithology
cm	Centimetre
CRM	Collision Risk Model
DAS	Digital Aerial Survey
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
ETG	Expert Topic Group
FeAST	Feature Activity Sensitivity Tool[1]
GSD	Ground Sampling Distance
HPAI	Highly Pathogenic Avian Influenza
HRA	Habitats Regulations Appraisal
JNCC	Joint Nature Conservation Committee
km	Kilometres
OAA	Option Agreement Area
OWF	Offshore Windfarm
PVA	Population Viability Analysis
sCRM	Stochastic Collision Risk Model
SD	Standard Deviation
SMP	Seabird Monitoring Programme
UK	United Kingdom
WDA	Windfarm Development Area
ZoI	Zone of Influence

[1] https://feature-activity-sensitivity-tool.scot/

GLOSSARY OF TERMS

Term	Description
Bathymetry	Topography of the seabed.
Breeding season	Furness (2015) defines breeding season as the period from modal return to the colony through to modal departure from the colony at the end of breeding, for birds at United Kingdom (UK) colonies.
Development Area	Application boundary for consenting purposes which, for the Project, consists of a Windfarm Development Area, Offshore Transmission Development Area, and Onshore Transmission Development Area.
Environmental Impact Assessment (EIA)	The process of evaluating the likely significant environmental effects of a proposed development over and above the existing circumstances (or 'baseline').
Inter-array cables (IAC)	Armoured cable containing electrical and fibre optic cores which link the wind turbine generators to each other and to the offshore substation platform(s).
MachairWind Offshore Windfarm	An offshore wind farm capable of exporting around 2 Gigawatts (GW) of renewable energy to the National Electricity Transmission System. MachairWind Offshore Windfarm comprises three Development Areas. The Windfarm Development Area is located on the west coast of Scotland to the northwest of Islay and west of Colonsay and the working assumption is that the MachairWind Offshore Windfarm will connect to a location within South Ayrshire. Work is ongoing to define the Offshore Transmission Development Area and Onshore Transmission Development Area. Separate consent and licence applications will be submitted for each Development Area.
Non-breeding season	Furness (2015) defines non-breeding season as the remaining part of the year that is not a part of breeding season.
OSPAR	OSPAR started in 1972 with the Oslo Convention against dumping and was broadened to cover land-based sources of marine pollution and the offshore industry by the Paris Convention of 1974. These two conventions were unified, updated and extended by the 1992 OSPAR Convention. OSPAR is so named because of the original Oslo and Paris Conventions ("OS" for Oslo and "PAR" for Paris).
Offshore Substation Platform (OSP)	An offshore platform with a fixed foundation located within the Offshore Transmission Development Area which houses electrical equipment such as transformers, switchgear, protection and control systems, and enables the windfarm's renewable electricity to be collected via inter-array cables and exported to the National Electricity Transmission System via offshore export cables.
Offshore Transmission Development Area (OfTDA)	The application boundary which extends seaward of Mean High Water Springs and within which the following will be consented (infrastructure includes but is not limited to): offshore export cable(s), OSP(s), OSP link cables (if required) and external cable protection. The OfTDA is subject to a Marine Licence(s) application under the Marine (Scotland) Act 2010.
Onshore Transmission Development Area (OnTDA)	The planning application boundary extending landward of Mean Low Water Springs and within which the following will be consented (infrastructure includes but is not limited to): landfall(s), onshore export cables, temporary construction compounds, and environmental mitigation areas. The OnTDA will be subject to a planning application under the Town and Country Planning (Scotland) Act 1997.
Option Agreement Area (OAA)	The seabed area awarded to ScottishPower Renewables in January 2022 through the Scotwind leasing round. Project-specific surveys have been based on either the

	OAA or Windfarm Development Area (WDA) boundary, with an appropriate buffer implemented in each case.
The Project	MachairWind Offshore Windfarm.
Scottish Marine Area	The area of Scotland's territorial sea limit (up to 12 nautical miles (nm) from baseline) as defined in the Marine (Scotland) Act 2010.
Wind Turbine Generator (WTG)	A wind turbine generator which converts wind energy into electrical energy. Each wind turbine generator is a complex system composed of a high number of components. Typically, the main components include the rotor assembly (composed of three blades and a hub); the nacelle (containing a generator, shaft and gearbox, power electronic converter and transformer); and the tower (containing lifting equipment and the switchgear).
Windfarm Development Area (WDA)	The application boundary within which consent will be sought for the WDA Infrastructure. The WDA is subject to a Section 36 consent and Marine Licence(s) application which is being applied for separately from the OfTDA and OnTDA.

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1 INTRODUCTION

1.1 OVERVIEW

1. This document outlines the proposed methodologies to support the Windfarm Development Area (WDA) Environmental Impact Assessment (EIA) Scoping Report and complete the WDA EIA for the proposed MachairWind Offshore Windfarm (OWF) ('the Project'). This report provides information on the baseline characterisation of the Option Agreement Area (OAA) and suitable buffer areas, using a combination of Project specific Digital Aerial Surveys (DAS), third-party DAS and desk-based assessments. The report provides additional technical information on the methods that will be used in the ornithology assessment and should be read in conjunction with **Chapter 11 Offshore Ornithology** of the WDA Scoping Report.

2. Methods used to undertake the impact assessment and the effects of these on populations are described for the EIA. Throughout, the methodology has been guided by the suite of NatureScot Guidance Notes. Any departures from this guidance are clearly highlighted and the reasons for this departure are explained. At the time of writing several guidance notes have not been issued and several tools were not in the public domain.

2 ENVIRONMENTAL IMPACT ASSESSMENT REPORT

2.1 BASELINE

2.1.1 Baseline Characterisation

3. The first step in the assessment of the predicted impact of the WDA on offshore ornithology receptors is the baseline characterisation of the OAA and buffer areas. The baseline characterisation will be based on recently collected data sourced by the Project specifically to assess potential impacts, namely:

- Third-party DAS data;
- Pre-existing data published in the grey and scientific literature; and
- Analyses of existing baseline data sources.

4. Newly collected data were the results of the DAS of the OAA plus a suitable buffer.

5. Existing information will follow the guidance provided by NatureScot and reviews of other suitable information on ornithology receptors with the potential to be impacted by the WDA. These data include published information on the distribution of seabirds at sea within the Zone of Influence (ZoI) of the WDA, seabird tracking information relevant to the location of the WDA, seabird colony count information within the ZoI, and migratory birds that may pass within the ZoI of the WDA.

2.1.2 Seasonal Definitions for Birds in the Scottish Marine Environment

6. The impact assessment will consider two population scales, the breeding season, and the non-breeding season. These will follow the NatureScot suggested seasonal definitions for birds in the Scottish marine environment (NatureScot, 2020). A summary of the species likely to be key for the WDA EIA of the Project is provided in **Table 2.1**.

7. Throughout the assessment, surveys will be matched to seasons based on the date of occurrence. However, where split months occur, the predicted impacts from that month (for collisions only) will be split between seasons to ensure that impacts are not double counted.

Table 2.1 Seasonal definitions for likely key species in the EIA for the Project

Species	Breeding season	Non-breeding season
Kittiwake *(Rissa Tridactyla)*	Mid-April – August	September – mid-April
Common gull *(Larus canus)*	April - August	September – March
Great black-backed gull *(Larus marinus)*	April – August	September – March
Herring gull (*Larus argentatus*)	April – August	September – March
Lesser black-backed gull *(Larus fuscus)*	Mid-March – August	September – mid-March
Common tern *(Sterna hirundo)*	May – mid-September	Mid-September - April
Arctic tern *(Sterna paradisaea)*	May – August	September - April
Great skua *(Stercorarius skua)*	Mid-April – mid-September	Mid-September – mid-April
Arctic skua *(Stercorarius parasiticus)*	May – August	September - April
Guillemot *(Uria Aalge)*	April – mid-August	Mid-August – March
Razorbill *(Alca Torda)*	April – mid-August	Mid-August – March
Puffin *(Fratercula Arctica)*	April – mid-August	Mid-August – March
Great northern diver *(Gavia immer)*	Not present in significant numbers (in Scottish marine areas)	October – mid-May
Storm petrel *(Hydrobates pelagicus)*	Mid-May – October	November – April
Fulmar *(Fulmarus glacialis)*	April – mid-September	Mid-September – March
Manx shearwater *(Puffinus puffinus)*	April – mid-October	Mid-October – March
Gannet *(Morus Bassanus)*	Mid-March – September	October – mid-March

2.1.3 Digital Aerial Surveys

2.1.3.1 Project's Digital Aerial Surveys

8. The survey method was designed to optimise the data collection for all bird and marine mammal species to achieve approximately 10% coverage using high-resolution digital still imagery captured from a twin-engine aircraft. Images were captured using a transect-based survey design with a 1.5-centimetre (cm) Ground Sampling Distance (GSD). Surveys were conducted by APEM using a bespoke camera system. The camera system was integrated with flight planning software allowing each survey transect to be accurately mapped prior to surveys being flown.

9. Between April 2021 and March 2023, the Project's DAS captured images at 1.5 cm GSD along 13 transect lines spaced approximately 3.2 kilometres (km) apart between image nodes within the OAA plus a 6 km buffer. From February 2022 until September 2023, the Project's DAS captured images at 1.5 cm GSD along 15 transect lines spaced approximately 2.3 km apart between image nodes, within the OAA plus a 10 km buffer **(Figure 2.1**). For all survey months, the images captured within the first 4 km of both buffer zones was analysed to provide data values for baseline characterisation.

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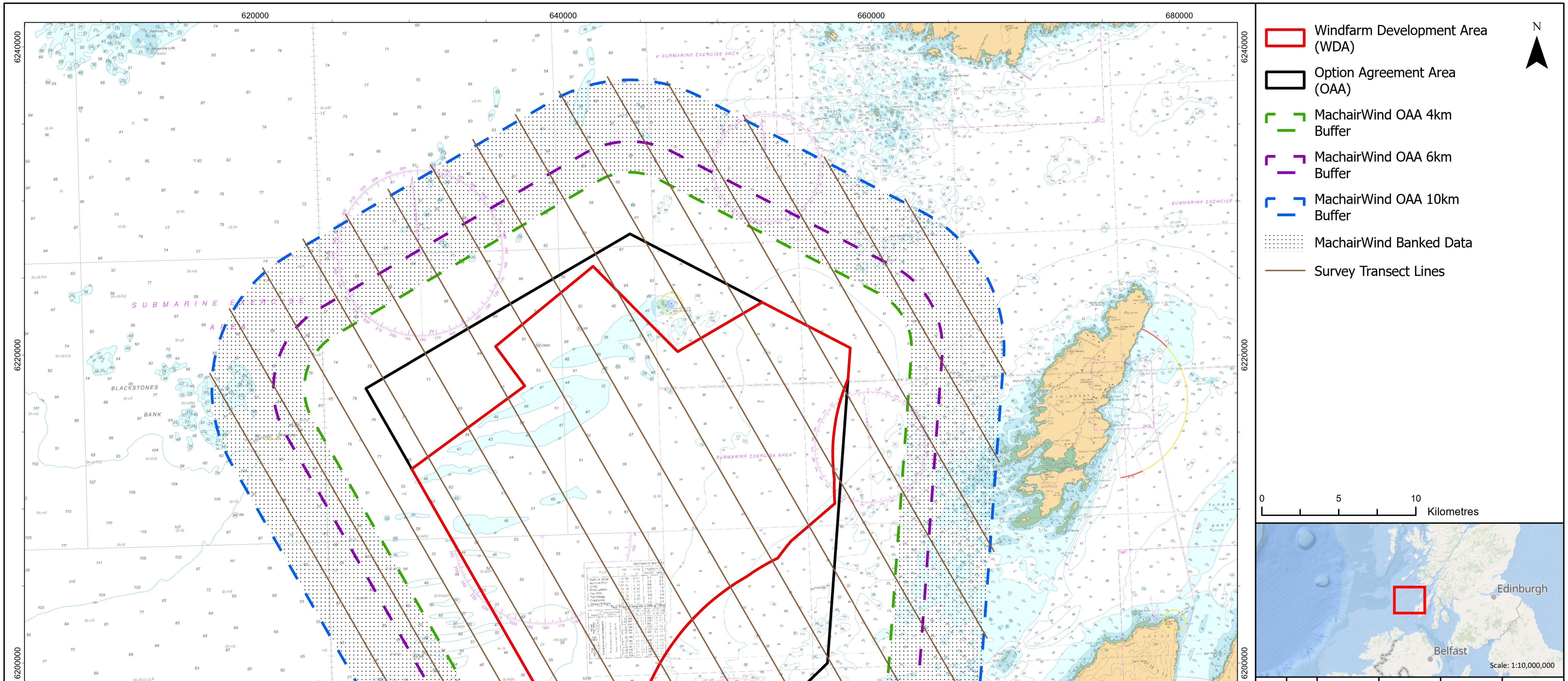

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1	04/09/2024	AB	GC	CB	PB

DRAWING NUMBER	MCW-GEN-GIS-MAP-RHS-000087		
DATUM	ETRS89	PROJECTION	UTM Zone 29N
SCALE	1:250,000	PAGE SIZE	A3
PROJECT TITLE	MachairWind		

Figure 2.1: OAA and WDA: Digital Aerial Survey Areas and Transect Lines

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Project: C:\Users\304634\OneDrive - Royal HaskoningDHV\WIP\PC3479 Team\PC3479 - WIP\E02 GIS & Drawings\F02_Figures\02_Scoping\WindFarmSite\Appendices\OffshoreOrnithologyMS\MCW_ScopingWFS_OffshoreOrnithologyMS.aprx
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10. Surveys of the OAA and buffer commenced in April 2021 and were completed in September 2023, providing 30 monthly samples across three breeding seasons and two non-breeding seasons (**Table** 2.2). These surveys were extended beyond the recommended minimum of 24 months across two years to provide coverage across a further breeding season following the 2022 Highly Pathogenic Avian Influenza (HPAI) epidemic.

11. It is important to note that two surveys were not completed within a single day:

- Sample 24: March 2023 (19 March transects 6 – 15, 23 March transects 1 – 5); and
- Sample 26: May 2023 (13 May 2023 transects 1 – 13, 14 May 2023 transects 14 – 15).

12. While these surveys were split between separate days due to logistical constraints, they were both completed within five days so would not be temporally independent (Kinlan et al. 2012) and so can be considered a single sample. This will be considered further in the analyses of the Projects DAS data.

13. Months during which no data was collected, were December 2021 and February 2022. In some cases, two surveys were carried out in the following month. **Table 2.2** gives the date of each survey and the proposed month the data will apply to. The approached described and agreed at Expert Topic Group (ETG) 2 will be followed in the Environmental Impact Assessment Report (EIAR).

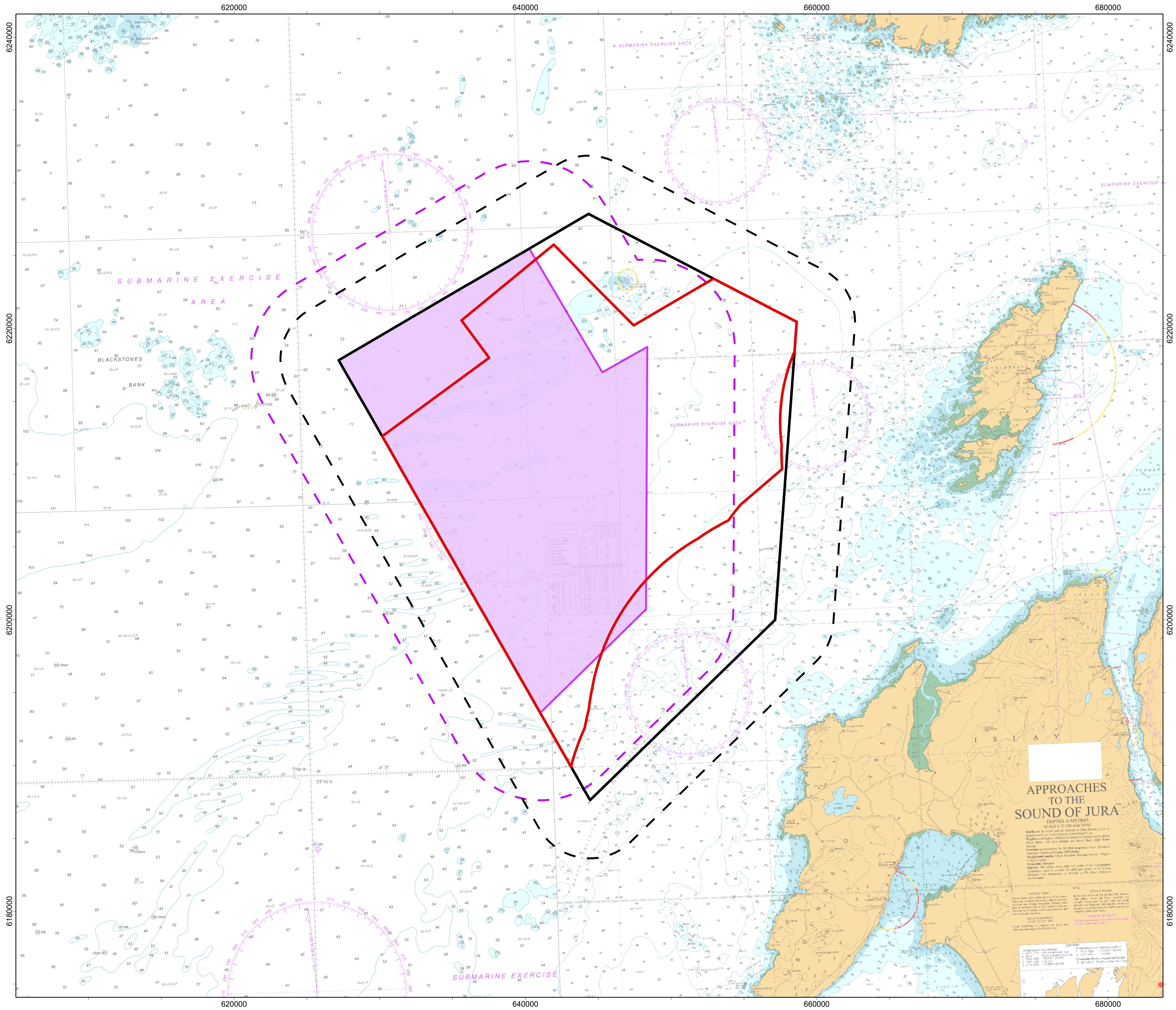
14. Not all surveys were completed in either the calendar month that was intended to be sampled, or within a single day. These were discussed with stakeholders during ETG meeting 2 on 22 November 2022. It was agreed with stakeholders that Sample 10 (**Table 2.2**) proposed as a February sample, was collected too late in March to be considered a February sample. This will be used as an additional March sample in the EIA. The March 2022 survey (Sample 11) was collected on 28 March, seven days after Sample 10. It was agreed that the temporal independence of these samples will be addressed in the EIAR. The June 2022 survey (Sample 14) was collected on 11 July 2022. It was agreed with stakeholders that this was too late in July to be considered as a June sample so will be used as a second July sample in the EIA. The March 2023 survey was collected on 19 and 23 March 2023. It was agreed that the effect of this spilt in data collection will be assessed in the EIA through comparison with other surveys collected in March in other years.

2.1.3.2 Third-Party Digital Arial Surveys

15. In addition, further survey data covering part of the OAA / WDA (**Figure 2.2**) were obtained from a third-party that surveyed the site prior to the announcement of exclusivity agreements with Crown Estate Scotland. Third-party survey methods were very similar to those used to collect baseline survey data, using the same provider (APEM). These provide a combination of further non-breeding season months and additional survey dates within the first breeding season between October 2020 and January 2022 (**Figure 2.2**).

Table 2.2 Survey date for each digital aerial survey sample collected and the proposed month the data will apply to

Sample No.	Date	Proposed Sampling Month
1	20/04/2021	April
2	13/05/2021	May
3	12/06/2021	June
4	06/07/2021	July
5	14/08/2021	August
6	29/09/2021	September
7	22/10/2021	October
8	23/11/2021	November
9	20/01/2022	January
10	21/03/2022	March
11	28/03/2022	March
12	24/04/2022	April
13	28/05/2022	May
14	11/07/2022	July
15	27/07/2022	July
16	21/08/2022	August
17	13/09/2022	September
18	04/11/2022	October
19	22/11/2022	November
20	02/12/2022	December
21	14/12/2022	December
22	28/01/2023	January
23	25/02/2023	February
24	19/03/2023	March
24	23/03/2023	March
25	22/04/2023	April
26	13/05/2023	May
27	07/06/2023	June
28	21/07/2023	July



Legend
Windfarm Development Area (WDA)
Option Agreement Area (OAA)
Option Agreement Area (4km Buffer)
Third Party Boundary
Third Party Boundary (6km Buffer)

N

0 5 10 Kilometres

REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER
1	04/09/2024	AB	GC	CB	PB

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PROJECT TITLE	MachairWind		

Figure 2.2: Third-Party Digital Aerial Survey Area and Buffer

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Table 2.3 Temporal sampling of the Project and additional third-party data

Year	**2020**									**2021**									**2022**									**2023**								
Month	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
MachairWind																		X 2				X 2					X 2									
Third-party																																				

Note: Months within the highlighted box cover the core breeding season months for all seabirds.

16. A total of nine third-party surveys overlapped temporally with the Project's surveys (**Table 2.4**). Only two surveys occurred within seven days of each other: the July 2021 surveys were on the same day and the August surveys were one day apart. Both of these survey data will be analysed and reported within the baseline characterisation, but they will not be treated as independent samples in the impact assessment, as discussed at ETG 1.

17. Only the results of the analyses of the Project's surveys will be included in the impact assessment. Further consideration will be given to the analysis and inclusion of the August 2021 third-party samples that were on the following day from the Project's survey.

Table 2.4 Dates of third-party and the Project's digital aerial surveys

Month	Third-party surveys	The Project's surveys	Days between surveys
October	01/10/2020	-	-
November	19/11/2020	-	-
December	07/12/2020	-	-
January	07/02/2021	-	-
February	01 and 04/03/2021	-	-
March	21/03/2021	-	-
April	03/04/2021	20/04/2021	17
May	01/05/2021	13/05/2021	12
June	01/06/2021	12/06/2021	11
July	06/07/2021	06/07/2021	0
August	15/08/2021	14/08/2021	1
September	01/09/2021	29/09/2021	28
October	11/10/2021	22/10/2021	11
November	15/11/2021	23/11/2021	8
December	03/12/2021	No survey completed	-
January	24/01/2022	20/01/2022	4

18. The combination of bespoke surveys for the Project and the third-party data provides four monthly samples in each month of the year except February and March, each of which have three samples (see **Table 2.5**). In total there are 46 samples across 36 months from October 2020 to September 2023, although two samples of the third-party data (July and August 2021) will be discounted from analyses as they are on the same or consecutive days.

Table 2.5 Total number of digital aerial surveys samples in each month from the Project and third-party surveys

Month	The Project	Third-party	Total
January	2	2	4
February	2	1	3
March	2	1	3
April	3	1	4
May	3	1	4
June	3	1	4
July	3	1	4
August	3	1	4
September	3	1	4
October	2	2	4
November	2	2	4
December	2	2	4
Total	**30**	**16**	**46**

19. The third-party DAS data did not provide the same spatial coverage as the bespoke surveys for the Project (**see Figure 2.2**). The survey area from the third-party data provides spatial coverage of the WDA, but not a complete buffer. There is no buffer for the WDA boundary on its eastern side, although a 2 km or 4 km buffer is available around the other boundaries of the WDA. This potentially limits the applicability of the third-party data to some stages of impact assessment, such as displacement mortality assessment.

20. The third-party data provides very useful additional information on the baseline characterisation of the site. These data also extend the temporal coverage of the WDA and large areas to the north, south and west. These data also provide increased coverage of the central area of the OAA and WDA, so aerial densities of birds from the third-party data can be compared directly with the aerial densities from the bespoke surveys for the Project, which could greatly increase the temporal coverage. The main limitation to the use of third-party data would be in the assessment of displacement using the matrix approach. Without the eastern buffer of the WDA being surveyed in the third-party data, displacement assessment could not be completed using the third-party data. However, it could provide useful context on the variation of total abundance within the Project, and this could be provided as additional contextual information. The integration of the third-party data into the assessment will be subject to further consultation with the ETG. This integration will consider the temporal independence of the data and the overlap with the WDA and suitable buffer.

2.1.4 Existing Data Sources and Analyses

21. A desk-based assessment will review the available information on the current baseline conditions of the ZoI of the WDA. This will be broadly split between two groups of birds including seabirds and migratory species. For each group, a search for available information will be made of:

- Spatial distributions in the area in which each species is at potential risk from the Project;
- Tracking information in the general area in which each species is at potential risk from the Project;

- Seabird colony information; and
- Migratory species population information.

22. Each of these is considered in more detail below.

2.1.4.1 At Sea Distribution Information

23. Available information on the distribution of seabirds at sea will be collated and described. This information will be used in combination with the baseline survey information to provide context on the relative importance of the ZoI of the Project for seabirds. Data sources are likely to include:

- An atlas of seabird distribution in north-west European waters (Stone et al., 1995);
- Distribution maps of cetacean and seabird populations in the North-East Atlantic (Waggitt et al., 2020);
- Breeding density, fine-scale tracking, and large-scale modelling reveal the regional distribution of four seabird species (Wakefield et al., 2017);
- Identifying important at-sea areas for seabirds using species distribution models and hotspot mapping (Cleasby et al., 2020);
- Islay OWF boat-based surveys (2009 - 2012) (Institute of Estuarine and Coastal Studies, 2012); and
- Argyll Array OWF boat-based surveys (2009 - 2011) (RPS, 2014).

2.1.4.2 Seabird Tracking Information

24. A literature search for seabird tracking information will be used to describe the potential for connectivity between the WDA and seabird breeding colonies. This will be used to help provide context to the general information on seabird foraging ranges from Woodward et al. (2019) and updated, where necessary, with the results of the review for the Marine Directorate Roadmap (once published). While foraging range information does provide useful information, without the context of where birds are foraging, the ranging information is incomplete. For instance, some species may forage up to a certain mean maximum distance from the colony, but not forage out to sea, so an understanding of the actual connectivity with offshore areas may be less certain when using foraging range data without the context of where birds are foraging.

25. The BirdLife seabird tracking database[2], RSPB FAME and STAR data[3], sources from Woodward et al. (2019) and results from searches of google scholar will be used to provide tracking information to help describe the use of the ZoI of the Project by seabirds and context to the mean of the maximum foraging range data. In the non-breeding season, the results of Global Location Sensor tracking of auks (Buckingham et al. 2022) will be used in the description of the baseline characteristics to help understand the seasonal variation in auk abundance in the Project survey area.

2.1.4.3 Available Seabird Colony Information

26. Within the mean of the maximum foraging range of each species from the Project, colony data will be obtained from either Burnell et al. (2023) or the Seabird Monitoring Programme (SMP) database. Any count obtained from Burnell et al. (2023) will be cross checked with the SMP Database for more recent count information. These data will be used to estimate the total regional population in the breeding season. Seabird population trends are expected to make use of Burnell et al. (2023) but may also extract further data from the SMP Database for key colonies within the regional population. Any regional or colony trends will be placed in context by comparison with either the information presented in Burnell et al. (2023) or from Joint Nature Conservation Committee (JNCC) (2021).

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[2] https://www.seabirdtracking.org/
[3] https://marine.gov.scot/information/fame-star-seabird-kittiwakes-guillemots-razorbills-and-shags-tracking-projects

27. A search will also be made of the SMP Database for available colony productivity information for key species within the ZoI of the Project. Within each colony, productivity information will be plotted, and descriptive statistics provided. These data are important in understanding trends information, as it may be apparent whether trends in population size may be due, at least partly, to changes in species productivity.

2.1.4.4 Available Migratory Species Tracking Information

28. Available tracking data for terrestrial waterbirds will be reviewed to compare with the available information in the strategic collision risk modelling tool, expected to be issued by the Scottish Government in the near future. This will be used to ensure that no important species or migratory corridors that include the location of the WDA are missed. At the time of writing, it is assumed that the stochastic Collision Risk Model (sCRM) tool will be available to inform the Project.

29. Tracking data will also be used to assess whether there is the potential for collisions to migratory waterbirds during the winter as birds may make inter-island movements.

2.1.4.5 Available Migratory Species Population Information

30. The most recent Wetland Bird Survey Annual Report will be used to understand the general trends in migratory waterbirds populations with the potential to interact with the WDA. In addition, due to the proximity of the island of Islay, the most recently available counts for key species on Islay will be reviewed and be used to place any sCRM results into context.

2.1.5 Data Analyses

31. Two analytical methods will be used to describe the use of the site by seabirds:

- Design-based analyses (**Section 2.1.5.1**); and
- Model-based analyses (**Section 2.1.5.2**).

32. The results of these analyses will be combined to provide a robust description of the densities and abundances of seabirds within the WDA boundary and buffers. The primary outputs that will be used will be model-based analyses and where these cannot be used due to data limitations then design-based analyses will be used, following advice from NatureScot. Information on why model-based analyses for any individual surveys were unsuccessful will be provided. Thus, the baseline characterisation and impact assessment will be informed by a mixture of outputs from two analytical methods.

33. NatureScot Guidance Note 2 states that, "*Density calculated from monthly surveys (either model or design based), which needs to be applied to half month periods because the seasonal definition splits the month, should be applied at the same value for each half month*" (NatureScot, 2023c). Thus, where NatureScot recommended seasonal periods are split across a month at either the start or end of a season, the value will be halved between each season.

2.1.5.1 Design-Based Analyses

34. Raw data from the Project's DAS will contain details of all objects (bird, marine mammal, vessels, etc.) as well as latitude and longitude coordinates for each object. All non-bird records will be removed prior to analysis. Analyses will be conducted for each survey separately. Bird locations will be assigned to the following areas:

- WDA boundary;
- WDA boundary plus 2 km buffer; and
- WDA boundary plus 4 km buffer.

35. Design-based density (birds/km^2) and abundance values will be estimated for individual species in each of the surveys using the 'R' Project statistical program (R Development Core Team, 2012).

36. The population abundance for each species on each survey will be calculated as the number of birds recorded multiplied by the total area divided by the area surveyed in that area. Densities will be obtained as the counts divided by the area surveyed. This is a simple extrapolation, that assumes similar densities are present in the un-surveyed areas. These calculations will be conducted for each of the areas described above.

37. To obtain measures of uncertainty around the estimated abundances and densities, a bootstrap resampling method used for analysing time-series data will be adapted as follows:

1. All transect lines tracked during each individual survey will be divided into 500 metre (m) segments.

2. The observations for each species on each individual survey will be resampled using a time-series bootstrap function (R library 'boot' function 'tsboot') with a blocking structure defined as 10 segments. Thus, resampling will be conducted at the level of groups of 10 segments, randomly selected on each of the 1,000 iterations conducted. A block size of 10 is likely to be selected as a precautionary length, with the assumption that beyond this number of segments there will be no detectable autocorrelation.

3. Each bootstrap iteration will provide a re-estimated number of observations which can be analysed to obtain population and densities as described above. From the bootstrap samples, the mean, the Standard Deviation (SD) and upper and lower 95% bootstrap confidence intervals (bootstrap confidence interval, 2.5th and 97.5th value in the ranked bootstraps) will be extracted from the bootstrap samples to provide the required measures of uncertainty.

4. Density and abundance estimates calculated for each species in each survey will be presented and used to describe the baseline conditions.

38. To calculate density and abundance for each species in each survey, this method assumes that the surveyed area is representative of the un-surveyed region, thus the design of survey is important (hence 'design-based').

39. Initial results of the design-based analyses for each species (where there were sufficient data) are provided in **Appendix J Ornithology Design-Based Analyses Results**.

2.1.5.2 Model-Based Analyses

40. Mean density surfaces will be fitted, where possible, using the MRSea package. NatureScot Guidance Note 2 recommends that MRSea is used when more than ten observations occur within a survey. While this will be attempted, many surveys with ten observations or more will not provide predictions from MRSea. The fundamental/initial model will be a Generalised Linear Model, with log-link and quasi-Poisson error structure or Poisson as required. An offset will be included for the area of the survey cell and a variety of covariates can be considered based on NatureScot Guidance Note 2:

- Bathymetry;
- Bathymetric slope;
- Sea surface temperature;
- Sea surface temperature gradient;
- Mixed layer depth (if available at fine scale resolution); and
- Chlorophyll α.

41. While the NatureScot guidance lists various "distance to" covariates as possible covariates to include within the model, these will be avoided as they tend to result in artefacts in the density surfaces, particularly with more complex coastlines. This was discussed at ETG 1 (14 June 2023), and feedback was received from NatureScot in response to the consultation on the Methods Statement (07 July 2023) (see the consultation responses in the Scoping Report).

42. Spatial smoothers will be estimated using the salsa2d algorithm in the MRSea package. Separate surfaces will be fitted for each of the species for each survey, where feasible, with all surveyed 1 km transect segments underpinning knot locations. These locations will be used to create a large number of potential knots, over which salsa2d can perform its search. The initial number of knots will be determined through exploratory analyses. Some adjustments to these settings are likely to be made for surfaces with convergence difficulties, in particular low levels of knots for very sparse species-surveys.

43. Bootstrap 95% confidence intervals will be generated using the MRSea parametric bootstrapping method, which provides confidence intervals for each 1 km^2 grid cell. Estimates to the various regions are arrived by summation over the 1 km^2 grid contained within these. Upper and lower confidence intervals are given by the 2.5 and 97.5 percentiles of the summed bootstrap surfaces.

44. For each survey, where data allows, the predicted abundance within the Project boundary, Project plus 2 km buffer and Project plus 4 km buffer will be presented with lower and upper bootstrap 95% confidence intervals.

45. Fitted mean density surface models will be presented by survey for each species where possible across the Project boundary and 4 km buffer.

2.1.6 Marine Bird Population Estimates

46. The EIA and Habitats Regulations Appraisal (HRA) for the Project will need to assess the predicted impacts relative to relevant population sizes. Populations sizes for seabirds will be obtained from sources that are matched as closely in time as possible to the site surveys of the OAA.

47. Population sizes for the EIA will be based on different spatial scales in the breeding season and non-breeding season, with the exception of guillemot.

48. For guillemots, the regional population will be defined as the breeding population size within the mean of the maximum foraging range (+ 1 SD) defined by Woodward et al. (2019). This will apply to both the breeding season and non-breeding season following the NatureScot guidance that assumes guillemots remain at their breeding colonies throughout the year.

2.1.6.1 Breeding Colony Population Estimates

49. Breeding colony estimates will be based on the reported values in Burnell et al. (2023). These will be checked against the SMP database to ensure that the colony data most closely matched to the survey timings are used. NatureScot Guidance Note 5 provides guidance on three scenarios of available seabird colony count data:

- Scenario 1 – Most colonies counted, except one major colony;
- Scenario 2 – Most colonies counted, except a few small colonies; and
- Scenario 3 – Most colonies are not counted.

50. Since this guidance was published before the publication of Burnell et al. (2023) it is expected that all colonies will have recent counts that are reported either in the Seabirds Count book or in the SMP database. Any more recent counts are likely to occur during the HPAI epidemic that has negatively affected some seabird populations. While some of the DAS of the OAA and buffer overlapped with

the 2022 and 2023 epidemic, other data did not. As such, great care will need to be taken to interpret the results of any seabird colony counts from 2022 and 2023.

51. Further guidance from NatureScot on how to address HPAI effects on the assessment of the potential impacts from the Project are awaited and will be followed once available. Ongoing consultation with NatureScot will facilitate agreement on the approach to assessment of HPAI as the EIA progresses.

2.1.6.2 Non-breeding season BDMPS

52. In the non-breeding season, the regional population size will be determined from the relevant Biologically Defined Minimum Population Scale (BDMPS) for each species (Furness, 2015). For most species, the Project is within United Kingdom (UK) Western Waters (± Channel) BDMPS Region.

53. The BDMPS approach provides estimated population sizes for a variety of seasons within the overall non-breeding season. The BDMPS seasons divide the non-breeding season defined by NatureScot into multiple seasons, depending upon the species being considered. Since NatureScot guidance does not divide the non-breeding season into multiple seasons, it will be necessary to compare the predicted impacts on the regional population to each seasonally defined BDMPS population size.

54. The combination of predicted impact and BDMPS seasonal population that has the largest impact on adult survival will be used as the most precautionary assessment of the significance. BDMPS populations for each species, region and season that are likely to be relevant to the MachairWind EIA are summarised in **Table 2.6.** Note that storm petrel was not assessed by Furness (2015) but as this species is migratory and was not recorded in the non-breeding season from DAS, the absence of a non-breeding population scale is not relevant.

55. Guillemot will be the only exception to this, where the same foraging range information used in the breeding season will be applied in the non-breeding season under the assumption that guillemot from all colonies spend all year in the broad vicinity of the colony. It will be noted that this assumption is not likely to be entirely true, even though some guillemots from some colonies do spend much of the non-breeding season at their breeding colony. Reference to the results of Global Location Sensor tracking by Buckingham et al. (2022) will be used to explain this further in the baseline characterisation of the WDA.

Table 2.6 Biologically Defined Minimum Population Scale regions and seasons for key species in the Project's WDA EIA

Species	Biologically Defined Minimum Population Scale (BDMPS) Season and Region	Adult population (individuals)
Kittiwake	Autumn migration (August to December) in 'United Kingdom (UK) western waters & Channel'	498,970
	Spring migration (January to April) in 'UK western waters & Channel'	375,711
Lesser black-backed gull	Autumn migration (August-October) in 'UK western waters'	110,708
	Winter (November to February) in 'UK western waters'	36,029
	Spring migration (March-April) in 'UK western waters'	110,708
Great black-backed gull	Non-breeding season (September to March) in 'UK west of Scotland waters'	14,238
Herring gull	Non-breeding season (September to February) in 'UK western waters'	87,134
Common tern	Migration seasons (late July-early September and April-May) in 'UK western waters'	40,216
Arctic tern	Migration seasons (July-early September and late April-May) in 'UK western waters'	48,538
Razorbill	Migration seasons (August to October, and January to March) in 'UK western waters'	316,928
	Winter (November and December) in 'UK western waters'	179,183
Puffin	Non-breeding season (mid-August to March) in 'UK western waters'	249,896
Great northern diver	Non-breeding season BDMPS (September to May) in West of Scotland	2,000*
Fulmar	Winter (November) in 'UK western waters & Channel'	363,383
	Migration seasons (September & October, December to March) in 'UK western waters & Channel'	490,041
Manx shearwater	Migration seasons (August to early October, late March to May) in 'UK western waters & Channel'	992,300
Gannet	Autumn (September to November) in 'UK western waters'	318,001
	Spring (December to March) in 'UK western waters'	391,540
* Adults and immatures From Furness (2015)		

2.2 POTENTIAL IMPACTS AND IMPACT PATHWAYS

56. OWF developments have the potential to impact marine bird populations through a variety of impact pathways. Following NatureScot Guidance Note 6 (NatureScot, 2023a) the primary impact pathways are:

- Collisions with operational turbines;
- Displacement from constructed wind farms;
- Barrier effects from operational wind farms; and
- Indirect effects on marine bird species prey and their habitats.

57. However, there are additional potential impact pathways that will also need to be considered in the EIA for the Project. NatureScot recommend the use of the Feature Activity Sensitivity Tool[4] (FeAST) published by Marine Scotland. At the time of writing the tool was not fully functional for seabirds. Information was provided by NatureScot on the pressures on seabirds that will be provided in FeAST, and these are summarised below. However, these pressures are from more activities than OWF development. When FeAST is fully working, the pressures on seabirds from OWF developments will be re-assessed. It is likely that the number of pressures listed below will be reduced.

2.2.1 FEAST

58. Pressures screened out of the EIA for the Project were identified using FeAST as:

- De-oxygenation;
- Electromagnetic changes;
- Nitrogen and phosphorus enrichment;
- Organic enrichment;
- Physical loss (to land or freshwater habitat);
- Physical removal (extraction of substratum);
- Salinity changes – local;
- Siltation rate changes (light);
- Sub-surface abrasion/penetration;
- Surface abrasion; and
- Temperature changes – local.

59. A total of 26 pressures on at least one species of seabird with the potential to be important in the EIA for the Project were identified using FeAST (see **Table 2.7** Pressures on key seabird species from FeAST). It is important to note that at the time of writing the tool was incomplete and did not allow the identification of pressures on seabirds associated with OWFs. The pressures shown in **Table 2.7** Pressures on key seabird species from FeAST relate to the features shown, but not to the pressures from OWF development. It is likely that some of these pressures are not relevant to OWF assessment and so will be revised for the EIA.

[4] https://feature-activity-sensitivity-tool.scot/

Table 2.7 Pressures on key seabird species from FeAST

Pressure	**Species**													
	Arctic tern	Atlantic puffin	Black-legged kittiwake	Common guillemot	European storm petrel	Great black-backed gull	Great northern diver	Great skua	Herring gull	Lesser black-backed gull	Manx shearwater	Northern fulmar	Northern gannet	Razorbill
Barrier to species movement	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Death or injury by collision below water	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Death or injury by collision above water	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Emergence regime changes - local	N	Y	N	Y	N	N	Y	N	N	Y	N	N	N	Y
Genetic modification & translocation of indigenous species	N	N	N	N	N	N	N	N	N	Y	N	N	N	N
Hydrocarbon & polycyclic aromatic hydrocarbon contamination (Includes those priority substances listed in Annex II of Directive 2008/105/EC).	N	N	N	N	N	Y	N	N	Y	N	N	N	N	N
Introduction of light or shading	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Introduction of microbial pathogens (disease), viruses or parasites	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Introduction of Other Substances (Solid, Liquid or Gas)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Introduction or spread of non-indigenous species & translocations (competition)	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Litter	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Transition elements and organo-metal (e.g. Chromium, Copper, TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y
Radionuclide contamination	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Reduction in availability or quality of prey	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Removal of non-target species (including lethal)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Removal of target species (including lethal)	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Siltation rate changes (heavy)	Y	Y	N	N	Y	N	N	N	N	N	N	N	N	N
Synthetic compound contamination (inc. pesticides, antifoulants, pharmaceuticals) Includes those priority substances listed in Annex II of Directive 2008/105/EC.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Temperature changes - regional/national	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Transition elements and organo-metal (e.g. Chromium, Copper, TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC.	N	N	N	N	N	Y	N	N	Y	N	N	N	N	N
Underwater noise	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Visual disturbance (behaviour)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Water clarity changes	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Water flow (tidal current) changes - local	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Wave exposure changes - local	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

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2.2.2 Consideration of Prey Species

60. In Guidance Note 6, NatureScot (2023a) note that OWF developments may indirectly impact seabirds by affecting their prey. The Project assessment will consider impacts to fish populations and benthic habitats within the WDA and cumulatively with other OWFs in the region. These will be considered in relation to their potential to cause significant effects on seabird populations.

61. NatureScot recommend that key impacts that will need to be considered include habitat loss, changes to trophic interactions and community structure and function, including prey species compositional changes e.g., changing from those dependent on sandy substrates to those species favouring rocky substrates. The EIAR Ornithology Chapter will cross reference with the chapters on benthic habitats and fish and shellfish populations. The ornithology chapter will include summaries of the key findings of these chapters in relation to the prey species (and their habitats) of each seabird species being assessed and references to the relevant sections of these chapters.

2.2.3 Cables

62. The installation of cables, including inter-array cables and Offshore Substation Platform link cables have the potential to disturb protected seabird species. In addition, indirect effects on prey and their habitats could also indirectly affect both seabirds and intertidal birds.

63. The export cable corridor is subject to a separate consenting and licensing process where detailed assessment of export cable laying activities will be undertaken once more accurate design details are understood.

2.3 ASSESSING COLLISION RISK OF MARINE BIRDS

64. There is a potential risk of collision for flying birds with the Wind Turbine Generator rotors and associated infrastructure resulting in injury or fatality to birds which fly through the WDA. Broadly, collision risk from the Project can occur to two groups of birds: seabirds passing through or using the WDA; and migrating terrestrial birds during migration periods.

2.3.1 Seabirds

65. Based on NatureScot Guidance Note 7 (NatureScot, 2023b), and the presence of species in the WDA and 4 km buffer, the following species were scoped into the assessment of potential collision risk:

- Kittiwake;
- Great black-backed gull;
- Common gull;
- Herring gull;
- Lesser black-backed gull;
- Common tern;
- Arctic tern;
- Great skua; and
- Arctic skua.

66. Assessment of potential collision risk to seabirds will be based upon two key elements:

- Aerial densities of seabirds within the WDA boundary; and
- The realistic worst-case scenario of size and number of turbines, determined from the engineering envelope.

67. Aerial densities are expected to be obtained from the results of the model-based analyses, or design-based analyses where there is insufficient data. Model-based estimates will be mixed with design-

based estimates, so in months where the month cannot be analysed using model-based approaches, design-based results will be used. While the model-based analyses are likely to result in predicted mean aerial densities of seabirds with smaller SDs than those from design-based analyses, it may be that these will not be available for every month of the year within each season.

68. Collision Risk Model (CRM) results will be provided for both stochastic and deterministic models and for Options 2 and 3. No site-based seabird flight heights will be obtained, so Options 1 and 4 will not be used. While it was available as a Beta version at the time of writing, all models will be run in the updated sCRM (Caneco, 2022).

69. Following NatureScot Guidance Note 7 (NatureScot, 2023b) outputs will be provided for:

- Most likely scenario – Option 2 (using the generic flight height dataset);
- Most likely scenario – Option 3 (using the generic flight height dataset);
- Worst-case scenario – Option 2 (using the generic flight height dataset);
- Worst-case scenario – Option 3 (using the generic flight height dataset); and
- Predicted seasonal (breeding and non-breeding season) totals and annual predicted total collision mortalities.

70. Biological input values will follow those recommended by Guidance Note 7 (NatureScot, 2023b) unless a species is not included within the guidance note. In those circumstances, the best available scientific knowledge will be used to obtain suitable biological input values, and these will be discussed with the ETG.

71. For each sCRM approach used, the PDF outputs from the model runs using the shiny app.[5] will be provided in a technical appendix, along with the seed run.

2.3.2 Stochastic and Deterministic CRM

72. Both stochastic and deterministic CRMs will be run using Caneco (2022) sCRM. Models will be run using the shiny app. so that PDF outputs from the tool can be provided in the CRM technical appendix. Details of the model version used, and the started seed value will be provided to allow repeatability of the analyses.

2.3.2.1 Biological Parameters

73. Biometric values for all species will be obtained from Guidance Note 7 Appendix 1 (NatureScot, 2023b). Should any additional species need to be modelled, and biometrics are not available, the values will be obtained from the British Trust for Ornithology (BTO) Birdfacts website[6], though the original reference will be provided for the data.

2.3.2.2 Input Aerial Densities

74. Monthly estimates of aerial densities of seabirds will be obtained from the results of analyses of the baseline survey data. The input variable to the CRM is the mean monthly density of flying birds from the samples of each calendar month in different years (including variance for the sCRM). Input will be based on either model-based or design-based analyses of records of birds in flight within the WDA footprint (with no buffer area) as described in **Appendix J Ornithology Design-Based Analyses Results**. Although there may be a mix of model-based and design-based estimates used to derive the input variable across different months, it is assumed that it is not acceptable to mix model-based monthly estimates with design-based monthly estimates for the same month (i.e. the CRM input for any particular month will not be a mix of model-based and design-based estimates,

5 A Shiny App for a stochastic sCRM for seabirds from https://dmpstats.shinyapps.io/sCRM/

6 https://www.bto.org/understanding-birds/welcome-birdfacts

but each monthly mean density estimate will be derived only from model-based results or only from design-based results). While the model-based analyses are likely to result in predicted mean aerial densities of seabirds with smaller SDs than those from design-based analyses, it may be that these will not be available for every month of the year within each season.

75. The CRM technical appendix will provide a table of input aerial densities for each species which will clearly show which values were obtained from design-based analyses and which were obtained from model-based analyses.

76. For the stochastic CRM the variability in aerial bird densities will be based on 1,000 samples from a distribution of mean densities.

2.3.2.3 Flight Height

77. The only source of height data that will be used in collision risk modelling will be from Johnston et al. (2014) (with associated corrigendum). No site-based flight height data will be presented or used in the EIA/HRA for the Project.

2.3.2.4 Avoidance Rates

78. At present, avoidance rates would follow Table 2 in Guidance Note 7 for the sCRM and Table 1 for the deterministic CRM (NatureScot, 2023b). However, should updated guidance become available, following the publication of new analyses by Ozsanlev-Harris et al. (2022), it will be followed. At present it is expected that this will apply to Option 2 only.

2.3.2.5 Presentation of CRM - Breeding Season

79. Results from the CRM will be presented as the predicted number of collisions for each month (or part month) in the species-specific breeding seasons defined in Guidance Note 9 (NatureScot, 2020). In addition, the seasonal total predicted collision mortality will be presented. The CRM technical appendix will present monthly and seasonal values for stochastic and deterministic model outputs for Options 2 and 3, where recommended avoidance rates allow. Collision mortalities derived under both the worst-case scenario and most likely scenario will be provided. These will be provided as PDF outputs from the shiny app with the starting seed value clearly provided.

80. Guidance Note 2 (NatureScot, 2023c) states, "*Density calculated from monthly surveys (either model or design based), which needs to be applied to half month periods because the seasonal definition splits the month, should be applied at the same value for each half month*". It is assumed that this means that the monthly value is halved for each half month when that month occurs in both the breeding and non-breeding season.

2.3.2.6 Presentation of CRM – Non-Breeding Season

81. Similarly, the non-breeding season outputs will be provided as monthly and seasonal predicted collisions based on species specific seasonal periods from Guidance Note 9 (NatureScot, 2020). Outputs will be provided in an identical manner to the breeding season values.

2.3.3 Migratory Collision Risk Assessments

82. OWFs have the potential to impact on populations of terrestrial migratory species through collisions with operational turbines during migration only. Using the recent Strategic review of birds on migration in Scottish waters (Woodward et al. 2023), the species that may migrate through the area where the Project is located were scoped in or out. A total of sixteen species were scoped out based on the relative locations of the Project and the species migratory corridors:

- 'East Atlantic' Light-bellied Brent Goose (North Greenland/Svalbard) (*Branta bernicla hrota)*;

- Dark-bellied Brent Goose (Western Siberia/Western Europe) (*Branta bernicla bernicla)*;
- 'Svalbard' Barnacle Goose (Svalbard/South-west Scotland) (*Branta leucopsis)*;
- Taiga Bean Goose (*Anser fabalis)*;
- 'European' White-fronted Goose (NW Siberia & NE/NW Europe) (*Anser albifrons albifrons)*;
- Bewick's Swan (*Cygnus columbianus bewickii)*;
- Nightjar (*Caprimulgus europaeus)*;
- Stone-curlew (*Burhinus oedicnemus)*;
- Avocet (*Recurvirostra avosetta)*;
- Black-tailed Godwit (*Limosa limosa*);
- Red-necked Phalarope (*Phalaropus lobatus)*;
- Wood Sandpiper (*Tringa glareola)*;
- Bittern (*Botaurus stellaris)*;
- Honey-buzzard (*Pernis apivorus)*;
- Marsh Harrier (*Circus aeruginosus)*; and
- Montagu's Harrier (*Circus pygargus)*.

83. Consequently 54 species were scoped into the assessment of collision risk of terrestrial migratory species. The species selected, the proportion at collision risk height, flight speed and avoidance rate are summarised in **Table 2.8.**

Table 2.8 Summary of species scoped into the assessment of collision risk to terrestrial migratory species

Species	% at Collision Risk Height	Flight Speed (m/s)	Avoidance Rate
'Nearctic' Light–bellied Brent Goose (Canada and Greenland/Ireland) *Branta bernicla hrota*	50%	17.9 ± 6.1	0.9998 ± 0.00001
'Greenland' Barnacle Goose (East Greenland/Scotland & Ireland) *Branta leucopsis*	100%	17.29 ± 2.08	0.9998 ± 0.00001
'Icelandic' Greylag Goose (Iceland/United Kingdom (UK) & Ireland) *Anser anser*	50%	12.0 ± 4.9	0.9998 ± 0.00001
Pink-footed Goose (East Greenland and Iceland/UK) *Anser brachyrhynchus*	50%	16.90 ± 0.16	0.9999 ± 0.0002
'Greenland' White-fronted Goose (Greenland/Ireland & UK) *Anser albifrons flavirostris*	100%	18.75 ± 7.19	0.9998 ± 0.00001
Whooper Swan *Cygnus cygnus*	50%	17.5 ± 4.2	0.9874 ± 0.00138
Shelduck *Tadorna tadorna*	50%	18.2 ± 4.3	0.9851 ± 0.00088
Shoveler *Spatula clypeata*	100%	18.3 (95% CI 15.6–20.9)	0.9851 ± 0.00088
Gadwall *Mareca strepera*	100%	19.6 (95% CI 18.5- 20.7)	0.9851 ± 0.00088
Wigeon *Mareca penelope*	100%	18.5 ± 2.28	0.9851 ± 0.00088
Mallard *Anas platyrhynchos*	100%	15.86 ± 2.00	0.9851 ± 0.00088
Pintail *Anas acuta*	100%	21.9 (95% CI 21.3–22.6)	0.9851 ± 0.00088
Teal *Anas crecca*	100%	17.4 ± 1.6	0.9851 ± 0.00088
Pochard *Aythya ferina*	100%	23.6 ± 2.0	0.9851 ± 0.00088
Tufted Duck *Aythya fuligula*	100%	21.1 ± 1.1	0.9851 ± 0.00088
Scaup *Aythya marila*	100%	21.1 ± 2.0	0.9851 ± 0.00088
Eider *Somateria mollissima mollissima*	25%	17.34 ± 2.40	0.9851 ± 0.00088
Velvet Scoter *Melanitta fusca*	100%	20.1 ± 4.7	0.9851 ± 0.00088
Common Scoter *Melanitta nigra*	100%	22.1 ± 4.0	0.9851 ± 0.00088
Long-tailed Duck *Clangula hyemalis*	100%	19.7 ± 1.7	0.9851 ± 0.00088
Goldeneye *Bucephala clangula*	100%	20.3 ± 3.8	0.9851 ± 0.00088
Goosander *Mergus merganser*	100%	19.7 ± 1.1	0.9851 ± 0.00088
Red-breasted Merganser *Mergus serrator*	100%	22.0 ± 2.9	0.9851 ± 0.00088
Corncrake *Crex crex*	100%	13.0 ± 2.0	0.9875 ± 0.00174
Spotted Crake *Porzana porzana*	100%	13.0 ± 2.0	0.9875 ± 0.00174
Great Crested Grebe *Podiceps cristatus*	100%	21.13 ± 1.55	0.9954 ± 0.00002
Slavonian Grebe *Podiceps auritus*	100%	21.13 ± 1.55	0.9954 ± 0.00002
Oystercatcher *Haematopus ostralegus*	100%	13.0 ± 2.5	0.9996 ± 0.00002

Species	% at Collision Risk Height	Flight Speed (m/s)	Avoidance Rate
Lapwing *Vanellus vanellus*	100%	12.8 ± 1.3	0.9996 ± 0.00002
Golden Plover *Pluvialis apricaria*	100%	16.5 ± 1.8	0.9996 ± 0.00002
Grey Plover *Pluvialis squatarola*	100%	16.5 ± 1.8	0.9996 ± 0.00002
Ringed Plover *Charadrius hiaticula*	100%	16.0 ± 1.1	0.9996 ± 0.00002
Dotterel *Charadrius morinellus*	100%	16.5 ± 1.8	0.9996 ± 0.00002
Whimbrel *Numenius phaeopus*	100%	13.8 ± 0.4	0.9996 ± 0.00002
Curlew *Numenius arquata*	100%	15.4 ± 3.3	0.9996 ± 0.00002
Bar-tailed Godwit *Limosa lapponica*	100%	18.3 ± 2.1	0.9996 ± 0.00002
Black-tailed Godwit *Limosa limosa* (*islandica*)	100%	18.1 ± 6.0	0.9996 ± 0.00002
Turnstone *Arenaria interpres*	100%	10.0 ± 3.3	0.9996 ± 0.00002
Knot *Calidris canutus*	100%	24.6 ± 4.6	0.9996 ± 0.00002
Ruff *Philomachus pugnax*	100%	16.9 ± 1.8	0.9996 ± 0.00002
Sanderling *Calidris alba*	100%	21.4 ± 1.1	0.9996 ± 0.00002
Dunlin *Calidris alpina*	100%	15.3 ± 1.9	0.9996 ± 0.00002
Purple Sandpiper *Calidris maritima*	100%	15.3 ± 1.9	0.9996 ± 0.00002
Snipe *Gallinago gallinago*	100%	17.1 ± 2.7	0.9996 ± 0.00002
Redshank *Tringa totanus*	100%	15.3 ± 4.1	0.9996 ± 0.00002
Greenshank *Tringa nebularia*	100%	12.3 ± 3.3	0.9996 ± 0.00002
Red-throated Diver *Gavia stellata*	25%	18.6 ± 3.9	0.9954 ± 0.00002
Black-throated Diver *Gavia arctica*	25%	19.3 ± 2.1	0.9954 ± 0.00002
Great Northern Diver *Gavia immer*	25%	19.5 ± 1.6	0.9954 ± 0.00002
Osprey *Pandion haliaetus*	50%	10.6 ± 3.1	0.9957 ± 0.00006
Hen Harrier *Circus cyaneus*	100%	11.4. ± 1.1	0.9957 ± 0.00006
White-tailed Eagle *Haliaeetus albicilla*	100%	14.4 ± 1.04	0.9872 ± 0.00192
Short-eared Owl *Asio flammeus*	100%	9.7 ± 2.0	0.9957 ± 0.00006
Merlin *Falco columbarius*	100%	12.7 ± 5.8	0.9891 ± 0.00033

84. At present, it is expected that the migratory CRM tool will follow the results of Work Package 3 from the ScotMER *“Strategic study of collision risk for birds on migration and further development of the stochastic collision risk modelling tool”* project. If this project is not completed in time for inclusion in the Project EIA and HRA, a bespoke migratory CRM of the Project will be completed using Wildfowl and Wetlands Trust and MacArthur Green (2014).

2.4 ASSESSING DISTRIBUTIONAL RESPONSES, DISPLACEMENT AND BARRIER EFFECTS OF MARINE BIRDS

85. There is evidence from operational OWFs that some seabird species may be displaced from the windfarm area and a buffer around it (Dierschke et al. 2016, Welcker et al. 2016, Vanermen et al. 2015) and evidence of a lack of such an effect (Trinder et al. 2024, Vallejo et al. 2017). In addition, there is a potential for OWFs to act as barriers to movement of seabirds.

86. Based on Guidance Note 8 (NatureScot, 2023d), and the presence of species in the WDA and 4 km buffer, the following species were scoped into the assessment of potential displacement and barrier effect risk:

- Kittiwake;
- Guillemot;
- Razorbill;
- Black guillemot;
- Puffin;
- Red-throated diver;
- Great northern diver;
- Fulmar;
- Manx shearwater; and
- Gannet.

87. Two methods will be applied to assess the effects of displacement of seabirds from within the WDA, and a buffer area around it:

- Matrix approach; and
- SeabORD.

88. Both methods will be applied, at least to some species. The matrix approach will be applied to all species considered susceptible to disturbance (i.e. have medium or high ‘Disturbance Sensitivity’ and ‘Habitat Specialization’ scores as assessed by Bradbury et al. (2014) (expanded from Furness et al. 2013), summarised in Table 1 by the Statutory Nature Conservation Bodies (SNCBs, 2022), while SeabORD is limited to kittiwake, guillemot, razorbill, and puffin.

2.4.1 Matrix Approach

89. The assessment of displacement from the WDA (and 2 km buffer) will be based on the predicted abundance of birds from the design-based or model-based analyses. As with the CRM assessment, the inputs from the design-based analyses will be used where model-based analyses cannot provide a robust abundance estimate (often due to data limitations). As with the CRM approach, within any one season the peak mean will be estimated using design-based and model-based results. Following NatureScot advice, model-based results will be preferred and where the model is unable to predict abundances of birds within the WDA and buffer, design-based analyses results will be used. Thus, a mix of abundance prediction methods will be used to inform the matrix.

90. From the monthly predicted abundance estimates, the mean seasonal peak population estimates will be calculated (i.e. the mean of the highest values within each season). An example of how the peak mean values will be calculated is shown in **Table 2.9**. In this example the abundance estimates in each month are entirely hypothetical. Non-breeding season abundance estimates are shaded blue, and breeding season abundance estimates are shaded yellow. Selected peak mean abundances in each season are shown in **bold**. Any seasons with incomplete survey across all months in that season will be excluded from the analyses.

Table 2.9 Example of estimation of season peak mean abundance estimates.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Year 1	5.3	**9.5**	6.4	7.1	2.8	9.9	**10.2**	3.8	6.6	8.0	1.5	9.2
Year 2	10.1	10.4	6.8	2.3	**10.0**	3.8	8.1	1.9	**10.8**	5.5	6.4	2.2
Peak Mean	10.15			10.1								

NOTE – these are hypothetical data and NOT an example of the data from surveys of the Project.

91. The peak mean seasonal abundance estimates will be used as inputs to a seasonal matrix providing a range of outputs across a range of both displacement rates and mortality rates. Displacement rates will be provided in 10% increments between 10% and 100%. Mortality rates will be provided in 1% increments to 5% and then 10% increments from 10% to 100%. Examples based on the inputs from **Table 2.9** were applied to the example matrices in **Table 2.10** and **Table 2.11**. Displacement and mortality rates will use the recommended values in NatureScot Guidance Note 8 (NatureScot, 2023d).

Table 2.10 Example matrix table for the assessment of predicted impacts on auks in the breeding season

		DISPLACEMENT										
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
MORTALITY	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1%	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
	2%	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
	3%	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
	4%	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4
	5%	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5
	10%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	15%	0.0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5
	20%	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
	30%	0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
	40%	0.0	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0
	50%	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.1
	60%	0.0	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.5	6.1
	70%	0.0	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.7	6.4	7.1
	80%	0.0	0.8	1.6	2.4	3.2	4.0	4.8	5.7	6.5	7.3	8.1
	90%	0.0	0.9	1.8	2.7	3.6	4.5	5.5	6.4	7.3	8.2	9.1
	100%	0.0	1.0	2.0	3.0	4.0	5.1	6.1	7.1	8.1	9.1	10.1

Table 2.11 Example matrix table for the assessment of predicted impacts on auks in the non-breeding season

		DISPLACEMENT										
		0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
MORTALITY	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1%	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
	2%	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
	3%	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3
	4%	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4
	5%	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5
	10%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	15%	0.0	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5
	20%	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
	30%	0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
	40%	0.0	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.7	4.1
	50%	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.6	4.1	4.6	5.1
	60%	0.0	0.6	1.2	1.8	2.4	3.0	3.7	4.3	4.9	5.5	6.1
	70%	0.0	0.7	1.4	2.1	2.8	3.6	4.3	5.0	5.7	6.4	7.1
	80%	0.0	0.8	1.6	2.4	3.2	4.1	4.9	5.7	6.5	7.3	8.1
	90%	0.0	0.9	1.8	2.7	3.7	4.6	5.5	6.4	7.3	8.2	9.1
	100%	0.0	1.0	2.0	3.0	4.1	5.1	6.1	7.1	8.1	9.1	10.2

92. Since predicted displacement impacts need to be used as input to the assessment against populations, the midpoint value from the matrix will be used to assess the predicted change in adult survival and is input to any Population Viability Analysis (PVA) required.

93. As highlighted in the Joint SNCB Interim Displacement Advice Note[7], the Displacement Technical Appendix will provide an annex with additional matrices for the WDA footprint only (i.e. with no buffer included), though the results from these matrices will not be used in the EIA or HRA.

2.4.2 SeabORD

94. SeabORD will not be used in the EIA, as the model is designed to assess impacts on individual colonies. The EIA will assess impacts on the regional population, rather than on individual colonies. Thus, seabORD will only be applied to the appropriate Special Protection Area colonies in the Report to Inform Appropriate Assessment for kittiwake, guillemot, razorbill, and puffin. These colonies will be identified during the HRA screening, noting the current restriction of modelling six colonies simultaneously in seabORD at the time of writing (see WDA **HRA Screening Report** (Royal HaskoningDHV and MacArthur Green, 2024)).

[7] https://data.jncc.gov.uk/data/9aecb87c-80c5-4cfb-9102-39f0228dcc9a/joint-sncb-interim-displacement-advice-note-2022.pdf

2.5 SEABIRD POPULATION VIABILITY ANALYSIS

2.5.1 Threshold for Undertaking Population Viability Analysis

95. A PVA will be run for any species where the project alone impact exceeds the recommended threshold of a decline in adult annual survival rate of more than 0.02 percentage points, e.g. a reduction in adult survival rate from 0.8000 to 0.7998. Where the project alone predicted impacts result in a smaller reduction in adult survival the assessment will be completed without reference to the results of a PVA. The recommended threshold will not be used as a measure of the importance of predicted impacts on a population.

2.5.2 Type of Model

96. Age structured stochastic (where possible) Leslie matrix models will be run using the Natural England PVA tool (Searle et al. 2019[8]). The most up to date version of the model will be used with the version number noted.

97. For some populations fully stochastic population models may not be possible. Should that be the case an attempt will be made to run the models without environmental stochasticity, and only demographic stochasticity included. If that model cannot be run, a fully deterministic model will be run.

2.5.3 Time Periods

98. Summary outputs from the PVA will be provided at intervals between 10 and 50 years in five-year increments in the PVA Technical Appendix. A summary of the PVA metrics at 25 and 50 years will be provided in the EIA chapter for each species where a PVA is used in the assessment. If the duration of the Project is less than 50 years, summaries of the PVA metrics will be provided at that point in the projection in addition to 25 and 50 years. The effects of the predicted impacts will be projected to 50 years regardless of the duration of the Project.

2.5.4 Starting Population Size

99. The starting population size for each species and season will be based on the same regional population sizes established using the approaches described in **Section 2.1.6**. This will result in either breeding season, non-breeding season, or both, population scales being modelled.

100. In the absence of detailed online published guidance from NatureScot, the non-breeding season assessment will be based on the BDMPS season with the largest predicted change in adult survival against that population. The predicted change in adult survival for all BDMPS non-breeding seasons will be clearly reported in the PVA Technical Appendix.

2.5.5 Life History Parameters

101. The primary source of life history information needed to parameterise the PVA will be Horswill & Robinson (2015). However, since many of these values have been obtained from studies in the North Sea a few of the parameters may not be suitable for modelling populations on the west coast of Scotland. Where it is considered necessary, changes will be made primarily to the productivity information used for west coast Scotland and Northern Ireland seabird colonies. Care will be taken to compare the projected population growth rate to the populations being modelled where productivity information from other sources is applied. This will be clearly indicated in the PVA Technical Appendix, and the reasons used, and sources of data will be provided.

[8] http://ec2-34-243-66-127.eu-west-1.compute.amazonaws.com/shiny/seabirds/PVATool_Nov2022/R/

2.5.6 Population Viability Analysis Metrics

102. Three PVA metrics will be reported in the PVA technical appendix:

- Counterfactual of Population Size;
- Counterfactual of Growth Rate; and
- The quantile from the unimpacted population that matched the 50% quantile for the impacted population (U=50%I) and the quantile from the impacted population that match the 50% quantile for the unimpacted population (I=50%U).

103. Metrics will be summarised as median and mean values with SDs and lower and upper 95% confidence intervals.

104. Plots of population size projection from the PVA will be provided across the period of the projection with the final year of the development clearly indicated if this is less than 50 years.

3 REFERENCES

Buckingham, L., Bogdanova, M.I., Green, J.A., Dunn, R.E., Wanless, S., Bennett, S., Bevan, R.M., Call, A., Canham, M., Corse, C.J. and Harris, M.P. (2022). Interspecific variation in non-breeding aggregation: a multi-colony tracking study of two sympatric seabirds. Marine Ecology Progress Series, 684: 181-197.

Burnell, D., Perkins, A.J., Newton, S.F., Bolton, M., Tierney, T.D., Dunn, T.E. (2023). Seabirds Count: A census of breeding seabirds in Britain and Ireland (2015–2021). Lynx Edicions.

Caneco, B. (2022). A Shiny App for a stochastic Collision Risk Model (sCRM) for seabirds. Available at: https://dmpstats.shinyapps.io/sCRM/. [Accessed 21/09/2024]

Cleasby, I. R., Owen, E., Wilson, L., Wakefield, E. D., O'Connell, P. and Bolton, M. (2020). Identifying important at-sea areas for seabirds using species distribution models and hotspot mapping. Biological Conservation, 241: 108375.

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

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

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

Horswill, C. & Robinson R. A. (2015). Review of seabird demographic rates and density dependence. JNCC Report No. 552. Joint Nature Conservation Committee, Peterborough.

Institute of Estuarine and Coastal Studies (2012). Marine Mammals and Ornithology Survey, Islay. Boat based surveys to identify seabirds undertaken from 2009 to 2011. Data available on the Marine Data Exchange.

Johnston, A., Cook, A.S., Wright, L.J., Humphreys, E.M. and Burton, N.H. (2014). Modelling flight heights of marine birds to more accurately assess collision risk with offshore wind turbines. Journal of Applied Ecology, 51(1), pp.31-41.

JNCC (2021). Seabird Monitoring Programme Report 1986–2019. Available at: SMP Report 1986–2019 | JNCC - Adviser to Government on Nature Conservation.

Kinlan, B.P., E.F. Zipkin, A.F. O'Connell, and Caldow, C. (2012). Statistical analyses to support guidelines for marine avian sampling: final report. U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Herndon, VA. OCS Study BOEM 2012-101. NOAA Technical Memorandum NOS NCCOS 158. xiv+77 pp.

NatureScot (2020). Guidance Note 9: Guidance to support Offshore Wind Applications: Seasonal periods for Birds in the Scottish Marine Environment. Version 2. October 2020.

NatureScot (2023a). Guidance Note 6: Guidance to support Offshore Wind Applications - Marine Ornithology Impact Pathways for Offshore Wind Developments. Version 1: January 2023.

NatureScot (2023b). Guidance Note 7: Guidance to support Offshore Wind Applications: Marine Ornithology - Advice for assessing collision risk of marine birds. Version 1: January 2023.

NatureScot (2023c). Guidance Note 2: Guidance to support Offshore Wind Applications: Advice for Marine Ornithology Baseline Characterisation Surveys and Reporting (Version 1: January 2023).

NatureScot (2023d). Guidance Note 8: Guidance to support Offshore Wind Applications: Marine Ornithology Advice for assessing the distributional responses, displacement and barrier effects of marine birds. Version 1: January 2023.

Royal HaskoningDHV and MacArthur Green (2024). MachairWind Windfarm Development Area HRA Screening Report.

RPS (2014). Argyll Array Offshore Wind Farm. Technical Report – Ornithology. Project Number: SGP6346. RPS Report Dated 21 January 2014.

Searle, K., Mobbs, D., Daunt, F., and Butler, A. (2019). A Population Viability Analysis Modelling Tool for Seabird Species. Centre for Ecology & Hydrology report for Natural England. Natural England Commissioned Report NECR274.

SNCB (2022). Joint SNCB Interim Displacement Advice Note. Available at: https://data.jncc.gov.uk/data/9aecb87c-80c5-4cfb-9102-39f0228dcc9a/joint-sncb-interim-displacement-advice-note-2022.pdf. [Accessed 21/09/2024]

Stone, C.J., Webb, A., Barton, C., Ratcliffe, N., Reed, T.C., Tasker, M.L., Camphuysen, C.J. & Pienkowski, M.W. (1995). An atlas of seabird distribution in north-west European waters, JNCC, Peterborough, ISBN 1 873701 94 2.

Trinder, M., O'Brien, S.H. and Deimel, J. (2024). A new method for quantifying redistribution of seabirds within operational offshore wind farms finds no evidence of within-wind farm displacement. Frontiers in Marine Science, 11. Available at: https://doi.org/10.3389/fmars.2024.1235061. [Accessed 21/09/2024]

Vallejo, G.C., Grellier, K., Nelson, E.J., McGregor, R.M., Canning, S.J., Caryl, F.M. and McLean, N. (2017). Responses of two marine top predators to an offshore wind farm. Ecology and Evolution, 7(21), pp.8698-8708.

Vanermen, N., Onkelinx, T., Courtens, W., Van De Walle, M., Verstraete, H. and Stienen, E.W. (2015). Seabird avoidance and attraction at an offshore wind farm in the Belgian part of the North Sea. Hydrobiologia, 756, pp.51-61.

Waggitt, J. J., Evans, P. G., Andrade, J., Banks, A. N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C. J. and Durinck, J. (2020). Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 57, 253-269.

Wakefield et al., (2017). Breeding density, fine-scale tracking, and large-scale modeling reveal the regional distribution of four seabird species. Ecological Applications, 27: 2074-2091.

Welcker, J. and Nehls, G. (2016). Displacement of seabirds by an offshore wind farm in the North Sea. Marine Ecology Progress Series, 554, pp.173-182.

Woodward, I.D., Franks, S.E., Bowgen, K., Davies, J.G., Green, R.M.W., Griffin, L.R., Mitchell, C., O'Hanlon, N., Pollock, C., Rees, E.C., Tremlett, C., Wright, L. and Cook, A.S.C.P. (2023). Strategic study of collision risk for birds on migration and further development of the stochastic collision risk modelling tool: Work Package 1: Strategic review of birds on migration in Scottish waters. Report by British Trust for Ornithology, Royal Society for the Protection of Birds and ECO-LG to The Scottish Government, Crown Estate Scotland and The Crown Estate.

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