Appendix 8.2 Collision Risk Modelling Report: September 2020 – March 2022

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Introduction

Overview

ITPEnergised was appointed by the Applicant to undertake collision risk modelling using data taken from their ornithological surveys (as commissioned by the Applicant) in support of a proposed wind farm development at Nisthill in Orkney. In order to assess the likely impacts of the Proposed Development on the local bird population analysis for the potential for collision risk has been undertaken on certain key species. The analysis has been undertaken using the design freeze layout and development boundary, as displayed in **Appendix 8.1: Figure 1**, and a provisional turbine specification as outlined in Table 1.

Table 1 Candidate Turbine – Siemens Gamesta SG-155

Parameter	Value
Viewshed Area (Within site)	120.33Ha (VP1 – 95.4: VP2 – 79.6)
Overlap	54.9 Ha
No turbines	4
Rotor Diameter	155 m
Hub Height	102.5 m
Max rotor depth	4.2
Max chord	4.5
Pitch	6
Rotation period	5.17 secs
Turbine 'lifetime'	25 years

Collision Risk Modelling

Band *et al.* (2007) described a method by which field data on bird flight activity can be gathered and used to quantify crudely the likelihood of collisions with turbines: the 'Band' Collision Risk Model (CRM). This method is more suitable for some species than others (Madders & Whitfield 2006). For example, fast moving raptors like merlin and most songbirds are difficult to detect beyond a distance of a few hundred metres and nocturnal species are difficult to detect at all. As a result, it is rarely possible to generate reliable estimates of flight activity for these species and collision risk is best determined qualitatively.

The Band CRM involves two methods to predict estimated collision fatalities, depending on the pattern of flight of the species involved: 'predictable' and 'unpredictable' flight methods. The predictable flight method (PFM) is appropriate when birds tend to move through an area in a relatively consistent direction, such as during migration or when moving between localised feeding and roosting sites. The unpredictable flight method (UFM) is more appropriate when flights are not in any particular direction and assumes that they are random.

Data Collection and Species Selection

Surveys were undertaken from two VP's between September 2020 and March 2022 with 115 hours at VP1 and 108 hours at VP2, this time period constitutes one breeding season and two non-breeding seasons.

A total of 8 target species were recorded from the VP surveys and are summarised below in Table 2. All the survey flights were recorded onto ArcGIS and the data entered into an excel spreadsheet and further analysed in order to select all the flights which were recorded at potential collision height ('PCH') within the viewshed the VP. PCH is the height between the low and high points of the rotor sweep of the turbine blades, namely between 25 and 180m, all flights and the total number of individuals recorded at PCH within the site boundary from each viewshed of the VP are displayed below in Table 2.

Records at specific height bands were only recorded within the site boundary meaning the CRZ is a volume which covers the site at PCH.

A total of six species with less than 500 seconds of the total number of 'at-risk' flight seconds over the 18-month period are not considered to be significantly affected by collision with the proposed turbines (Table 2).

Of the two remaining species, one was considered to use the site in a random way (great skua) and one was considered to use the site in a predicable way and such assessed using the linear model (red-throated diver).

Table 2 Target Species Recorded September 2020 – August 2021

Species	Flights	Total no birds in flights	Duration	In site	In site @ PCH	Total No. Of At Risk Flight Sec.	Collison Risk Modelling carried Out
Arctic skua	3	3	192	148	103	103	NO
Great skua	29	33	1495	1288	1039	1175 (247 in 09/2020 and **928** in 2021 BS)	**YES**
Hen harrier	50	50	6154	4980	32	**32**	NO
Peregrine	4	4	1023	460	416	416	NO
Red throated diver	9	10	1534	983	911	**942**	**YES**

Species	Flights	Total no birds in flights	Duration	In site	In site @ PCH	Total No. Of At Risk Flight Sec.	Collison Risk Modelling carried Out
Short-eared owl	13	13	1424	1353	261	**261**	NO
White-fronted goose	1	13	323	0	0	0	NO
Whooper swan	1	3	112	52	52	52	NO

Methods

Collision risk has been calculated based as an average figure for the area covered by the site **(Appendix 8.1: Figure 1)** and based on a layout of four wind turbines of the specifications outlined in Table 1. It should be noted that the resultant figures provide an average for the site as a whole and does not allow for the potential of configuring a layout in order to minimise the impacts of the proposed turbines.

The predicted level of collision mortality is based on results obtained from a collision risk model which uses flight activity data, species' parameters and turbine specifications to obtain a collision rate as outlined in SNH guidance (SNH, 2000). The collision risk modelling follows two models, firstly the random flight model which is used for foraging or displaying birds and secondly the regular model used for commuting or migrating birds.

The guidance also outlines bird biometrics including bird length and wingspan as well as flight speeds and recommended avoidance rates which are inputs into the model and the figures for the species carried forward for collision risk in this assessment are outlined in Table 3 below.

Data on bird flight speed and biometrics were taken from Alerstam *et al.* (2007) and the published avoidance rates was used (SNH 2017).

Detailed data on survey dates, times and weather can be found in **Appendix 8.1: Annex A: Table A1.** For reference, all great skua flights at PCH are presented in Figure 1 and red-throated diver in Figure 2.

Table 3 Target Species Bird Biometrics

Species Name	Bird length (m)	Wingspan (m)	Flight speed (m/s)	Avoidance Rate (%)
Great skua	0.56	1.36	14.9	99.5
Red-throated diver	0.61	1.11	17.0	99.5

Results

Two species were taken forward for collision risk modelling, one, great skua (random model) and the other red-throated diver (linear model).

Full working examples for each are outlined in below and summary of all the results for clarity are shown in Table 4 below.

Table 4 Collision Risk Modelling Results

Species Name	Year 1 Collision Rate	Year 2 Collision Rate	Mean - Annual Collison rate	Collisions - Scheme Lifetime (using notional 25 years for comparison)	Years per collision
Great skua	0.04	n/a	n/a	0.96	25.9
Red-throated diver	0.08	n/a	n/a	1.88	13.3

CRM Calculations

Stage 1: Number of Birds Flying Through the Rotors per Year

Calculate the number of hours of observation expressed in hectare hours.

Hectare hours = viewshed@PCH (in site) * survey duration (hrs)

vp1 =95.4Ha

vp2 =79.6Ha

Overlap = 54.9 Ha

Table 5 – Hectare Hours Calculation – April to September 2021 for Great Skua and red-throated diver only

Date	VP	Start Time	End Time	Hours	Ha hours
07-Apr-21	1	14:00	17:00	3	286.2
10-Apr-21	2	07:00	10:00	3	238.8
19-Apr-21	1	04:30	07:30	3	286.2
19-Apr-21	2	13:00	16:00	3	238.8
04-May-21	2	15:00	18:00	3	238.8
04-May-21	1	19:00	22:00	3	286.2
25-May-21	2	06:00	09:00	3	238.8
25-May-21	1	13:00	16:00	3	286.2
07-Jun-21	1	03:30	06:30	3	286.2
08-Jun-21	2	19:00	22:00	3	238.8

Date	VP	Start Time	End Time	Hours	Ha hours
15-Jun-21	2	07:00	10:00	3	238.8
15-Jun-21	1	11:00	14:00	3	286.2
12-Jul-21	2	09:00	12:00	3	238.8
12-Jul-21	1	14:00	17:00	3	286.2
20-Jul-21	2	07:00	10:00	3	238.8
20-Jul-21	1	18:00	21:00	3	286.2
03-Aug-21	1	05:00	08:00	3	286.2
03-Aug-21	2	12:00	15:00	3	238.8
24-Aug-21	2	06:00	09:00	3	238.8
24-Aug-21	1	15:00	18:00	3	286.2
14-Sep-21	2	08:00	11:00	3	238.8
14-Sep-21	1	13:00	16:00	3	286.2
28-Sep-21	1	07:00	10:00	3	286.2
28-Sep-21	2	16:00	19:00	3	238.8
Total					6300

Calculate hectare seconds = hectare hours * 3600

= 6300 * 3600

= 22,680,000

Great skua were recorded in September 2020 but as this period was not part of a full continuous breeding season, calculations are based on the full 2021 breeding season recordings i.e. between April and September 2021 when great skua, which spend the winter out on the open ocean, are present in the UK.

A total of 24 great skua flights were recorded between April and September 2021 including a combined total of 26 great skua. Of the 24 flights, 18 were recorded 'at-risk', i.e at collision height over the Site, and therefore are included in the collision risk modelling (See Figure 1).

Calculate the bird observation in all areas and percentage of time birds active in overall observed area.

Table 5 All Great Skua flights April – September 2021

Date	Number	VP	<PCH	PCH	>PCH	At-risk seconds
25-May-21	1	2	0	25	0	25
25-May-21	1	2	0	48	0	48
25-May-21	1	1	18	0	0	0
25-May-21	1	1	7	35	0	35
25-May-21	1	1	5	25	0	25
25-May-21	1	1	10	0	0	0
07-Jun-21	1	1	0	40	0	40
07-Jun-21	1	1	0	55	0	55
07-Jun-21	1	1	5	26	0	26
07-Jun-21	1	1	1	7	0	7
07-Jun-21	1	1	0	55	0	55
07-Jun-21	1	1	14	0	0	0
15-Jun-21	1	1	9	43	0	43
15-Jun-21	1	1	0	105	0	105
20-Jul-21	1	2	0	42	0	42
20-Jul-21	1	1	0	40	0	40
20-Jul-21	1	1	0	48	0	48
03-Aug-21	3	1	0	48	0	144
24-Aug-21	1	2	51	0	0	0
24-Aug-21	1	2	53	0	0	0
24-Aug-21	1	1	8	41	0	41
24-Aug-21	1	1	0	68	0	68
14-Sep-21	1	2	0	41	0	41
28-Sep-21	1	1	0	40	0	40
Total						**928**

Bird Activity = Total bird flight time / hectare seconds

= 928 / 22,680,000

BA = 0.0000409171

Overall Area covered by VPs = 120.1Ha

Proportion of time potentially active = Area x BA = 0.004914145

Hours potentially active = 2995

Seconds potentially active (2995*3600) = 10780722

Number of seconds of bird occur in airspace = sec potentially active * bird activity

= 10780722* 0.004914145

= 52978.02702

Calculate flight risk volume (Vw)

Vw = 1201000 (m2) * rotor diameter (m)

Vw = 186155000

Calculate combined rotor swept volume

Vr = number of turbines (n) * pi * r2 * (max chord + bird length)

Vr = 4 * (pi * 6006.25) * (4.5 + 0.56)

Vr = 190105.02

Calculate bird occurrence in swept volume

Occurrence = no of sec of bird occ * combined rotor swept volume/flight risk volume

= 52978.02702* (Vr/Vw)

= 52978.02702* (190105.02/ 186155000)

= 54.10216694

Calculate bird transits time and potential number of transits per year

Transit time = (max chord + bird length) / bird speed (m2)

= (4.5 + 0.56) / 14.9

= 0.339597315

No. of transits = occurrence / transit time

= 54.10216694/ 0.339597315

= 159.312705

Stage 2 Collision Risk of Bird Passing through Rotor (Assuming No Avoidance)

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Only enter input parameters in blue											W Band	12/05/2022
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3					Upwind:			Downwind:			
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution	
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r	
BirdLength	0.56	m	0.025	0.575	6.33	22.03	0.86	0.00107	21.49	0.84	0.00105	
Wingspan	1.36	m	0.075	0.575	2.11	7.52	0.29	0.00220	6.98	0.27	0.00204	
F: Flapping (0) or gliding (+1)	1		0.125	0.702	1.27	5.40	0.21	0.00263	4.74	0.18	0.00231	
			0.175	0.860	0.90	4.67	0.18	0.00318	3.86	0.15	0.00263	
Bird speed	14.9	m/sec	0.225	0.994	0.70	4.21	0.16	0.00368	3.27	0.13	0.00287	
RotorDiam	155	m	0.275	0.947	0.58	3.38	0.13	0.00362	2.49	0.10	0.00267	
RotationPeriod	5.17	sec	0.325	0.899	0.49	2.80	0.11	0.00355	1.96	0.08	0.00248	
			0.375	0.851	0.42	2.37	0.09	0.00347	1.57	0.06	0.00230	
			0.425	0.804	0.37	2.28	0.09	0.00377	1.52	0.06	0.00252	
			0.475	0.756	0.33	2.04	0.08	0.00378	1.33	0.05	0.00246	
Bird aspect ratioo: β	0.41		0.525	0.708	0.30	1.85	0.07	0.00378	1.18	0.05	0.00242	
			0.575	0.660	0.28	1.68	0.07	0.00377	1.06	0.04	0.00238	
			0.625	0.613	0.25	1.54	0.06	0.00375	0.97	0.04	0.00235	
			0.675	0.565	0.23	1.42	0.06	0.00373	0.89	0.03	0.00233	
			0.725	0.517	0.22	1.31	0.05	0.00369	0.82	0.03	0.00232	
			0.775	0.470	0.20	1.21	0.05	0.00365	0.77	0.03	0.00232	
			0.825	0.422	0.19	1.12	0.04	0.00360	0.72	0.03	0.00232	
			0.875	0.374	0.18	1.04	0.04	0.00354	0.69	0.03	0.00234	
			0.925	0.327	0.17	0.96	0.04	0.00347	0.66	0.03	0.00236	
			0.975	0.279	0.16	0.89	0.03	0.00339	0.63	0.02	0.00240	
				Overall p(collision) =			**Upwind**	**6.7%**		**Downwind**	**4.7%**	
								Average	**5.7%**			

Annual Collision Rate assuming no avoidance

= No. of transits * Ave probability of collision

= (159.312705/ 100) x 5.7

= 9.080824187

Corrected for avoidance

= 9.080824187– ((9.080824187/ 100) *99.5)

= 0.045404121

Corrected for downtime

= 0.045404121* 0.85

= 0.038593503

= **0.04** collisions per year (25.9 years per collision)

Over notional lifetime of the scheme

0.038593503 * 25 = **0.96**

Red Throated Diver – Linear

A total of 9 red-throated diver registrations were recorded totalling 10 individuals from VP surveys, of which all flights were recorded through the risk window, crossing the window a total of 19 times. The flights included in the linear model and are shown in Figure 2.

Stage 1: Number of Birds Flying Through the Rotors per Year

Calculation of the 'risk window'; Cross section area equal to the width of the wind farm across the general direction of flight multiplied by the height of turbine to rotor tip. Width of wind farm was determined using GIS.

Width of transit flight (Ws)	= 1590m
Turbine height (th)	= 180m
Risk Window (W)	= Ws * th
	= 1590m * 180m
	= 286,200 m^2

Calculate the area occupied by rotor blades (A)

Number of turbine (n)	= 4
Rotor radius (r)	= 77.5
A	= n * π *r2
A	= 4 * 3.14* 6,006.25
A	= 75,438.5 m^2

Express the area occupied by rotor blades (A) as a proportion of the risk window (W)

Proportion (P)	= A/W
	= 75,438.5 / 286,200
	= 0.2636

Calculate the number of bird potentially flying through the site per year (N)

N	= number of red-throated diver transits at PCH per year
	= hourly rate of transit * available hours for flight

Hours surveyed between April 2021 and September 2021

	= hectare hours (correcting for overlap) / hectares visible in Study area
	= 6300 / 120.3
	= 52.369
No. of divers observed in same period	= 19 transits in 11 flights
Hourly rate of transit	= 19 / 52.369
	= 0.3628

Hours available for flight are equal to number of daylight hours in the same period plus 25% of night hours.

Hours available = 2994.645

= 2994.645* 1.25

= 3362.75

N = hours available * rate of transit = 3362.75 * 0.32462

= 1200.04

Calculate the number of birds flights (Nf) to fly through the rotor (P)

Nf = N * P

= 1200.04 * 0.2636

= 316.3

Stage 2: Collision Risk of Bird Passing Through Rotor (Assuming No Avoidance)

Stage 2 was calculated using the prepopulated spreadsheet provided by Scottish Natural Heritage (SNH) for calculating the probability of collision for any species (available at: http://www.snh.gov.uk/docs/C234672.xls)

Variable highlighted in blue where entered into the spreadsheet. Bird biometrics where determined using the British Trust for Ornithology website (http://www.bto.org/about-birds/birdfacts) bird flight speeds were assumed using the flight speeds characterised by Bruderer and Boldt (2001).

CALCULATION OF COLLISION RISK FOR BIRD PASSING THROUGH ROTOR AREA												
Only enter input parameters in blue											W Band	14/06/2022
K: [1D or [3D] (0 or 1)	1		**Calculation of alpha and p(collision) as a function of radius**									
NoBlades	3					Upwind:			Downwind:			
MaxChord	4.5	m	r/R	c/C	α	collide		contribution	collide		contribution
Pitch (degrees)	6		radius	chord	alpha	length	p(collision)	from radius r	length	p(collision)	from radius r
BirdLength	0.61	m	0.025	0.575	7.22	23.95	0.82	0.00102	23.41	0.80	0.00100
Wingspan	1.11	m	0.075	0.575	2.41	8.16	0.28	0.00209	7.62	0.26	0.00195
F: Flapping (0) or gliding (+1)	1		0.125	0.702	1.44	5.88	0.20	0.00251	5.22	0.18	0.00223
			0.175	0.860	1.03	5.10	0.17	0.00305	4.29	0.15	0.00257
Bird speed	17	m/sec	0.225	0.994	0.80	4.60	0.16	0.00354	3.67	0.13	0.00282
RotorDiam	155	m	0.275	0.947	0.66	3.69	0.13	0.00346	2.80	0.10	0.00263
RotationPeriod	5.17	sec	0.325	0.899	0.56	3.05	0.10	0.00338	2.20	0.08	0.00244
			0.375	0.851	0.48	2.84	0.10	0.00364	2.04	0.07	0.00262
			0.425	0.804	0.42	2.52	0.09	0.00365	1.76	0.06	0.00255
			0.475	0.756	0.38	2.25	0.08	0.00365	1.54	0.05	0.00250
Bird aspect ratioo: β	0.55		0.525	0.708	0.34	2.03	0.07	0.00364	1.37	0.05	0.00245
			0.575	0.660	0.31	1.85	0.06	0.00363	1.23	0.04	0.00241
			0.625	0.613	0.29	1.69	0.06	0.00361	1.11	0.04	0.00238
			0.675	0.565	0.27	1.55	0.05	0.00358	1.02	0.03	0.00235
			0.725	0.517	0.25	1.43	0.05	0.00354	0.94	0.03	0.00233
			0.775	0.470	0.23	1.32	0.05	0.00349	0.88	0.03	0.00232
			0.825	0.422	0.22	1.22	0.04	0.00344	0.82	0.03	0.00232
			0.875	0.374	0.21	1.13	0.04	0.00338	0.78	0.03	0.00233
			0.925	0.327	0.20	1.05	0.04	0.00331	0.74	0.03	0.00234
			0.975	0.279	0.19	0.97	0.03	0.00324	0.71	0.02	0.00236
				Overall p(collision) =			**Upwind**	**6.5%**		**Downwind**	**4.7%**
								Average	**5.6%**		

Calculation of collision rate

Collision Rate = Nf * average probability of collision

= 316.31 * 0.056

= 17.571

Calculation of collision rate applying 99.5% avoidance rate (Figure for 99.8% avoidance rate in brackets)

= 17.71 * 0.005 (*0.002)

= 0.089 (0.035)

1. Correct collision rate for down time (assuming wind farm operates at 85%)

= (0.063 / 100) * 85

Annual Collision Risk = **0.075** (0.03)

2. Calculate the number of year per collision

= 1 / 0.048

Year per collision = **13.3** (33.3)

3. Calculate the number of collisions per lifetime of the scheme (given a 25 value for comparison)

= 0.048 * 25

Collision / 25 years = **1.88** (0.75)

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