Appendix C: Collision Risk Estimates for Key Seabird Species at Inch Cape Offshore Wind Farm

REPORT

Collision Risk Estimates for Key Seabird Species at Inch Cape Offshore Wind Farm

Comparisons with consented designs

Client: Inch Cape Offshore Limited

Reference: PB2991-RHD-ZZ-XX-RP-Z-0001

Status: S0/P02.01

Date: 11 0000 2022

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Classification
Confidential

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Appendices

Acronyms

CRM	Collision risk modelling
EIAR	Environmental Impact Assessment Report
ICOL	Inch Cape Offshore Limited
LAT	Lowest Astronomical Tide
MSL	Mean sea level
SOSS	Strategic Ornithological Support Services
SPA	Special Protection Area

1 Introduction

In 2018, ICOL submitted a new application for the Inch Cape Offshore Wind Farm with a revised design that would allow the development of a project that could utilise progressions in turbine technology since the 2014 consent. The revised design was aimed at reducing the environmental impacts and increasing the cost competitiveness of the project, primarily by reducing the overall number of turbines and increasing the height of the turbines being installed. Section 36 and Marine Licence Consents for the revised design were granted by Scottish Ministers in 2019.

The Inch Cape Offshore Wind Farm Section 36 Consent sets out parameters, but provides by condition 7 that the Development must be constructed and operated in accordance with the Application (which includes the submitted EIAR). The ornithology chapter of the EIAR assessed two design scenarios (referred to as A and B). The two scenarios represent the extent of the design envelope, each giving a maximum rotor swept area below 50 m above mean sea level of 87,000 m^2 (a commitment in the EIAR, see for example Table 11.4, "Worst Case Scenario Definition"). The Marine Licence sets out parameters for both of these assessed design scenarios ("Part 2 – The Works"), but provides that where the final design agreed through the Development Specification and Layout Plan ("DSLP") falls between design scenarios A and B, the collision risk to birds must be no greater than assessed in the Appropriate Assessment (Marine Scotland 2019). The Marine Licence also provides by condition 3.1.1 that the works must be constructed and operated in accordance with the Application (which includes the EIAR). Both the Section 36 Consent and Marine Licence provide a condition requiring approval of the DSLP.

Since the revised design of the Inch Cape Offshore Wind Farm was consented1, a Preferred Design scenario (in terms of turbine numbers and dimensions) for the Wind Farm has been identified. It falls within a combination of the parameters from design scenarios A and B. For completeness, in order to ensure that for the proposed design scenario the collision risk to birds is no greater than the consented worst-case parameters, CRM for the Preferred Design scenario is included within this report. For the avoidance of doubt, CRM will also be submitted along with the DSLP for approval under the Section 36 and Marine Licence conditions.

This report compares the predicted collision mortality for the current Preferred Design with the two design scenarios assessed in the 2018 EIAR. This is undertaken for each of the three species of seabird for which collision mortality was considered to be relevant effect pathway in the assessment for the Project – i.e. gannet, kittiwake and herring gull (Marine Scotland 2017, ICOL 2018a).

[1] *Microsoft Word - ICOL Revised Design - ANNEX C Decision Notice and Conditions - V3 - FINAL (marine.gov.scot)*

2 Predicting collision mortality

2.1 Turbine parameters

The turbine parameters which are relevant to CRM are presented for the Preferred Design and for the two design scenarios assessed in the 2018 EIAR in Table 1.

Table 1. Comparison of the turbine parameters relevant to the estimation of collision mortality using the SOSS offshore CRM (Band 2012) for the Preferred Design and for the two design scenarios assessed in the 2018 EIAR.

Parameter	Preferred Design	Design Scenario A	Design Scenario B
Number of turbines	72	72	40
Number rotors per turbine	3	3	3
Hub height (m)[1]	152.7	116.1	152.6
Rotor radius (m)	118	83.5	125
Height to upper blade tip (m)[1]	270.7	199.6	277.6
Height to lower blade tip (m)[1]	34.7	32.6	27.6
Maximum blade width (m)	5.1	6.0	7.8
Rotor speed (rpm)[2]	7.19	8.72	5.72
Pitch (°)[2]	4.38	10	10
Monthly time operational (%)[2]	94	80	80

[1]Values are given relative to MSL because the CRM is calculated relative to MSL. MSL is taken as 2.9m above LAT for the development area.
[2]Presented as the annual average as calculated from monthly-specific estimates. The monthly and species-specific seasonal period values are given in Appendix A.

It is also the case that the nominal turbine spacing associated with the Preferred Design (i.e. 1,025 m) will decrease compared to the values set out for the two designs scenarios assessed in the 2018 EIAR (i.e. 1,278 m for both designs). However, turbine spacing does not affect collision estimates (as calculated by the SOSS offshore CRM) and is not included as a parameter in this model.

2.2 Methods and approach

To determine the predicted collision mortality associated with the refined turbine parameters, CRM was undertaken exactly as for the for the two design scenarios assessed in the 2018 EIAR with only the turbine parameters changed in line with the details in Table 1 (ICOL 2018a). Thus, the 'Band spreadsheet' version of the SOSS offshore CRM was used (Band 2012), with the model options, avoidance rates, nocturnal activity rates and bird parameters consistent with what was used in the assessment and as detailed in Table 2. The mean monthly bird flight densities for each species were also unaltered from the values used in the 2018 EIAR (compare Appendix A with Annex 11C.1 in ICOL 2018a). Recent advice from Marine Scotland and NatureScot on undertaking CRM continues to advocate the use of the 'Band spreadsheet' version of the SOSS offshore CRM (Marine Scotland 2022, NatureScot 2021).

Table 2. Model options and avoidance rates used in the deterministic CRM for each species, together with species-specific flight behaviour and morphological parameters.

Species	Band model option[1]	Avoidance rate[2]	Nocturnal activity score	Bird length (m)[3]	Wingspan (m)[3]	Flight speed ($m.s^{-1}$)[4]	Flight type
Gannet	2	98.9%	1 (=0%)	0.94	1.73	14.9	Flapping
Kittiwake	2	98.9%	2 (=25%)	0.39	1.08	13.1	Flapping
Herring gull[5]	2 and 3	99.5%	2 (=25%)	0.60	1.44	12.8	Flapping

[1]Details of model options are provided in Band (2012), with the flight height data of Johnston *et al.* (2014a,b) used in each case.
[2]Avoidance rates used for each species are as advised for the relevant model option by SNCBs (2014).
[3]From BTO Birdfacts (https://www.bto.org/about-birds/birdfacts) [Accessed 10/05/2018].
[4]From Pennycuik (1997) for gannet and Alerstam *et al.* (2007) for kittiwake and herring gull.
[5]CRMs for herring gull were undertaken using both options 2 and 3 in the assessment for the revised design of the Inch Cape Offshore Wind Farm but with the assessment based on the option 3 outputs (ICOL 2018b,c).

In addition to the above CRMs, NatureScot also requested that collision estimates for the Preferred Design Scenario should also be calculated using the stochastic version of the CRM (McGregor et al. 2018) and according to the bird input parameters set out in the NatureScot consultation response of 29 July 2022. These are detailed in Table 3 below but noting the 'corrections' that are outlined in the bullet points below. The stochastic CRMs are undertaken for the purpose of providing estimates that are consistent with more recent CRM estimates, as advised by NatureScot (per comms 07/10/22).

In relation to the estimates for the Preferred Design Scenario calculated using the stochastic CRM, it should be noted that:

- The SD values for the avoidance rates for each of the species advised by NatureScot in their consultation response were incorrectly given as 2 x SD, so that the correct SD values as advised in the SNCBs (2014) guidance note were used in the stochastic CRMs.
- The SD for gannet bird length advised by NatureScot in their consultation response (i.e. 0.324) was assumed to be incorrect and was replaced by a value of 0.0325 in the stochastic CRMs.
- To express variability in the monthly density estimates for each of the species on which CRMs were undertaken, the SD values presented in Appendix 11C (Table 11C.2) of the EIA for the Revised Design[2] were used. NatureScot state that their preferred approach to expressing variation in monthly density estimates within the stochastic CRM is to use the option based on calculating bootstrapped estimates from a distribution of mean densities (pers. comm., 07/10/22). This is not possible in the case of the monthly density data for the Inch Cape wind farm because for each survey the counts of birds in flight are only available as the total number of birds recorded, total number of snapshot samples and the mean number of birds per snapshot sample.

[2] *appendix_11c_estimation_of_the_development._reva.pdf (marine.gov.scot)*

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Table 3. Model options and avoidance rates used in the stochastic CRM for each species, together with species-specific flight behaviour and morphological parameters.

Species	**Band model option**	**Avoidance rate**	Nocturnal activity score	Bird length (m)	Wingspan (m)	Flight speed (m.s^{-1})	**Flight type**
Gannet	2	0.989 (±0.001 SD)	1.32 (=8% ±10.0)	0.94 (±0.0325 SD)	1.72	14.9	Gliding
Kittiwake	2	0.989 (±0.001 SD)	2 (=25%) and 3 (=50%)	0.39 (±0.005 SD)	1.08 (±0.04 SD)	13.1 (±0.40 SD)	Flapping
Herring Gull	2	0.995 (±0.0005 SD)	2 (=25%) and 3 (=25%)	0.60	1.44 (±0.03 SD)	12.8 (±1.8 SD)	Flapping

2.3 Collision estimates

The collision estimates calculated for the Preferred Design are lower than the worst-case design on which the consent was based for each of the three species considered (or in the case of the option 2, but not option 3, estimates for herring gull, equivalent to this worst-case scenario) (Table 4 and 5). This is the case irrespective of whether the estimates are considered for the full annual period or (with the exception of the option 2 estimates for herring gull) for the breeding season of each species[3] (noting that the effects apportioned to the key SPA populations of these three species are substantially higher for the breeding than non-breeding season – ICOL 2018c). For herring gull, actual numbers of breeding season collisions are very small with the differences between the Preferred and consented designs for the option 2 estimates being due to fractions of a bird and associated rounding to the nearest whole bird. For all three species, the collision estimates for the Preferred Design are close to the lower of the estimates for the two designs assessed in the 2018 EIAR, representing a reduction of approximately 10 – 15% from the worst-case estimates for gannet and kittiwake.

The collision estimates using the stochastic CRM presented in Table 5 below show the same patterns as described above in terms of the differences between the Preferred and consented designs, with the absolute estimates for each design scenario differing from those presented in Table 4 as a result of the differences in bird input parameters (particularly the nocturnal activity levels) and modelling approaches used.

[3] *As defined by NatureScot in Guidance note - Seasonal definitions for birds in the Scottish Marine Environment.pdf (nature.scot)*

Table 4. Comparison of annual and breeding season deterministic model collision estimates for the Preferred Design and for the two designs assessed in the 2018 EIAR (with the worst-case on which consent based shown in bold). Comparisons are undertaken for the three species for which collision mortality was considered a relevant effect pathway in the assessment for the Project.

Species	Preferred design		2018 EIAR design scenarios			
			A		B	
	Annual	Breeding season	Annual	Breeding season	Annual	Breeding season
Gannet	105	98	105	96	**117**	**108**
Kittiwake	61	36	64	36	**72**	**40**
Herring gull (option 2)	4	**2**	**4**	1	3	1
Herring gull (option 3)	2	1	**3**	**1**	2	1

Table 5. Comparison of annual and breeding season stochastic model collision estimates for the Preferred Design and for the two designs assessed in the 2018 EIAR (with the worst-case on which consent based shown in bold). Comparisons are undertaken for the three species for which collision mortality was considered a relevant effect pathway in the assessment for the Project.

Species	Nocturnal Activity	Preferred design		2018 EIAR design scenarios			
				A		B	
		Annual	Breeding season	Annual	Breeding season	Annual	Breeding season
Gannet	8%	121 (16 – 340)	113 (14 – 318)	124 (17 – 341)	114 (15 – 317)	132 (22 – 333)	121 (19 – 309)
Kittiwake	25%	70 (11 – 161)	39 (4 – 93)	76 (12 – 178)	40 (4 – 97)	85 (14 – 187)	46 (4 – 102)
	50%	80 (13 – 183)	43 (4 – 102)	86 (13 – 197)	43 (4 – 101)	97 (18 – 213)	49 (6 – 111)
Herring gull (option 2)	25%	5 (1 – 13)	3 (0 -8)	5 (1 – 13)	2 (0 – 7)	5 (1 – 11)	2 (0 – 6)
	50%	6 (1 – 15)	3 (0 – 8)	7 (2 – 15)	3 (0 – 7)	6 (2 – 12)	2 (0 – 6)
Herring gull (option 3)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

3 Conclusions

The turbine parameters for the Inch Cape Offshore Wind Farm have been refined in relation to the detailed specification of the turbine model to be deployed by the Project. The collision estimates associated with the Preferred Design are lower than the worst-case for collision mortality assessed in the 2018 EIAR for each of the three seabird species for which collision mortality was considered a relevant effect pathway in the assessment for the Project. Therefore, for the Preferred Design the collision risk to birds is no greater than the consented worst-case parameters.

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Appendix A: Excel worksheets showing the input parameters used for the collision risk models undertaken for the refined turbine design

Gannet

COLLISION RISK ASSESSMENT	used in overall collision risk sheet	used in available hours sheet
Sheet 1 - Input data	used in migrant collision risk sheet	used in large array correction sheet
	used in single transit collision risk sheet or extended model	not used in calculation but stated for reference

	Units	**Value**	**Data sources**											
Bird data														
Species name		**Gannet**												
Bird length	m	0.94												
Wingspan	m	1.73												
Flight speed	m/sec	14.9												
Nocturnal activity factor (1-5)		1												
Flight type, flapping or gliding		flapping												
			Data sources											
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km		0.1505	0.556	0.5785	2.1745	4.328	3.7765	3.6285	5.134	1.512	1.0355	0.193	0
Proportion at rotor height	%	1.1%												
Proportion of flights upwind	%	50.0%												
			Data sources											
Birds on migration data														
Migration passages	birds		0	0	0	0	0	0	0	0	2000	4000	0	0
Width of migration corridor	km													
Proportion at rotor height	%													
Proportion of flights upwind	%	50.0%												
	Units	**Value**	**Data sources**											
Windfarm data														
Name of windfarm site		**IC - Large**												
Latitude	degrees	56.49												
Number of turbines		72												
Width of windfarm	km	6.774												
Tidal offset	m													
	Units	**Value**	**Data sources**											
Turbine data														
Turbine model														
No of blades		3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rotation speed	rpm	7.01	7.51	7.51	7.25	7.03	6.90	6.84	6.86	7.01	7.19	7.27	7.39	7.56
Rotor radius	m	118												
Hub height	m	152.7	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly proportion of time operational	%		94.49%	95.56%	93.99%	93.06%	90.03%	90.08%	90.49%	92.91%	93.31%	95.52%	96.90%	96.42%
Max blade width	m	5.100												
Pitch	degrees	3.57	6.20	5.81	4.84	3.26	3.62	3.51	2.79	3.17	3.84	4.32	5.01	6.16

Murray Grant:
Not relevant: No option 1 models run

RPM		
Breeding	Aut Pass	Spr Pass
7.01	7.33	7.46

Pitch		
Breeding	Aut Pass	Spr Pass
3.57	4.66	5.75

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Kittiwake

COLLISION RISK ASSESSMENT		used in overall collision risk sheet	used in available hours sheet
Sheet 1 - Input data		used in migrant collision risk sheet	used in large array correction sheet
		used in single transit collision risk sheet or extended model	not used in calculation but stated for reference

	Units	Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Units	**Value**		**Data sources**										
Bird data														
Species name		**Ki**												
Bird length	m	0.39												
Wingspan	m	1.08												
Flight speed	m/sec	13.1												
Nocturnal activity factor (1-5)		2												
Flight type, flapping or gliding		flapping												
				Data sources										
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km		0.2	0.048	0.569	0.612	0.839	1.998	3.682	0.487	2.495	1.591	0.628	0.347
Proportion at rotor height	%	0.80%												
Proportion of flights upwind	%	50.0%												
				Data sources										
Birds on migration data														
Migration passages	birds		0	0	0	4000	2000	0	0	0	2000	4000	0	0
Width of migration corridor	km	8												
Proportion at rotor height	%	75%												
Proportion of flights upwind	%	50.0%												
	Units	**Value**		**Data sources**										
Windfarm data														
Name of windfarm site		**Inch Cape**												
Latitude	degrees	56.49												
Number of turbines		72												
Width of windfarm	km	6.774												
Tidal offset	m	0												
	Units	**Value**		**Data sources**										
Turbine data														
Turbine model		**Large turbine**												
No of blades		3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rotation speed	rpm	6.93	7.51	7.51	7.25	7.03	6.90	6.84	6.86	7.01	7.19	7.27	7.39	7.56
Rotor radius	m	118												
Hub height	m	152.7	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly proportion of time operational	%		94.49%	95.56%	93.99%	93.06%	90.03%	90.08%	90.49%	92.91%	93.31%	95.52%	96.90%	96.42%
Max blade width	m	5.100												
Pitch	degrees	3.27	6.20	5.81	4.84	3.26	3.62	3.51	2.79	3.17	3.84	4.32	5.01	6.16

murray.grant:
Not relevant: No option 1 models run

RPM		
Breeding	Aut Pass	Spr Pass
6.93	7.28	7.32

Pitch		
Breeding	Aut Pass	Spr Pass
3.27	4.50	5.03

Herring gull

COLLISION RISK ASSESSMENT		used in overall collision risk sheet		used in available hours sheet
Sheet 1 - Input data		used in migrant collision risk sheet		used in large array correction sheet
		used in single transit collision risk sheet or extended model		not used in calculation but stated for reference

	Units	**Value**	**Data sources**
Bird data			
Species name		**Herring gull**	
Bird length	m	0.60	
Wingspan	m	1.44	
Flight speed	m/sec	12.8	
Nocturnal activity factor (1-5)		2	
Flight type, flapping or gliding		flapping	

Murray Grant:
Not relevant: No option 1 models run

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Data sources											
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km		0.1001021	0.0484165	0	0	0.0244738	0.1218324	0	0.0242601	0	0.0252525	0.0483092	0.1472915
Proportion at rotor height	%	5.0%												
Proportion of flights upwind	%	50.0%												
			Data sources											
Birds on migration data														
Migration passages	birds		0	0	0	0	0	0	0	0	2000	4000	0	0
Width of migration corridor	km													
Proportion at rotor height	%													
Proportion of flights upwind	%	50.0%												

	Units	**Value**	**Data sources**
Windfarm data			
Name of windfarm site		**IC - Large**	
Latitude	degrees	56.49	
Number of turbines		72	
Width of windfarm	km	6.774	
Tidal offset	m		

	Units	**Value**	**Data sources**											
Turbine data														
Turbine model														
No of blades		3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rotation speed	rpm	6.93	7.51	7.51	7.25	7.03	6.90	6.84	6.86	7.01	7.19	7.27	7.39	7.56
Rotor radius	m	118												
Hub height	m	152.7	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly proportion of time operational	%		94.49%	95.56%	93.99%	93.06%	90.03%	90.08%	90.49%	92.91%	93.31%	95.52%	96.90%	96.42%
Max blade width	m	5.100												
Pitch	degrees	3.27	6.20	5.81	4.84	3.26	3.62	3.51	2.79	3.17	3.84	4.32	5.01	6.16

RPM	
Breeding	Non-breed
6.93	7.42

Pitch	
Breeding	Non-breed
3.27	5.39