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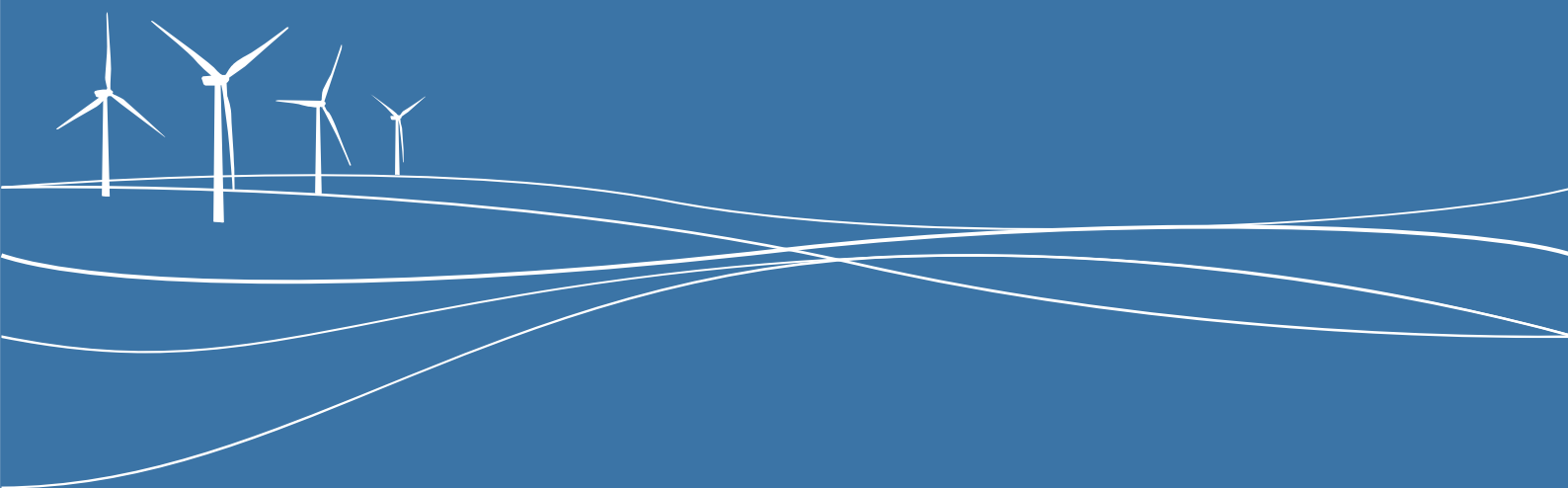
East Anglia THREE

Appendix 13.3

Collision Risk Modelling Methodology and Predictions

Environmental Statement
Volume 3
Document Reference - 6.3.13 (3)

Author – APEM Ltd
East Anglia THREE Limited
Date – November 2015
Revision History – Revision A



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East Anglia THREE Windfarm Environmental Statement

Appendix 13.3

Collision Risk Modelling Methodology and Predictions

September 2015

Report completed by APEM Ltd, on behalf of East Anglia Offshore Wind Ltd.

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This report should be cited as:

APEM (2015). *East Anglia THREE Windfarm Collision Risk Modelling Methodology and Predictions.* APEM Scientific Report 413914-CRM-01/C.

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Table of Contents

1 INTRODUCTION

1. The main potential risks to birds from offshore windfarms are collision; disturbance / displacement; barrier to movement; and habitat change / loss. There is an increase in potential risk of collision with wind turbines if they are located in areas in which there is a high level of flight activity. That high level of flight activity can be associated with locations where food supplies are concentrated or with areas where there is a high turnover of individuals (possibly commuting daily between nesting and feeding areas or passing through the area on seasonal migrations). That collision risk can be quantified using collision risk modelling (CRM).

2. In line with best practice, CRM has been carried out for the proposed East Anglia THREE project (the proposed project) to provide information for six seabird species, using the most recent version of the Band collision risk model (Band 2012) that has been designed specifically for application to offshore windfarm developments.

3. For the seabirds selected, the CRM is based upon the mean density of flying birds per month derived from the aerial surveys carried out between 2011 and 2013.

4. Three Band CRM modelling options have been used in this assessment:

   - Basic Band CRM Option 1 with site-specific percentage at potential collision height (PCH)
   - Basic Band CRM Option 2
   - Extended Band CRM Option 3

5. Band CRM Options 1, 2 and 3 are explained in section 3 below. Within this report the outputs from all three Band CRM Options have been presented with a range of avoidance rates shown in Table 1. The numbers of birds that are predicted to collide with the wind turbines per year from each of the Band CRM Options are presented in section 3, Table 5.

2 METHODOLOGY

6. The CRM methodology outlined by Band (2012) has been followed for the modelling and assessment of impacts predicted from the proposed project. The options that were applied in the CRM for the proposed project were:

- Basic Band CRM Option 1 with site-specific flight heights
  CRM was carried out using the Basic Band model that applies a uniform distribution of bird flights between the lowest and the highest levels of the rotors. The percentage of bird flights passing between the lowest and the highest levels of the rotors (i.e. birds at potential collision height [PCH]) is determined from the observations of bird flight heights made during the site specific surveys (for the proposed project this was 24 months of aerial survey data). Site-specific PCH was calculated using flight height data from birds in flight in the East Anglia THREE site.

- Basic Band CRM Option 2 with generic flight heights
  CRM was carried out using the Basic Band model that applies a uniform distribution of bird flights between the lowest and the highest levels of the rotors. The proportion of birds flying between the lowest and the highest levels of the rotors (i.e. at PCH) was determined from the results of the SOSS-02 project (Cook et al. 2012) that analysed the flight height measurements taken from boat surveys conducted around the UK. The project was updated following Johnston et al. (2014), and the revised published spreadsheet (filename: "Final_Report_SOSS02_FlightHeights2014") was used to determine the 'generic' percentage of flights at PCH for each species based on the proposed project's wind turbine parameters.

- Extended Band CRM Option 3
  CRM was carried out using the Extended Band model that accounts for the skewed vertical distribution of bird flight heights between the lowest and the highest levels of the rotors. Most seabird species are observed flying more frequently at the lower level of the rotor swept height (i.e. closer to the sea surface) than at heights equivalent to the rotor hub height or at the upper levels of the rotor and the probability of being struck by the moving rotor varies with vertical position. Extended Band Option 3 uses the data spreadsheet ("…FlightHeights2014") that accompanies the SOSS-02 report that is the result of a statistical analysis of a large number of boat surveys across multiple study sites. This data is fed into the Band model in order to allow for the flight distribution to be calculated based upon the windfarm parameters of the proposed project.

7. The parameters used in the Band CRM are presented in Section 3.1 below. Table 1 relates the Band Options to the species specific avoidance rates that were applied in the modelling. The avoidance rates that have been selected for use in the CRM follow the guidance from Cook et al. (2014) and additional advice received from MacArthur Green in relation to the Statutory Nature Conservation Bodies (SNCBs) review of avoidance rates to be applied in the Band models (JNCC et al. 2014 in response to Cook et al. 2014).

Table 1. Collision risk models with associated avoidance rates for the East Anglia THREE windfarm

Species	Band Option 1 - Basic Model	Band Option 2 - Basic Model	Band Option 3 - Extended Model
	Site-specific PCH	Generic PCH (Cook et al. 2012)	"…FlightHeights2014" distribution data (Johnston et al. 2014)
Fulmar	0.980, 0.990	0.980, 0.990	0.900, 0.950, 0.980, 0.990
Gannet	0.980, 0.989	0.980, 0.989	0.900, 0.950, 0.980, 0.990
Kittiwake	0.980, 0.989, 0.992	0.980, 0.989, 0.992	0.900, 0.950, 0.980, 0.990
LBB gull	0.980, 0.990, 0.995	0.980, 0.990, 0.995	0.980, 0.989
Herring gull	0.980, 0.990, 0.995	0.980, 0.990, 0.995	0.980, 0.990
GBB gull	0.980, 0.990, 0.995	0.980, 0.990, 0.995	0.980, 0.989

3 COLLISION RISK MODELLING METHODOLOGY

3.1 Collision risk modelling input parameters

8. Table 2 presents the CRM species input parameters for the selected seabirds. Species biometrics were obtained from Robinson (2005) and the nocturnal activity rate was based on a 1 to 5 scoring index for each species in Garthe and Hüppop (2004) or King et al. (2009), with the spreadsheet converting these factors into daytime activity as follows; 1 = 0%, 2 = 25%, 3 = 50%, 4 = 75%, 5 = 100%. Predicted mortality estimates based on a reduction of the nocturnal activity factor by one for each species are presented in Appendix C. The number of available daylight hours is calculated within the CRM spreadsheet (Band 2012) based on the latitude of the windfarm development.

9. The proportions of birds in flight at potential collision height derived from the East Anglia THREE aerial surveys are presented in Appendix B.

Table 2. Species biometrics used in the collision risk modelling of the East Anglia THREE windfarm

Species	Body Length (m)	Wingspan (m)	Flight Speed (ms^{-1})	Nocturnal Activity Factor (1 to 5) [5]	Flight type
Fulmar	0.48 [1]	1.07 [1]	13.0 [2]	4 [4]	Gliding
Gannet	0.94 [1]	1.72 [1]	14.9 [2]	2 [4]	Gliding
Kittiwake	0.39 [1]	1.08 [1]	13.1 [2]	3 [4]	Flapping
LBB gull	0.58 [1]	1.42 [1]	13.1 [3]	3 [4]	Flapping
Herring gull	0.60 [1]	1.44 [1]	12.8 [3]	3 [4]	Flapping
GBB gull	0.71 [1]	1.58 [1]	13.7 [3]	3 [4]	Flapping

[1] Robinson (2005)
[2] Pennycuick (1997)
[3] Alerstam (2007)
[4] Garthe & Hüppop (2004)
[5] The CRM spreadsheet converts this factor from 1 to 5 into 0% / 25% / 50% / 75% / 100% daytime activity respectively.

10. The determination of the rotor strike probability for each species, that is part of the overall CRM process, is calculated in the CRM spreadsheet (Band 2012) based on each species flying in a straight line along the longest length of the windfarm. It incorporates the calculation of rotor strike probability for both upwind and downwind flights and the associated change in mortality risks.

11. Input parameters for the wind turbine specifications used within the CRM are shown in Table 4. East Anglia THREE Limited (EATL) provided the data on theoretical

maximum operational times for the proposed East Anglia THREE project's wind turbines (Table 3), which have been incorporated into the CRM. These times represent a theoretical maximum or WCS, as they do not account for any downtime that is required for wind turbines during unplanned servicing or maintenance.

Table 3. Theoretical operational time of East Anglia THREE windfarm turbines

Month	Operational Time (%)
January	95.23
February	93.65
March	92.30
April	91.04
May	91.78
June	88.86
July	90.00
August	89.60
September	92.20
October	94.29
November	95.40
December	95.03

Table 4. Wind turbine specification for the East Anglia THREE windfarm (22-176m)

Item	Value	Parameter assumptions
Turbine Model	7 MW turbine	Worst case assumed to be maximum number of smaller turbines.
Number of turbines	172	Provided by EAOW.
No. of blades	3	-
Rotation speed (rpm)	11	Based on upper range of Siemens turbine provided for EAONE
Rotor radius (m)	77	Based on dimensions of Siemens turbine provided for EAONE.
Hub height (m)	99.2034	Measured against mean sea level. Based on dimensions of Siemens turbine provided for EAONE.
Max. blade width (m)	5	Based on dimensions of Siemens turbine provided for EAONE.
Pitch (degrees)	15	Mid point between 0 and 30.
Tidal offset (m)	0	No tidal offset due to all parameters being measured against mean sea level.
Width of windfarm (km)	33.25	Top right corner to bottom left corner of: BDFP_EA3_SiBdry_v06_140204rs
Latitude (degrees)	52.67	Updated based on new site area: BDFP_EA3_SiBdry_v06_140204rs

4 SUMMARY OF COLLISION RISK MODELLING

12. To estimate the mortality rates for the species that have been modelled through the CRM the mean abundance and associated bird densities have been calculated per month based on the 2011 to 2013 aerial survey data. These estimates have been used to calculate the predicted annual mortality rates for a range of avoidance rates and are presented in Table 5 for the key seabirds. The predicted mortality associated with the variance of the recommended avoidance rates are presented in Appendix D.

Table 5. Summary of annual mortality rates for six key seabirds for Band Option 1-3 and associated avoidance rates

Avoidance Rate	Band CRM Option[1]	Fulmar	Gannet	Kittiwake	LBB gull	Herring gull	GBB gull
0.900	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	5	238	445	-	-	-
0.950	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	3	119	223	-	-	-
0.980	1	0	101	266	79	77	220
	2	7	146	310	41	104	167
	3	1	48	89	18	49	83
0.989	1	-	56	146	-	-	-
	2	-	80	170	-	-	-
	3	-	-	-	10	-	46
0.990	1	0	-	-	39	39	110
	2	4	-	-	21	52	84
	3	1	24	45	-	25	-
0.992	1	-	-	106	-	-	-
	2	-	-	124	-	-	-
	3	-	-	-	-	-	-
0.995	1	-	-	-	20	19	55
	2	-	-	-	10	26	42
	3	-	-	-	-	-	-

[1] 1 = Band Option 1 with site-specific PCH; 2 = Band Option 2 with generic flight height distribution; 3= Band Option 3 with generic flight height distribution

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ANNEX A: COLLISION RISK MODELLING OUTPUTS FOR EAST ANGLIA THREE SEABIRDS

The tables contained within Appendix A present the initial results of collision risk modelling (CRM) completed for the East Anglia THREE site for seabirds. They include outputs using: Basic Band CRM Option 1 with Site-specific potential collision height (PCH); Basic Band Option 1 with Generic PCH; and Extended Band Option 3.

Each of the three options is presented with outputs resulting from the species and model option specific avoidance rates identified in Section 2 and Table 1 of the main report.

The Worst Case Scenario has assumed a rotor swept area to calculate the PCH of between 22 m and 176 m for the lower and upper wind turbines reaches.

Tables A to C contain species specific monthly mortality rates for the key seabirds

Table A. Band Option 1 monthly predicted mortality estimates of six key seabirds with associated avoidance rates for the East Anglia THREE Site

Species	Avoidance Rate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annum
Fulmar	0.980	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.990	0	0	0	0	0	0	0	0	0	0	0	0	0
Gannet	0.980	0	0	4	5	0	3	2	1	6	2	62	17	101
	0.989	0	0	2	3	0	2	1	1	3	1	34	9	56
Kittiwake	0.980	34	32	10	12	5	9	0	0	0	4	49	111	266
	0.989	19	18	5	7	3	5	0	0	0	2	27	61	146
	0.992	14	13	4	5	2	4	0	0	0	1	19	44	106
LBB gull	0.980	6	0	0	7	8	6	0	29	15	0	9	0	79
	0.990	3	0	0	3	4	3	0	14	8	0	4	0	39
	0.995	1	0	0	2	2	2	0	7	4	0	2	0	20
Herring gull	0.980	13	15	0	0	0	0	0	0	0	0	11	37	77
	0.990	7	8	0	0	0	0	0	0	0	0	6	19	39
	0.995	3	4	0	0	0	0	0	0	0	0	3	9	19
GBB gull	0.980	50	63	0	15	0	0	11	0	0	10	17	53	220
	0.990	25	32	0	8	0	0	6	0	0	5	9	27	110
	0.995	13	16	0	4	0	0	3	0	0	3	4	13	55

Table B. Band Option 2 monthly predicted mortality estimates of six key seabirds with associated avoidance rates for the East Anglia THREE Site

Species	Avoidance Rate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annum
Fulmar	0.980	1	1	0	1	1	0	0	0	0	0	0	2	7
	0.990	1	0	0	0	0	0	0	0	0	0	0	1	4
Gannet	0.980	0	0	6	7	0	4	4	2	8	3	89	24	146
	0.989	0	0	3	4	0	2	2	1	5	1	49	13	80
Kittiwake	0.980	40	37	11	14	6	10	0	0	0	4	57	129	310
	0.989	22	21	6	8	3	6	0	0	0	2	31	71	170
	0.992	16	15	5	6	3	4	0	0	0	2	23	52	124
LBB gull	0.980	3	0	0	3	4	3	0	15	8	0	4	0	41
	0.990	2	0	0	2	2	2	0	8	4	0	2	0	21
	0.995	1	0	0	1	1	1	0	4	2	0	1	0	10
Herring gull	0.980	18	21	0	0	0	0	0	0	0	0	15	50	104
	0.990	9	10	0	0	0	0	0	0	0	0	8	25	52
	0.995	4	5	0	0	0	0	0	0	0	0	4	12	26
GBB gull	0.980	38	48	0	11	0	0	9	0	0	8	13	40	167
	0.990	19	24	0	6	0	0	4	0	0	4	6	20	84
	0.995	10	12	0	3	0	0	2	0	0	2	3	10	42

Table C. Band Option 3 monthly predicted mortality estimates of six key seabirds with associated avoidance rates for the East Anglia THREE Site

Species	Avoidance Rate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annum
Fulmar	0.900	1	0	0	0	1	0	0	0	0	0	0	1	5
	0.950	0	0	0	0	0	0	0	0	0	0	0	1	3
	0.980	0	0	0	0	0	0	0	0	0	0	0	0	1
	0.990	0	0	0	0	0	0	0	0	0	0	0	0	1
Gannet	0.900	0	0	9	12	0	7	6	3	14	4	145	39	238
	0.950	0	0	5	6	0	4	3	1	7	2	72	19	119
	0.980	0	0	2	2	0	1	1	1	3	1	29	8	48
	0.990	0	0	1	1	0	1	1	0	1	0	14	4	24
Kittiwake	0.900	57	54	16	21	9	15	0	0	0	6	81	186	445
	0.950	29	27	8	10	5	7	0	0	0	3	41	93	223
	0.980	11	11	3	4	2	3	0	0	0	1	16	37	89
	0.990	6	5	2	2	1	1	0	0	0	1	8	19	45
LBB gull	0.980	1	0	0	1	2	1	0	6	3	0	2	0	18
	0.989	1	0	0	1	1	1	0	4	2	0	1	0	10
Herring gull	0.980	8	10	0	0	0	0	0	0	0	0	7	24	49
	0.990	4	5	0	0	0	0	0	0	0	0	4	12	25
GBB gull	0.980	19	24	0	6	0	0	4	0	0	4	6	20	83
	0.989	10	13	0	3	0	0	2	0	0	2	4	11	46

ANNEX B: PROPORTION OF FLYING INDIVIDUALS AT POTENTIAL COLLISION HEIGHT

Appendix B presents the proportion of birds recorded flying at potential collision height for the six key seabirds species recorded within the East Anglia THREE site (Table D).

Bird flight height (altitude) was estimated from the digital still images. It was determined using bespoke APEM software that applies a set of rules developed in-house and trigonometry to provide an estimate of flight height to within 1 to 5m. The trigonometric calculation is based on species-specific bird measurements, image ground sample distance (GSD; the distance between pixel centres) and the known height of the aircraft as that image was taken. These parameters are entered into APEM's flight height calculator to estimate the height of each individual bird captured in survey images. Flight height estimates are less reliable for birds that are diving or turning sharply (this affects the measurement of body length and wing span from the image) and so such birds are removed from the sample used to calculate flight heights. The flight heights of species recorded within the East Anglia THREE site have been collated to establish the percentage of birds flying within the proposed project's rotor sweep (i.e. the area within which a wind turbine rotates).

Table D. Proportion (%) at potential collision height between 22 – 176m for the key seabirds observed flying in the East Anglia THREE site

Species	Total flying	Number at potential collision height	Proportion at potential collision height (%)
Fulmar	96	0	0.00
Gannet [1]	251	17	6.77
Kittiwake	208	21	10.10
LBB gull	11	5	45.45
Herring gull	29	6	20.69
GBB gull	38	15	39.47

[1] Total flying gannets recorded was n=252. One individual was deemed unsuitable for flight height estimation. Gannet numbers are based on the number of individuals recorded within the windfarm plus 4km buffer.

ANNEX C: EFFECT OF PREDICTED MORTALITIES OF BAND OPTION 1 FOR FIVE KEY SEABIRDS BASED ON NOCTURNAL SENSITIVITY

Appendix C presents information on the predicted mortalities using Band CRM Option 1 of gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull in relation to a reduction of 1 nocturnal activity factor in comparison to Garthe & Hüppop (2004).

The reduction in mortalities ranges from approximately 15% to 28% for lesser black-backed gull and gannet respectively (Table E).

Table E. Band Option 1 predicted annual mortality of Garthe & Huppop (2004)

Species	Avoidance Rate	Garthe & Hüppop (2004)		Reduced nocturnal activity		Reduction (%)
		Nocturnal Activity	Annual mortality	Nocturnal Activity	Annual mortality	
Gannet	0.989	2	56	1	40	28.57
Kittiwake	0.989	3	146	2	113	22.61
LBB gull	0.995	3	20	2	17	14.46
Herring gull	0.995	3	19	2	15	24.14
GBB gull	0.995	3	55	2	43	21.86

Table F present the monthly mortality estimates as a result of the reduction in nocturnal activity.

Table F. Band Option 1 predicted monthly mortalities per species as a result of a reduction in nocturnal activity

Species	Avoidance Rate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annum
Gannet	0.989	0	0	2	2	0	2	1	1	3	1	24	6	40
Kittiwake	0.989	14	14	4	6	3	4	0	0	0	2	21	45	113
LBB gull	0.995	1	0	0	1	2	1	0	6	3	0	2	0	17
Herring gull	0.995	3	3	0	0	0	0	0	0	0	0	2	7	15
GBB gull	0.995	9	12	0	3	0	0	3	0	0	2	3	10	43

ANNEX D: PREDICTED COLLISION RISK ESTIMATES AND ASSOCIATED VARIANCE ESTIMATES FOR BAND OPTION 1 AND BAND OPTION 3 FOR THE KEY SEABIRDS

Appendix D presents information on the predicted mortality in relation to the mean avoidance rate including variance estimates for Band Option 1 for gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull (Table G). The predicted mortality in relation to the mean avoidance rate including variance for Band Option 3 are also included for lesser black-backed gull, herring gull and great black-backed gull (Table G).

Table G. Mean mortality estimates including variance estimates for Band Option 1 and Band Option 3

Band CRM Option	Species	Avoidance Rate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annum
1	Gannet	0.987	0	0	3	3	0	2	2	1	4	1	40	11	66
		0.989	0	0	2	3	0	2	1	1	3	1	34	9	56
		0.991	0	0	2	2	0	1	1	0	3	1	28	7	46
1	Kittiwake	0.987	22	21	6	8	3	6	0	0	0	2	32	72	173
		0.989	19	18	5	7	3	5	0	0	0	2	27	61	146
		0.991	15	14	4	6	2	4	0	0	0	2	22	50	120
1	LBB gull	0.994	2	0	0	2	2	2	0	9	5	0	3	0	24
		0.995	1	0	0	2	2	2	0	7	4	0	2	0	20
		0.996	1	0	0	1	2	1	0	6	3	0	2	0	16
1	Herring gull	0.994	4	5	0	0	0	0	0	0	0	0	3	11	23
		0.995	3	4	0	0	0	0	0	0	0	0	3	9	19
		0.996	3	3	0	0	0	0	0	0	0	0	2	7	15
1	GBB gull	0.994	15	19	0	5	0	0	3	0	0	3	5	16	66
		0.995	13	16	0	4	0	0	3	0	0	3	4	13	55
		0.996	10	13	0	3	0	0	2	0	0	2	3	11	44
3	LBB gull	0.987	1	0	0	1	1	1	0	4	2	0	1	0	12
		0.989	1	0	0	1	1	1	0	4	2	0	1	0	10
		0.991	1	0	0	1	1	1	0	3	2	0	1	0	8
3	Herring gull	0.988	5	6	0	0	0	0	0	0	0	0	4	14	30
		0.990	4	5	0	0	0	0	0	0	0	0	4	12	25
		0.992	3	4	0	0	0	0	0	0	0	0	3	10	20
3	GBB gull	0.987	12	16	0	4	0	0	3	0	0	3	4	13	54
		0.989	10	13	0	3	0	0	2	0	0	2	4	11	46
		0.991	9	11	0	3	0	0	2	0	0	2	3	9	38

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**1. Fulmar**	
Bird length	m	0.48	
Wingspan	m	1.07	
Flight speed	m/sec	13.0	
Nocturnal activity factor (1-5)		4	
Flight type, flapping or gliding		gliding	

Bird survey data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km			0.3239	0.1866	0.0802	0.1609	0.2279	0.1313	0.0216	0.1082	0.1397	0.0464	0.0796	0.5085
Proportion at rotor height	%	0.00%													
Proportion of flights upwind	%	50.0%													

Birds on migration data			Data sources
Migration passages	birds		
Width of migration corridor	km		
Proportion at rotor height	%		
Proportion of flights upwind	%		

	Units	Value	Data sources
Windfarm data			
Name of windfarm site		**EA THREE**	
Latitude	degrees	52.67	
Number of turbines		172	
Width of windfarm	km	33.25	
Tidal offset	m	0	

	Units	Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Turbine data		0												
Turbine model		**7MW turbine**												
No of blades		3												
Rotation speed	rpm	11												
Rotor radius	m	77												
Hub height	m	99.2034												
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000												
Pitch	degrees	15												

Avoidance rates used in presenting results	Data sources (if applicable)
95.00%	
98.00%	
98.00%	
99.00%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

	from Sheet 1 - input data
	from Sheet 6 - available hours
	from Sheet 3 - single transit collision risk
	from survey data
	calculated field

Bird details:

Species		1. Fulmar
Flight speed	m/sec	13.0
Nocturnal activity factor (1-5)		4
Nocturnal activity (% of daytime)		75%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**year average**
Proportion of time operational	%	95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%

Stage A - flight activity

Daytime areal bird density	birds/sq km	0.32392	0.18664	0.0802	0.1609	0.227913	0.131279	0.021624	0.108223	0.139675	0.046402	0.079563	0.50846	
Proportion at rotor height	%	0.0%												
Total daylight hours per month	hrs	255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs	489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor		196086	104097	50735	100917	150896	85091	14413	70825	86423	28946	46939	305897	

Option 1 -Basic model - Stages B, C and D

														per annum
Potential bird transits through rotors		0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collision risk for single rotor transit	(from sheet 3)	6.3%												
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Option 2-Basic model using proportion from flight distribution		**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**

Option 3-Extended model using flight height distribution Fulmar

Proportion at rotor height	(from sheet 4)	0.5%												
Potential bird transits through rotors	Flux integral	0.0014	273	145	71	140	210	118	20	99	120	40	65	425	**1726**
Collisions assuming no avoidance	Collision integral	0.00004	**8**	**4**	**2**	**4**	**6**	**3**	**1**	**3**	**4**	**1**	**2**	**13**	**51**
Average collision risk for single rotor transit		3.2%													

Stage E - applying avoidance rates

Using which of above options?	**Option 1**	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	birds per month														
Collisions assuming avoidance rate	or year	95.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Collisions after applying large array correction		95.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**0**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**2. Gannet**	
Bird length	m	0.94	
Wingspan	m	1.72	
Flight speed	m/sec	14.9	
Nocturnal activity factor (1-5)		2	
Flight type, flapping or gliding		gliding	

Bird survey data													
Daytime bird density	birds/sq km		0.000	0.000	0.082	0.100	0.000	0.054	0.043	0.020	0.117	0.039	1.493	0.415
Proportion at rotor height	%	6.77%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	**Data sources (if applicable)**
90.00%	
95.00%	
98.00%	
98.90%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Bird details:															
Species		2. Gannet													
Flight speed	m/sec	14.9													
Nocturnal activity factor (1-5)		2													
Nocturnal activity (% of daytime)		25%													
Windfarm data:															
Latitude	degrees	52.7													
Number of turbines		172													
Rotor radius	m	77													
Minimum height of rotor	m	99.2034													
Total rotor frontal area	sq m	3203758													
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0	0	0.082	0.0995	0	0.054136	0.042652	0.019686	0.117458	0.038715	1.493408	0.414777	
Proportion at rotor height	%	6.8%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			0	0	42187	54731	0	33662	26924	11610	61152	18756	629725	169297	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			0	0	2857	3707	0	2280	1824	786	4142	1270	42651	11466	**70983**
Collision risk for single rotor transit	(from sheet 3)	7.6%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**0**	**0**	**200**	**256**	**0**	**153**	**124**	**53**	**289**	**91**	**3082**	**825**	**5074**
Option 2-Basic model using proportion from flight distribution			**0**	**0**	**288**	**369**	**0**	**221**	**179**	**77**	**417**	**131**	**4444**	**1190**	**7316**
Option 3-Extended model using flight height distribution		Gannet													
Proportion at rotor height	(from sheet 4)	9.8%													
Potential bird transits through rotors	Flux integral	0.0487	0	0	2056	2667	0	1640	1312	566	2980	914	30683	8249	**51066**
Collisions assuming no avoidance	Collision integral	0.00241	**0**	**0**	**94**	**120**	**0**	**72**	**58**	**25**	**136**	**43**	**1447**	**388**	**2383**
Average collision risk for single rotor transit		4.9%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 1**	0.00%	0	0	200	256	0	153	124	53	289	91	3082	825	**5074**
Collisions assuming avoidance rate	birds per month or year	90.00%	0	0	20	26	0	15	12	5	29	9	308	83	**507**
		95.00%	0	0	10	13	0	8	6	3	14	5	154	41	**254**
		98.00%	0	0	4	5	0	3	2	1	6	2	62	17	**101**
		98.90%	0	0	2	3	0	2	1	1	3	1	34	9	**56**
Collisions after applying large array correction		90.00%	0	0	20	26	0	15	12	5	29	9	308	82	**506**
		95.00%	0	0	10	13	0	8	6	3	14	5	154	41	**253**
		98.00%	0	0	4	5	0	3	2	1	6	2	62	17	**101**
		98.90%	0	0	2	3	0	2	1	1	3	1	34	9	**56**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**3. Kittiwake**	
Bird length	m	0.39	
Wingspan	m	1.08	
Flight speed	m/sec	13.1	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.5969	0.5974	0.158	0.198	0.0787	0.1333	0	0	0	0.0607	0.8555	1.9646
Proportion at rotor height	%	10.10%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	**Data sources (if applicable)**
95.00%	
98.00%	
98.90%	
99.20%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		3. Kittiwake
Flight speed	m/sec	13.1
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.59689	0.59743	0.158	0.198	0.078743	0.133251	0	0	0	0.060698	0.855496	1.964576	
Proportion at rotor height	%	10.1%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			292523	277648	86092	110417	47592	79940	0	0	0	32004	412877	948005	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			29534	28032	8692	11148	4805	8071	0	0	0	3231	41685	95712	**230909**
Collision risk for single rotor transit	(from sheet 3)	6.1%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**1717**	**1602**	**490**	**619**	**269**	**438**	**0**	**0**	**0**	**186**	**2427**	**5552**	**13300**
Option 2-Basic model using proportion from flight distribution			**1998**	**1865**	**570**	**721**	**313**	**510**	**0**	**0**	**0**	**216**	**2826**	**6463**	**15483**
Option 3-Extended model using flight height distribution		Kittiwake													
Proportion at rotor height	(from sheet 4)	11.8%													
Potential bird transits through rotors	Flux integral	0.0613	17932	17020	5278	6769	2917	4900	0	0	0	1962	25310	58114	**140202**
Collisions assuming no avoidance	Collision integral	0.00206	**575**	**536**	**164**	**207**	**90**	**147**	**0**	**0**	**0**	**62**	**813**	**1859**	**4453**
Average collision risk for single rotor transit		3.4%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 1**	0.00%	1717	1602	490	619	269	438	0	0	0	186	2427	5552	**13300**
Collisions assuming avoidance rate	birds per month or year	95.00%	86	80	24	31	13	22	0	0	0	9	121	278	**665**
		98.00%	34	32	10	12	5	9	0	0	0	4	49	111	**266**
		98.90%	19	18	5	7	3	5	0	0	0	2	27	61	**146**
		99.20%	14	13	4	5	2	4	0	0	0	1	19	44	**106**
Collisions after applying large array correction		95.00%	86	80	24	31	13	22	0	0	0	9	121	277	**664**
		98.00%	34	32	10	12	5	9	0	0	0	4	49	111	**266**
		98.90%	19	18	5	7	3	5	0	0	0	2	27	61	**146**
		99.20%	14	13	4	5	2	4	0	0	0	1	19	44	**106**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**4. LBB Gull**	
Bird length	m	0.58	
Wingspan	m	1.42	
Flight speed	m/sec	13.1	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.0197	0	0	0.0205	0.0232	0.018	0	0.0862	0.048	0	0.0294	0
Proportion at rotor height	%	45.45%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	95.00%	**Data sources (if applicable)**
	98.00%	
	99.00%	
	99.50%	

COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		4. LBB Gull
Flight speed	m/sec	13.1
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.01969	0	0	0.0205	0.023228	0.018045	0	0.086183	0.048042	0	0.029429	0	
Proportion at rotor height	%	45.5%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			9648	0	0	11438	14039	10826	0	50761	25973	0	14203	0	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			4385	0	0	5199	6381	4921	0	23073	11806	0	6456	0	**62221**
Collision risk for single rotor transit	(from sheet 3)	6.9%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**290**	**0**	**0**	**328**	**406**	**303**	**0**	**1434**	**755**	**0**	**427**	**0**	**3944**
Option 2-Basic model using proportion from flight distribution			**152**	**0**	**0**	**173**	**214**	**160**	**0**	**754**	**397**	**0**	**225**	**0**	**2075**
Option 3-Extended model using flight height distribution		LBBG													
Proportion at rotor height	(from sheet 4)	23.9%													
Potential bird transits through rotors	Flux integral	0.1522	1468	0	0	1741	2136	1648	0	7725	3953	0	2161	0	**20832**
Collisions assuming no avoidance	Collision integral	0.00708	**65**	**0**	**0**	**74**	**91**	**68**	**0**	**322**	**170**	**0**	**96**	**0**	**886**
Average collision risk for single rotor transit		4.7%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 1**	0.00%	290	0	0	328	406	303	0	1434	755	0	427	0	**3944**
Collisions assuming avoidance rate	birds per month or year	95.00%	14	0	0	16	20	15	0	72	38	0	21	0	**197**
		98.00%	6	0	0	7	8	6	0	29	15	0	9	0	**79**
		99.00%	3	0	0	3	4	3	0	14	8	0	4	0	**39**
		99.50%	1	0	0	2	2	2	0	7	4	0	2	0	**20**
Collisions after applying large array correction		95.00%	14	0	0	16	20	15	0	72	38	0	21	0	**197**
		98.00%	6	0	0	7	8	6	0	29	15	0	9	0	**79**
		99.00%	3	0	0	3	4	3	0	14	8	0	4	0	**39**
		99.50%	1	0	0	2	2	2	0	7	4	0	2	0	**20**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**5. Herring gull**	
Bird length	m	0.60	
Wingspan	m	1.44	
Flight speed	m/sec	12.8	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.0991	0.1235	0	0	0	0	0	0	0	0.086	0.2829
Proportion at rotor height	%	20.69%											
Proportion of flights upwind	%	50.0%											

			Data sources
Birds on migration data			
Migration passages	birds		
Width of migration corridor	km		
Proportion at rotor height	%		
Proportion of flights upwind	%		

	Units	Value	Data sources
Windfarm data			
Name of windfarm site		**EA THREE**	
Latitude	degrees	52.67	
Number of turbines		172	
Width of windfarm	km	33.25	
Tidal offset	m	0	

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	**Data sources (if applicable)**
95.00%	
98.00%	
99.00%	
99.50%	

COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		5. Herring gull
Flight speed	m/sec	12.8
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.09906	0.12348	0	0	0	0	0	0	0	0	0.085951	0.282877	
Proportion at rotor height	%	20.7%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			47435	56073	0	0	0	0	0	0	0	0	40531	133376	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			9814	11601	0	0	0	0	0	0	0	0	8386	27595	**57396**
Collision risk for single rotor transit	(from sheet 3)	7.1%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**664**	**772**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**569**	**1864**	**3868**
Option 2-Basic model using proportion from flight distribution			**890**	**1035**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**762**	**2498**	**5185**
Option 3-Extended model using flight height distribution		Herring gull													
Proportion at rotor height	(from sheet 4)	27.7%													
Potential bird transits through rotors	Flux integral	0.1862	8832	10440	0	0	0	0	0	0	0	0	7547	24834	**51653**
Collisions assuming no avoidance	Collision integral	0.00937	**423**	**492**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**362**	**1188**	**2465**
Average collision risk for single rotor transit		5.0%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 1**	0.00%	664	772	0	0	0	0	0	0	0	0	569	1864	**3868**
Collisions assuming avoidance rate	birds per month or year	95.00%	33	39	0	0	0	0	0	0	0	0	28	93	**193**
		98.00%	13	15	0	0	0	0	0	0	0	0	11	37	**77**
		99.00%	7	8	0	0	0	0	0	0	0	0	6	19	**39**
		99.50%	3	4	0	0	0	0	0	0	0	0	3	9	**19**
Collisions after applying large array correction		95.00%	33	39	0	0	0	0	0	0	0	0	28	93	**193**
		98.00%	13	15	0	0	0	0	0	0	0	0	11	37	**77**
		99.00%	7	8	0	0	0	0	0	0	0	0	6	19	**39**
		99.50%	3	4	0	0	0	0	0	0	0	0	3	9	**19**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**6. GBB Gull**	
Bird length	m	0.71	
Wingspan	m	1.58	
Flight speed	m/sec	13.7	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.1781	0.2401	0	0.0492	0	0	0.0341	0	0	0.0349	0.0615	0.1928
Proportion at rotor height	%	39.47%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	**Data sources (if applicable)**
95.00%	
98.00%	
99.00%	
99.50%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		6. GBB Gull
Flight speed	m/sec	13.7
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.17806	0.24014	0	0.0492	0	0	0.034122	0	0	0.034926	0.061543	0.192847	
Proportion at rotor height	%	39.5%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			91259	116715	0	28709	0	0	21886	0	0	19259	31062	97320	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			36023	46072	0	11332	0	0	8639	0	0	7602	12261	38416	**160346**
Collision risk for single rotor transit	(from sheet 3)	7.3%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**2505**	**3151**	**0**	**753**	**0**	**0**	**568**	**0**	**0**	**523**	**854**	**2666**	**11020**
Option 2-Basic model using proportion from flight distribution			**1902**	**2393**	**0**	**572**	**0**	**0**	**431**	**0**	**0**	**397**	**649**	**2024**	**8368**
Option 3-Extended model using flight height distribution		GBBG													
Proportion at rotor height	(from sheet 4)	30.0%													
Potential bird transits through rotors	Flux integral	0.2061	18812	24060	0	5918	0	0	4512	0	0	3970	6403	20062	**83737**
Collisions assuming no avoidance	Collision integral	0.01091	**948**	**1193**	**0**	**285**	**0**	**0**	**215**	**0**	**0**	**198**	**323**	**1009**	**4172**
Average collision risk for single rotor transit		5.3%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 1**	0.00%	2505	3151	0	753	0	0	568	0	0	523	854	2666	**11020**
Collisions assuming avoidance rate	birds per month or year	95.00%	125	158	0	38	0	0	28	0	0	26	43	133	**551**
		98.00%	50	63	0	15	0	0	11	0	0	10	17	53	**220**
		99.00%	25	32	0	8	0	0	6	0	0	5	9	27	**110**
		99.50%	13	16	0	4	0	0	3	0	0	3	4	13	**55**
Collisions after applying large array correction		95.00%	125	157	0	38	0	0	28	0	0	26	43	133	**550**
		98.00%	50	63	0	15	0	0	11	0	0	10	17	53	**220**
		99.00%	25	31	0	8	0	0	6	0	0	5	9	27	**110**
		99.50%	13	16	0	4	0	0	3	0	0	3	4	13	**55**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**1. Fulmar**	
Bird length	m	0.48	
Wingspan	m	1.07	
Flight speed	m/sec	13.0	
Nocturnal activity factor (1-5)		4	
Flight type, flapping or gliding		gliding	

Bird survey data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km			0.3239	0.1866	0.0802	0.1609	0.2279	0.1313	0.0216	0.1082	0.1397	0.0464	0.0796	0.5085
Proportion at rotor height	%	0.55%													
Proportion of flights upwind	%	50.0%													

Birds on migration data			Data sources
Migration passages	birds		
Width of migration corridor	km		
Proportion at rotor height	%		
Proportion of flights upwind	%		

	Units	Value	Data sources
Windfarm data			
Name of windfarm site		**EA THREE**	
Latitude	degrees	52.67	
Number of turbines		172	
Width of windfarm	km	33.25	
Tidal offset	m	0	

	Units	Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Turbine data		0												
Turbine model		**7MW turbine**												
No of blades		3												
Rotation speed	rpm	11												
Rotor radius	m	77												
Hub height	m	99.2034												
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000												
Pitch	degrees	15												

Avoidance rates used in presenting results		Data sources (if applicable)
	95.00%	
	98.00%	
	98.00%	
	99.00%	

COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		1. Fulmar
Flight speed	m/sec	13.0
Nocturnal activity factor (1-5)		4
Nocturnal activity (% of daytime)		75%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**year average**
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.32392	0.18664	0.0802	0.1609	0.227913	0.131279	0.021624	0.108223	0.139675	0.046402	0.079563	0.50846	
Proportion at rotor height	%	0.6%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			196086	104097	50735	100917	150896	85091	14413	70825	86423	28946	46939	305897	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			1078	573	279	555	830	468	79	390	475	159	258	1682	**6827**
Collision risk for single rotor transit	(from sheet 3)	6.3%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**65**	**34**	**16**	**32**	**48**	**26**	**4**	**22**	**28**	**9**	**15**	**101**	**400**
Option 2-Basic model using proportion from flight distribution			**58**	**31**	**15**	**29**	**43**	**24**	**4**	**20**	**25**	**9**	**14**	**91**	**362**
Option 3-Extended model using flight height distribution		Fulmar													
Proportion at rotor height	(from sheet 4)	0.5%													
Potential bird transits through rotors	Flux integral	0.0014	273	145	71	140	210	118	20	99	120	40	65	425	**1726**
Collisions assuming no avoidance	Collision integral	0.00004	**8**	**4**	**2**	**4**	**6**	**3**	**1**	**3**	**4**	**1**	**2**	**13**	**51**
Average collision risk for single rotor transit		3.2%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 2**	0.00%	58	31	15	29	43	24	4	20	25	9	14	91	**362**
Collisions assuming avoidance rate	birds per month or year	95.00%	3	2	1	1	2	1	0	1	1	0	1	5	**18**
		98.00%	1	1	0	1	1	0	0	0	0	0	0	2	**7**
		98.00%	1	1	0	1	1	0	0	0	0	0	0	2	**7**
		99.00%	1	0	0	0	0	0	0	0	0	0	0	1	**4**
Collisions after applying large array correction		95.00%	3	2	1	1	2	1	0	1	1	0	1	5	**18**
		98.00%	1	1	0	1	1	0	0	0	0	0	0	2	**7**
		98.00%	1	1	0	1	1	0	0	0	0	0	0	2	**7**
		99.00%	1	0	0	0	0	0	0	0	0	0	0	1	**4**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**2. Gannet**	
Bird length	m	0.94	
Wingspan	m	1.72	
Flight speed	m/sec	14.9	
Nocturnal activity factor (1-5)		2	
Flight type, flapping or gliding		gliding	

Bird survey data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km			0	0	0.08202	0.09952	0	0.05414	0.04265	0.01969	0.11746	0.03872	1.49341	0.41478
Proportion at rotor height	%	6.8%													
Proportion of flights upwind	%	50.0%													

Birds on migration data			Data sources
Migration passages	birds		
Width of migration corridor	km		
Proportion at rotor height	%		
Proportion of flights upwind	%		

	Units	Value	Data sources
Windfarm data			
Name of windfarm site		**EA THREE**	
Latitude	degrees	52.67	
Number of turbines		172	
Width of windfarm	km	33.25	
Tidal offset	m	0	

	Units	Value	Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Turbine data															
Turbine model		**5MW turbine**													
No of blades		3													
Rotation speed	rpm	11													
Rotor radius	m	77													
Hub height	m	99.2034													
Monthly proportion of time operational	%			95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000													
Pitch	degrees	15													

Avoidance rates used in presenting results		**Data sources (if applicable)**
	90.00%	
	95.00%	
	98.00%	
	98.90%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		2. Gannet
Flight speed	m/sec	14.9
Nocturnal activity factor (1-5)		2
Nocturnal activity (% of daytime)		25%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational (%)	95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%

Stage A - flight activity

Daytime areal bird density	birds/sq km		0	0	0.082	0.0995	0	0.054136	0.042652	0.019686	0.117458	0.038715	1.493408	0.414777	
Proportion at rotor height	%	6.8%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			0	0	42187	54731	0	33662	26924	11610	61152	18756	629725	169297	

Option 1 -Basic model - Stages B, C and D

														per annum
Potential bird transits through rotors			0	0	2857	3707	0	2280	1824	786	4142	1270	42651	11466	**70983**
Collision risk for single rotor transit	(from sheet 3)	7.6%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**0**	**0**	**200**	**256**	**0**	**153**	**124**	**53**	**289**	**91**	**3082**	**825**	**5074**
Option 2-Basic model using proportion from flight distribution			**0**	**0**	**288**	**369**	**0**	**221**	**179**	**77**	**417**	**131**	**4444**	**1190**	**7316**

Option 3-Extended model using flight height distribution — 2. Gannet

Proportion at rotor height	(from sheet 4)	9.8%												
Potential bird transits through rotors	Flux integral	0.0487	0	0	2056	2667	0	1640	1312	566	2980	914	30683	8249	**51066**
Collisions assuming no avoidance	Collision integral	0.00241	**0**	**0**	**94**	**120**	**0**	**72**	**58**	**25**	**136**	**43**	**1447**	**388**	**2383**
Average collision risk for single rotor transit		4.9%													

Stage E - applying avoidance rates

Using which of above options?	**Option 2**	0.00%	0	0	288	369	0	221	179	77	417	131	4444	1190	**7316**
Collisions assuming avoidance rate	birds per month or year	90.00%	0	0	29	37	0	22	18	8	42	13	444	119	**732**
		95.00%	0	0	14	18	0	11	9	4	21	7	222	60	**366**
		98.00%	0	0	6	7	0	4	4	2	8	3	89	24	**146**
		98.90%	0	0	3	4	0	2	2	1	5	1	49	13	**80**
Collisions after applying large array correction		90.00%	0	0	29	37	0	22	18	8	42	13	444	119	**730**
		95.00%	0	0	14	18	0	11	9	4	21	7	222	59	**365**
		98.00%	0	0	6	7	0	4	4	2	8	3	89	24	**146**
		98.90%	0	0	3	4	0	2	2	1	5	1	49	13	**80**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**3. Kittiwake**	
Bird length	m	0.39	
Wingspan	m	1.08	
Flight speed	m/sec	13.1	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.5969	0.5974	0.158	0.198	0.0787	0.1333	0	0	0	0.0607	0.8555	1.9646
Proportion at rotor height	%	10.10%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	**Data sources (if applicable)**
95.00%	
98.00%	
98.90%	
99.20%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		3. Kittiwake
Flight speed	m/sec	13.1
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.59689	0.59743	0.158	0.198	0.078743	0.133251	0	0	0	0.060698	0.855496	1.964576	
Proportion at rotor height	%	10.1%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			292523	277648	86092	110417	47592	79940	0	0	0	32004	412877	948005	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			29534	28032	8692	11148	4805	8071	0	0	0	3231	41685	95712	**230909**
Collision risk for single rotor transit	(from sheet 3)	6.1%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**1717**	**1602**	**490**	**619**	**269**	**438**	**0**	**0**	**0**	**186**	**2427**	**5552**	**13300**
Option 2-Basic model using proportion from flight distribution			**1998**	**1865**	**570**	**721**	**313**	**510**	**0**	**0**	**0**	**216**	**2826**	**6463**	**15483**
Option 3-Extended model using flight height distribution		Kittiwake													
Proportion at rotor height	(from sheet 4)	11.8%													
Potential bird transits through rotors	Flux integral	0.0613	17932	17020	5278	6769	2917	4900	0	0	0	1962	25310	58114	**140202**
Collisions assuming no avoidance	Collision integral	0.00206	**575**	**536**	**164**	**207**	**90**	**147**	**0**	**0**	**0**	**62**	**813**	**1859**	**4453**
Average collision risk for single rotor transit		3.4%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 2**	0.00%	1998	1865	570	721	313	510	0	0	0	216	2826	6463	**15483**
Collisions assuming avoidance rate	birds per month or year	95.00%	100	93	29	36	16	25	0	0	0	11	141	323	**774**
		98.00%	40	37	11	14	6	10	0	0	0	4	57	129	**310**
		98.90%	22	21	6	8	3	6	0	0	0	2	31	71	**170**
		99.20%	16	15	5	6	3	4	0	0	0	2	23	52	**124**
Collisions after applying large array correction		95.00%	100	93	28	36	16	25	0	0	0	11	141	323	**774**
		98.00%	40	37	11	14	6	10	0	0	0	4	56	129	**310**
		98.90%	22	21	6	8	3	6	0	0	0	2	31	71	**170**
		99.20%	16	15	5	6	3	4	0	0	0	2	23	52	**124**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**4. LBB Gull**	
Bird length	m	0.58	
Wingspan	m	1.42	
Flight speed	m/sec	13.1	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.0197	0	0	0.0205	0.0232	0.018	0	0.0862	0.048	0	0.0294	0
Proportion at rotor height	%	45.45%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	95.00%	**Data sources (if applicable)**
	98.00%	
	99.00%	
	99.50%	

COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		4. LBB Gull
Flight speed	m/sec	13.1
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.01969	0	0	0.0205	0.023228	0.018045	0	0.086183	0.048042	0	0.029429	0	
Proportion at rotor height	%	45.5%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			9648	0	0	11438	14039	10826	0	50761	25973	0	14203	0	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			4385	0	0	5199	6381	4921	0	23073	11806	0	6456	0	**62221**
Collision risk for single rotor transit	(from sheet 3)	6.9%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**290**	**0**	**0**	**328**	**406**	**303**	**0**	**1434**	**755**	**0**	**427**	**0**	**3944**
Option 2-Basic model using proportion from flight distribution			**152**	**0**	**0**	**173**	**214**	**160**	**0**	**754**	**397**	**0**	**225**	**0**	**2075**
Option 3-Extended model using flight height distribution		LBBG													
Proportion at rotor height	(from sheet 4)	23.9%													
Potential bird transits through rotors	Flux integral	0.1522	1468	0	0	1741	2136	1648	0	7725	3953	0	2161	0	**20832**
Collisions assuming no avoidance	Collision integral	0.00708	**65**	**0**	**0**	**74**	**91**	**68**	**0**	**322**	**170**	**0**	**96**	**0**	**886**
Average collision risk for single rotor transit		4.7%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 2**	0.00%	152	0	0	173	214	160	0	754	397	0	225	0	**2075**
Collisions assuming avoidance rate	birds per month or year	95.00%	8	0	0	9	11	8	0	38	20	0	11	0	**104**
		98.00%	3	0	0	3	4	3	0	15	8	0	4	0	**41**
		99.00%	2	0	0	2	2	2	0	8	4	0	2	0	**21**
		99.50%	1	0	0	1	1	1	0	4	2	0	1	0	**10**
Collisions after applying large array correction		95.00%	8	0	0	9	11	8	0	38	20	0	11	0	**104**
		98.00%	3	0	0	3	4	3	0	15	8	0	4	0	**41**
		99.00%	2	0	0	2	2	2	0	8	4	0	2	0	**21**
		99.50%	1	0	0	1	1	1	0	4	2	0	1	0	**10**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**5. Herring gull**	
Bird length	m	0.60	
Wingspan	m	1.44	
Flight speed	m/sec	12.8	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.0991	0.1235	0	0	0	0	0	0	0	0.086	0.2829
Proportion at rotor height	%	20.69%											
Proportion of flights upwind	%	50.0%											

			Data sources
Birds on migration data			
Migration passages	birds		
Width of migration corridor	km		
Proportion at rotor height	%		
Proportion of flights upwind	%		

	Units	Value	Data sources
Windfarm data			
Name of windfarm site		**EA THREE**	
Latitude	degrees	52.67	
Number of turbines		172	
Width of windfarm	km	33.25	
Tidal offset	m	0	

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	**Data sources (if applicable)**
95.00%	
98.00%	
99.00%	
99.50%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		5. Herring gull
Flight speed	m/sec	12.8
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**year average**
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.09906	0.12348	0	0	0	0	0	0	0	0	0.085951	0.282877	
Proportion at rotor height	%	20.7%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			47435	56073	0	0	0	0	0	0	0	0	40531	133376	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			9814	11601	0	0	0	0	0	0	0	0	8386	27595	**57396**
Collision risk for single rotor transit	(from sheet 3)	7.1%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**664**	**772**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**569**	**1864**	**3868**
Option 2-Basic model using proportion from flight distribution			**890**	**1035**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**762**	**2498**	**5185**
Option 3-Extended model using flight height distribution		Herring gull													
Proportion at rotor height	(from sheet 4)	27.7%													
Potential bird transits through rotors	Flux integral	0.1862	8832	10440	0	0	0	0	0	0	0	0	7547	24834	**51653**
Collisions assuming no avoidance	Collision integral	0.00937	**423**	**492**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**362**	**1188**	**2465**
Average collision risk for single rotor transit		5.0%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 2**	0.00%	890	1035	0	0	0	0	0	0	0	0	762	2498	**5185**
Collisions assuming avoidance rate	birds per month or year	95.00%	45	52	0	0	0	0	0	0	0	0	38	125	**259**
		98.00%	18	21	0	0	0	0	0	0	0	0	15	50	**104**
		99.00%	9	10	0	0	0	0	0	0	0	0	8	25	**52**
		99.50%	4	5	0	0	0	0	0	0	0	0	4	12	**26**
Collisions after applying large array correction		95.00%	44	52	0	0	0	0	0	0	0	0	38	125	**259**
		98.00%	18	21	0	0	0	0	0	0	0	0	15	50	**104**
		99.00%	9	10	0	0	0	0	0	0	0	0	8	25	**52**
		99.50%	4	5	0	0	0	0	0	0	0	0	4	12	**26**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**6. GBB Gull**	
Bird length	m	0.71	
Wingspan	m	1.58	
Flight speed	m/sec	13.7	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.1781	0.2401	0	0.0492	0	0	0.0341	0	0	0.0349	0.0615	0.1928
Proportion at rotor height	%	39.47%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	**Data sources (if applicable)**
95.00%	
98.00%	
99.00%	
99.50%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		6. GBB Gull
Flight speed	m/sec	13.7
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.17806	0.24014	0	0.0492	0	0	0.034122	0	0	0.034926	0.061543	0.192847	
Proportion at rotor height	%	39.5%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			91259	116715	0	28709	0	0	21886	0	0	19259	31062	97320	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			36023	46072	0	11332	0	0	8639	0	0	7602	12261	38416	**160346**
Collision risk for single rotor transit	(from sheet 3)	7.3%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**2505**	**3151**	**0**	**753**	**0**	**0**	**568**	**0**	**0**	**523**	**854**	**2666**	**11020**
Option 2-Basic model using proportion from flight distribution			**1902**	**2393**	**0**	**572**	**0**	**0**	**431**	**0**	**0**	**397**	**649**	**2024**	**8368**
Option 3-Extended model using flight height distribution		GBBG													
Proportion at rotor height	(from sheet 4)	30.0%													
Potential bird transits through rotors	Flux integral	0.2061	18812	24060	0	5918	0	0	4512	0	0	3970	6403	20062	**83737**
Collisions assuming no avoidance	Collision integral	0.01091	**948**	**1193**	**0**	**285**	**0**	**0**	**215**	**0**	**0**	**198**	**323**	**1009**	**4172**
Average collision risk for single rotor transit		5.3%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 2**	0.00%	1902	2393	0	572	0	0	431	0	0	397	649	2024	**8368**
Collisions assuming avoidance rate	birds per month or year	95.00%	95	120	0	29	0	0	22	0	0	20	32	101	**418**
		98.00%	38	48	0	11	0	0	9	0	0	8	13	40	**167**
		99.00%	19	24	0	6	0	0	4	0	0	4	6	20	**84**
		99.50%	10	12	0	3	0	0	2	0	0	2	3	10	**42**
Collisions after applying large array correction		95.00%	95	120	0	29	0	0	22	0	0	20	32	101	**418**
		98.00%	38	48	0	11	0	0	9	0	0	8	13	40	**167**
		99.00%	19	24	0	6	0	0	4	0	0	4	6	20	**84**
		99.50%	10	12	0	3	0	0	2	0	0	2	3	10	**42**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**1. Fulmar**	
Bird length	m	0.48	
Wingspan	m	1.07	
Flight speed	m/sec	13.0	
Nocturnal activity factor (1-5)		4	
Flight type, flapping or gliding		gliding	

Bird survey data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km			0.3239	0.1866	0.0802	0.1609	0.2279	0.1313	0.0216	0.1082	0.1397	0.0464	0.0796	0.5085
Proportion at rotor height	%	0.55%													
Proportion of flights upwind	%	50.0%													

Birds on migration data			Data sources
Migration passages	birds		
Width of migration corridor	km		
Proportion at rotor height	%		
Proportion of flights upwind	%		

	Units	Value	Data sources
Windfarm data			
Name of windfarm site		**EA THREE**	
Latitude	degrees	52.67	
Number of turbines		172	
Width of windfarm	km	33.25	
Tidal offset	m	0	

	Units	Value	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Turbine data														
Turbine model		**7MW turbine**												
No of blades		3												
Rotation speed	rpm	11												
Rotor radius	m	77												
Hub height	m	99.2034												
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000												
Pitch	degrees	15												

Avoidance rates used in presenting results	Data sources (if applicable)
90.00%	
95.00%	
98.00%	
99.00%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		1. Fulmar
Flight speed	m/sec	13.0
Nocturnal activity factor (1-5)		4
Nocturnal activity (% of daytime)		75%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**year average**
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.32392	0.18664	0.0802	0.1609	0.227913	0.131279	0.021624	0.108223	0.139675	0.046402	0.079563	0.50846	
Proportion at rotor height	%	0.6%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			196086	104097	50735	100917	150896	85091	14413	70825	86423	28946	46939	305897	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			1078	573	279	555	830	468	79	390	475	159	258	1682	**6827**
Collision risk for single rotor transit	(from sheet 3)	6.3%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**65**	**34**	**16**	**32**	**48**	**26**	**4**	**22**	**28**	**9**	**15**	**101**	**400**
Option 2-Basic model using proportion from flight distribution			**58**	**31**	**15**	**29**	**43**	**24**	**4**	**20**	**25**	**9**	**14**	**91**	**362**
Option 3-Extended model using flight height distribution		Fulmar													
Proportion at rotor height	(from sheet 4)	0.5%													
Potential bird transits through rotors	Flux integral	0.0014	273	145	71	140	210	118	20	99	120	40	65	425	**1726**
Collisions assuming no avoidance	Collision integral	0.00004	**8**	**4**	**2**	**4**	**6**	**3**	**1**	**3**	**4**	**1**	**2**	**13**	**51**
Average collision risk for single rotor transit		3.2%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 3**	0.00%	8	4	2	4	6	3	1	3	4	1	2	13	**51**
Collisions assuming avoidance rate	birds per month or year	90.00%	1	0	0	0	1	0	0	0	0	0	0	1	**5**
		95.00%	0	0	0	0	0	0	0	0	0	0	0	1	**3**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Collisions after applying large array correction		90.00%	1	0	0	0	1	0	0	0	0	0	0	1	**5**
		95.00%	0	0	0	0	0	0	0	0	0	0	0	1	**3**
		98.00%	0	0	0	0	0	0	0	0	0	0	0	0	**1**
		99.00%	0	0	0	0	0	0	0	0	0	0	0	0	**1**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**2. Gannet**	
Bird length	m	0.94	
Wingspan	m	1.72	
Flight speed	m/sec	14.9	
Nocturnal activity factor (1-5)		2	
Flight type, flapping or gliding		gliding	

Bird survey data			Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km			0	0	0.08202	0.09952	0	0.05414	0.04265	0.01969	0.11746	0.03872	1.49341	0.41478
Proportion at rotor height	%	6.8%													
Proportion of flights upwind	%	50.0%													

Birds on migration data			Data sources
Migration passages	birds		
Width of migration corridor	km		
Proportion at rotor height	%		
Proportion of flights upwind	%		

	Units	Value	Data sources
Windfarm data			
Name of windfarm site		**EA THREE**	
Latitude	degrees	52.67	
Number of turbines		172	
Width of windfarm	km	33.25	
Tidal offset	m	0	

	Units	Value	Data sources	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Turbine data															
Turbine model		**5MW turbine**													
No of blades		3													
Rotation speed	rpm	11													
Rotor radius	m	77													
Hub height	m	99.2034													
Monthly proportion of time operational	%			95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000													
Pitch	degrees	15													

Avoidance rates used in presenting results		**Data sources (if applicable)**
	90.00%	
	95.00%	
	98.00%	
	98.90%	

COLLISION RISK ASSESSMENT

Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		2. Gannet
Flight speed	m/sec	14.9
Nocturnal activity factor (1-5)		2
Nocturnal activity (% of daytime)		25%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational (%)	95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%

Stage A - flight activity

Daytime areal bird density	birds/sq km		0	0	0.082	0.0995	0	0.054136	0.042652	0.019686	0.117458	0.038715	1.493408	0.414777	
Proportion at rotor height	%	6.8%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			0	0	42187	54731	0	33662	26924	11610	61152	18756	629725	169297	

Option 1 -Basic model - Stages B, C and D

														per annum
Potential bird transits through rotors			0	0	2857	3707	0	2280	1824	786	4142	1270	42651	11466	**70983**
Collision risk for single rotor transit	(from sheet 3)	7.6%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**0**	**0**	**200**	**256**	**0**	**153**	**124**	**53**	**289**	**91**	**3082**	**825**	**5074**
Option 2-Basic model using proportion from flight distribution			**0**	**0**	**288**	**369**	**0**	**221**	**179**	**77**	**417**	**131**	**4444**	**1190**	**7316**

Option 3-Extended model using flight height distribution — 2. Gannet

Proportion at rotor height	(from sheet 4)	9.8%												
Potential bird transits through rotors	Flux integral	0.0487	0	0	2056	2667	0	1640	1312	566	2980	914	30683	8249	**51066**
Collisions assuming no avoidance	Collision integral	0.00241	**0**	**0**	**94**	**120**	**0**	**72**	**58**	**25**	**136**	**43**	**1447**	**388**	**2383**
Average collision risk for single rotor transit		4.9%													

Stage E - applying avoidance rates

Using which of above options?	**Option 3**	0.00%	0	0	94	120	0	72	58	25	136	43	1447	388	**2383**
	birds per month													
Collisions assuming avoidance rate	or year	90.00%	0	0	9	12	0	7	6	3	14	4	145	39	**238**
		95.00%	0	0	5	6	0	4	3	1	7	2	72	19	**119**
		98.00%	0	0	2	2	0	1	1	1	3	1	29	8	**48**
		98.90%	0	0	1	1	0	1	1	0	1	0	14	4	**24**
Collisions after applying large array correction		90.00%	0	0	9	12	0	7	6	3	14	4	144	39	**238**
		95.00%	0	0	5	6	0	4	3	1	7	2	72	19	**119**
		98.00%	0	0	2	2	0	1	1	1	3	1	29	8	**48**
		98.90%	0	0	1	1	0	1	1	0	1	0	14	4	**24**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**3. Kittiwake**	
Bird length	m	0.39	
Wingspan	m	1.08	
Flight speed	m/sec	13.1	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.5969	0.5974	0.158	0.198	0.0787	0.1333	0	0	0	0.0607	0.8555	1.9646
Proportion at rotor height	%	10.10%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	**Data sources (if applicable)**
90.00%	
95.00%	
98.00%	
99.00%	

COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		3. Kittiwake													
Flight speed	m/sec	13.1													
Nocturnal activity factor (1-5)		3													
Nocturnal activity (% of daytime)		50%													
Windfarm data:															
Latitude	degrees	52.7													
Number of turbines		172													
Rotor radius	m	77													
Minimum height of rotor	m	99.2034													
Total rotor frontal area	sq m	3203758													
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**year average**
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.59689	0.59743	0.158	0.198	0.078743	0.133251	0	0	0	0.060698	0.855496	1.964576	
Proportion at rotor height	%	10.1%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			292523	277648	86092	110417	47592	79940	0	0	0	32004	412877	948005	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			29534	28032	8692	11148	4805	8071	0	0	0	3231	41685	95712	**230909**
Collision risk for single rotor transit	(from sheet 3)	6.1%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**1717**	**1602**	**490**	**619**	**269**	**438**	**0**	**0**	**0**	**186**	**2427**	**5552**	**13300**
Option 2-Basic model using proportion from flight distribution			**1998**	**1865**	**570**	**721**	**313**	**510**	**0**	**0**	**0**	**216**	**2826**	**6463**	**15483**
Option 3-Extended model using flight height distribution		Kittiwake													
Proportion at rotor height	(from sheet 4)	11.8%													
Potential bird transits through rotors	Flux integral	0.0613	17932	17020	5278	6769	2917	4900	0	0	0	1962	25310	58114	**140202**
Collisions assuming no avoidance	Collision integral	0.00206	**575**	**536**	**164**	**207**	**90**	**147**	**0**	**0**	**0**	**62**	**813**	**1859**	**4453**
Average collision risk for single rotor transit		3.4%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 3**	0.00%	575	536	164	207	90	147	0	0	0	62	813	1859	**4453**
	birds per month														
Collisions assuming avoidance rate	or year	90.00%	57	54	16	21	9	15	0	0	0	6	81	186	**445**
		95.00%	29	27	8	10	5	7	0	0	0	3	41	93	**223**
		98.00%	11	11	3	4	2	3	0	0	0	1	16	37	**89**
		99.00%	6	5	2	2	1	1	0	0	0	1	8	19	**45**
Collisions after applying large array correction		90.00%	57	54	16	21	9	15	0	0	0	6	81	186	**445**
		95.00%	29	27	8	10	5	7	0	0	0	3	41	93	**222**
		98.00%	11	11	3	4	2	3	0	0	0	1	16	37	**89**
		99.00%	6	5	2	2	1	1	0	0	0	1	8	19	**45**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**4. LBB Gull**	
Bird length	m	0.58	
Wingspan	m	1.42	
Flight speed	m/sec	13.1	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.0197	0	0	0.0205	0.0232	0.018	0	0.0862	0.048	0	0.0294	0
Proportion at rotor height	%	45.45%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	95.00%	**Data sources (if applicable)**
	98.00%	
	98.90%	
	99.00%	

COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		4. LBB Gull
Flight speed	m/sec	13.1
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.01969	0	0	0.0205	0.023228	0.018045	0	0.086183	0.048042	0	0.029429	0	
Proportion at rotor height	%	45.5%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			9648	0	0	11438	14039	10826	0	50761	25973	0	14203	0	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			4385	0	0	5199	6381	4921	0	23073	11806	0	6456	0	**62221**
Collision risk for single rotor transit	(from sheet 3)	6.9%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**290**	**0**	**0**	**328**	**406**	**303**	**0**	**1434**	**755**	**0**	**427**	**0**	**3944**
Option 2-Basic model using proportion from flight distribution			**152**	**0**	**0**	**173**	**214**	**160**	**0**	**754**	**397**	**0**	**225**	**0**	**2075**
Option 3-Extended model using flight height distribution		LBBG													
Proportion at rotor height	(from sheet 4)	23.9%													
Potential bird transits through rotors	Flux integral	0.1522	1468	0	0	1741	2136	1648	0	7725	3953	0	2161	0	**20832**
Collisions assuming no avoidance	Collision integral	0.00708	**65**	**0**	**0**	**74**	**91**	**68**	**0**	**322**	**170**	**0**	**96**	**0**	**886**
Average collision risk for single rotor transit		4.7%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 3**	0.00%	65	0	0	74	91	68	0	322	170	0	96	0	**886**
Collisions assuming avoidance rate	birds per month or year	95.00%	3	0	0	4	5	3	0	16	8	0	5	0	**44**
		98.00%	1	0	0	1	2	1	0	6	3	0	2	0	**18**
		98.90%	1	0	0	1	1	1	0	4	2	0	1	0	**10**
		99.00%	1	0	0	1	1	1	0	3	2	0	1	0	**9**
Collisions after applying large array correction		95.00%	3	0	0	4	5	3	0	16	8	0	5	0	**44**
		98.00%	1	0	0	1	2	1	0	6	3	0	2	0	**18**
		98.90%	1	0	0	1	1	1	0	4	2	0	1	0	**10**
		99.00%	1	0	0	1	1	1	0	3	2	0	1	0	**9**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**5. Herring gull**	
Bird length	m	0.60	
Wingspan	m	1.44	
Flight speed	m/sec	12.8	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.0991	0.1235	0	0	0	0	0	0	0	0.086	0.2829
Proportion at rotor height	%	20.69%											
Proportion of flights upwind	%	50.0%											

			Data sources
Birds on migration data			
Migration passages	birds		
Width of migration corridor	km		
Proportion at rotor height	%		
Proportion of flights upwind	%		

	Units	Value	Data sources
Windfarm data			
Name of windfarm site		**EA THREE**	
Latitude	degrees	52.67	
Number of turbines		172	
Width of windfarm	km	33.25	
Tidal offset	m	0	

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results	95.00%	**Data sources (if applicable)**
	98.00%	
	99.00%	
	99.50%	

COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		5. Herring gull
Flight speed	m/sec	12.8
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.09906	0.12348	0	0	0	0	0	0	0	0	0.085951	0.282877	
Proportion at rotor height	%	20.7%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			47435	56073	0	0	0	0	0	0	0	0	40531	133376	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			9814	11601	0	0	0	0	0	0	0	0	8386	27595	**57396**
Collision risk for single rotor transit	(from sheet 3)	7.1%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**664**	**772**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**569**	**1864**	**3868**
Option 2-Basic model using proportion from flight distribution			**890**	**1035**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**762**	**2498**	**5185**
Option 3-Extended model using flight height distribution		Herring gull													
Proportion at rotor height	(from sheet 4)	27.7%													
Potential bird transits through rotors	Flux integral	0.1862	8832	10440	0	0	0	0	0	0	0	0	7547	24834	**51653**
Collisions assuming no avoidance	Collision integral	0.00937	**423**	**492**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**362**	**1188**	**2465**
Average collision risk for single rotor transit		5.0%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 3**	0.00%	423	492	0	0	0	0	0	0	0	0	362	1188	**2465**
Collisions assuming avoidance rate	birds per month or year	95.00%	21	25	0	0	0	0	0	0	0	0	18	59	**123**
		98.00%	8	10	0	0	0	0	0	0	0	0	7	24	**49**
		99.00%	4	5	0	0	0	0	0	0	0	0	4	12	**25**
		99.50%	2	2	0	0	0	0	0	0	0	0	2	6	**12**
Collisions after applying large array correction		95.00%	21	25	0	0	0	0	0	0	0	0	18	59	**123**
		98.00%	8	10	0	0	0	0	0	0	0	0	7	24	**49**
		99.00%	4	5	0	0	0	0	0	0	0	0	4	12	**25**
		99.50%	2	2	0	0	0	0	0	0	0	0	2	6	**12**

COLLISION RISK ASSESSMENT
Sheet 1 - Input data

used in overall collision risk sheet
used in migrant collision risk sheet
used in single transit collision risk sheet or extended model
used in available hours sheet
used in large array correction sheet
not used in calculation but stated for reference

	Units	Value	Data sources
Bird data			
Species name		**6. GBB Gull**	
Bird length	m	0.71	
Wingspan	m	1.58	
Flight speed	m/sec	13.7	
Nocturnal activity factor (1-5)		3	
Flight type, flapping or gliding		flapping	

Bird survey data													
Daytime bird density	birds/sq km		0.1781	0.2401	0	0.0492	0	0	0.0341	0	0	0.0349	0.0615	0.1928
Proportion at rotor height	%	39.47%												
Proportion of flights upwind	%	50.0%												

Birds on migration data		
Migration passages	birds	
Width of migration corridor	km	
Proportion at rotor height	%	
Proportion of flights upwind	%	

	Units	
Windfarm data		
Name of windfarm site		**EA THREE**
Latitude	degrees	52.67
Number of turbines		172
Width of windfarm	km	33.25
Tidal offset	m	0

	Units	Value											
Turbine data		0											
Turbine model		**7MW turbine**											
No of blades		3											
Rotation speed	rpm	11											
Rotor radius	m	77											
Hub height	m	99.2034											
Monthly proportion of time operational	%		95.23%	93.65%	92.30%	91.04%	91.78%	88.86%	90.00%	89.60%	92.20%	94.29%	95.40%	95.03%
Max blade width	m	5.000											
Pitch	degrees	15											

Avoidance rates used in presenting results		**Data sources (if applicable)**
	95.00%	
	98.00%	
	98.90%	
	99.00%	

COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

All data input on Sheet 1:
no data entry needed on this sheet!

from Sheet 1 - input data
from Sheet 6 - available hours
from Sheet 3 - single transit collision risk
from survey data
calculated field

Bird details:

Species		6. GBB Gull
Flight speed	m/sec	13.7
Nocturnal activity factor (1-5)		3
Nocturnal activity (% of daytime)		50%

Windfarm data:

Latitude	degrees	52.7
Number of turbines		172
Rotor radius	m	77
Minimum height of rotor	m	99.2034
Total rotor frontal area	sq m	3203758

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		95%	94%	92%	91%	92%	89%	90%	90%	92%	94%	95%	95%	92.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.17806	0.24014	0	0.0492	0	0	0.034122	0	0	0.034926	0.061543	0.192847	
Proportion at rotor height	%	39.5%													
Total daylight hours per month	hrs		255	275	367	417	488	503	506	457	382	331	264	240	
Total night hours per month	hrs		489	397	377	303	256	217	238	287	338	413	456	504	
Flux factor			91259	116715	0	28709	0	0	21886	0	0	19259	31062	97320	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			36023	46072	0	11332	0	0	8639	0	0	7602	12261	38416	**160346**
Collision risk for single rotor transit	(from sheet 3)	7.3%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**2505**	**3151**	**0**	**753**	**0**	**0**	**568**	**0**	**0**	**523**	**854**	**2666**	**11020**
Option 2-Basic model using proportion from flight distribution			**1902**	**2393**	**0**	**572**	**0**	**0**	**431**	**0**	**0**	**397**	**649**	**2024**	**8368**
Option 3-Extended model using flight height distribution		GBBG													
Proportion at rotor height	(from sheet 4)	30.0%													
Potential bird transits through rotors	Flux integral	0.2061	18812	24060	0	5918	0	0	4512	0	0	3970	6403	20062	**83737**
Collisions assuming no avoidance	Collision integral	0.01091	**948**	**1193**	**0**	**285**	**0**	**0**	**215**	**0**	**0**	**198**	**323**	**1009**	**4172**
Average collision risk for single rotor transit		5.3%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 3**	0.00%	948	1193	0	285	0	0	215	0	0	198	323	1009	**4172**
Collisions assuming avoidance rate	birds per month or year	95.00%	47	60	0	14	0	0	11	0	0	10	16	50	**209**
		98.00%	19	24	0	6	0	0	4	0	0	4	6	20	**83**
		98.90%	10	13	0	3	0	0	2	0	0	2	4	11	**46**
		99.00%	9	12	0	3	0	0	2	0	0	2	3	10	**42**
Collisions after applying large array correction		95.00%	47	60	0	14	0	0	11	0	0	10	16	50	**208**
		98.00%	19	24	0	6	0	0	4	0	0	4	6	20	**83**
		98.90%	10	13	0	3	0	0	2	0	0	2	4	11	**46**
		99.00%	9	12	0	3	0	0	2	0	0	2	3	10	**42**