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Abbreviations and Acronyms

COWRIE	Collaborative Offshore Wind Research into the Environment
CRM	Collision Risk Model
ES	Environmental Statement
ESAS	European Seabirds at Sea
MSL	Mean Sea Level
MS-LOT	Marine Scotland Licencing and Operations Team
РСН	Potential Collision Height
SD	Standard Deviation
SOSS	Strategic Ornithological Support Services
SNCB	Statutory Nature Conservation Body

11C Estimation of the Development Alone and Cumulative Collision Risk

11C.1 Introduction

- 1 The Scoping Opinion from Marine Scotland Licencing and Operations Team (MS-LOT) identifies six key seabird species on which potential impacts from the Development should be assessed (*Appendix 11A: Baseline Technical Report*). Of these six species, the Scoping Opinion advises that collision risk should be considered for three i.e. gannet, kittiwake and herring gull.
- 2 This report presents the details of the approach and methods used to estimate the potential collision risk to these three seabird species, along with the outputs from the resulting collision risk models (CRMs). This is undertaken both for the different design options being considered for the Development, and for the 2014 and 2017 designs for the other three Forth and Tay wind farms (i.e. Neart na Gaoithe, Seagreen Alpha and Seagreen Bravo).

11C.2 Methods

11C.2.1 Collision risk modelling

- 3 CRMs were undertaken using the Strategic Ornithological Support Services (SOSS) offshore CRM (Band 2012). The SOSS offshore CRM can generate collision estimates by two different methods (basic and extended models), each of which have two different options. The basic model assumes a uniform flight height distribution across the rotor swept heights, whilst the extended model uses species-specific modelled flight height distributions to account for variation in the distribution of flights across the rotor swept heights (Band 2012, Johnston *et al.* 2014a, b). Seabird flight height distributions tend to be skewed towards the lower rotor swept heights, where collision risk is lower (Band 2012), so that for most species the extended model will give lower collision estimates than the basic for a given avoidance rate and set of wind farm parameters.
- Each of the basic and extended models can be run using either site-specific flight height data (i.e. as collected from the development area in question) or generic flight height data, which derive from pre-construction surveys for wind farm developments at 32 sites in the UK and elsewhere in Europe (Johnston *et al.* 2014a, b). This gives rise to options 1 (site-specific flight height data) and 2 (generic flight height data) for the basic model and options 3 (generic flight height data) and 4 (site-specific flight height data) for the extended model (Band 2012).
- 5 Work undertaken to derive species-specific avoidance rates for use with the SOSS offshore CRM failed to identify suitable values for gannet and kittiwake in relation to the extended model (Cook *et al.* 2014). Therefore, as advised in the Scoping Opinion, the CRMs for the current assessment are undertaken using options 1 and 2 for gannet and kittiwake and options 1, 2 and 3 for herring gull. The avoidance rates applied to the CRMs for each species and model option follow the available Statutory Nature Conservation Bodies (SNCBs) advice (SNCBs 2014), and are as advised in the Scoping Opinion (*Table 11C.1*). Variation about the

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estimated collision estimates, as calculated with the recommended avoidance rate, is expressed by applying the mean avoidance rate ±2 standard deviations (SDs).

Species	Model option						
	1	2	3				
Gannet	98.9% (± 0.2%)	98.9% (± 0.2%)	N/A				
Kittiwake	98.9% (± 0.2%)	98.9% (± 0.2%)	N/A				
Herring gull	99.5% (± 0.1%)	99.5% (± 0.1%)	99.0% (± 0.2%)				

Table 11C.1 Avoidance rates (± 2 SD) used in the CRMs according to species and model option

6 Some of the seasonal periods advised for gannet and kittiwake encompassed half months (e.g. for gannet the spring passage and breeding periods were from December to mid-March and mid-March to September, respectively). In these cases, half of the estimated collisions for the 'split' month were allocated to each of the two consecutive seasonal periods encompassing the month (as advised in the Scoping Opinion).

11C.2.2 Bird densities and flight heights

- 7 Collision risk is estimated on the basis of the densities of birds in flight recorded within the Development Area, whilst the flight height estimates are used to determine the percentage of the birds in flight which occur at rotor swept heights. The bird flight density and flight height data used in the current CRMs are as for the CRMs used for the Inch Cape 2013 Environmental Statement (ES) and Marine Scotland 2014 Appropriate Assessment, with these data being treated in the same way as for the earlier CRMs (ICOL 2013, MS-LOT 2014).
- 8 Thus, the flight densities of each species within the Development Area are calculated using data collected during the baseline surveys, which were carried out by an adapted European Seabirds at Sea (ESAS) method and following guidelines for Collaborative Offshore Wind Research into the Environment (COWRIE) (Camphuysen *et al.* 2004, Maclean *et al.* 2009). These surveys were undertaken at approximately monthly intervals, from September 2010 and September 2012 (inclusive). Details of the methods used to count birds in flight and estimate the monthly densities are provided in *Appendix 11A*.
- 9 As advised in the Scoping Opinion, the mean flight densities for each month (as calculated from the values from the different survey years) were used as the inputs to the CRMs. There was only one survey for November (there being no 2010 November survey), whilst the estimates for May 2011 derived from the survey undertaken on 3 June 2011 (there being two separate June surveys but no May survey in 2011). The mean monthly flight densities (with the associated SDs) are given in *Table 11C.2*.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov ¹	Dec
Gannet	0.150	0.556	0.578	2.174	4.328	3.776	3.628	5.134	1.512	1.035	0.193	0.000
	±0.072	±0.235	±0.184	±1.720	±1.286	±1.068	±2.479	±2.388	±0.646	±0.250	-	±0.000
Kittiwake	0.200	0.048	0.569	0.612	0.839	1.998	3.682	0.487	2.495	1.591	0.628	0.347
	±0.001	±0.068	±0.604	±0.422	±0.475	±1.378	±2.826	±0.277	±3.299	±0.036	-	±0.354
Herring gull	0.100	0.048	0.000	0.000	0.024	0.122	0.000	0.024	0.000	0.025	0.048	0.147
	±0.001	±0.000	±0.000	±0.000	±0.035	±0.172	±0.000	±0.034	±0.000	±0.036	-	±0.067
¹ No SD can be calculated for November because there was only a single survey in that month.												

Table 11C.2 Mean monthly flight densities ± 1 SD (birds/km²) for each of the three species for which collision risk is estimated

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- 10 As described above (*Table 11C.2.1*), the CRMs were undertaken using options 1 and 2 for gannet and kittiwake, and options 1, 2 and 3 for herring gull. The option 2 and 3 CRMs used the generic flight height data for each species (Johnston *et al.* 2014a, b). Site-specific flight height data for each species were collected during the ESAS-type baseline surveys, with these data being derived from the entire survey area (encompassing the Development Area and a surrounding four kilometre buffer) to increase sample size. Flight heights were recorded in five metre height bands up to 50 m, above which 10 m bands were used up to 100 m, and subsequently 50 m bands. However, to account for an apparent tendency to bias recording towards the 10 m intervals, the flight height records from the five metre height bands were amalgamated into 10 m bands.
- 11 For gannet and herring gull (the two larger species), the recorded flight heights were used from all observations, irrespective of whether or not they derived from the 300 x 300m snapshot count areas. However, for kittiwake, flight height records were restricted to those deriving from the snapshot count areas. This was on the basis that there was a greater chance of under-recording low flying birds beyond 300 m from the vessel, given the smaller size of this species. Thus, flight heights were estimated for;
 - 12,655, 825 and 911 gannets during the breeding, autumn passage and spring passage periods, respectively;
 - 1,417, 755 and 210 kittiwakes during the breeding, autumn passage and spring passage periods, respectively; and
 - 80 and 253 herring gulls during the breeding and non-breeding periods, respectively.
- 12 For the site-specific data, the percentage of flights occurring within the rotor swept heights (or the potential collision height – PCH) was calculated separately for each of the seasonal periods applied to each species (see below). To calculate the percentage of birds at PCH, the number of birds recorded in those height bands encompassed by PCH was summed and expressed as a percentage of the total number of birds. Where there was partial overlap between a height band and PCH, then the number of birds at PCH within the height band was assumed to be proportional to the extent of overlap (e.g. an overlap of two metres equating to 20 per cent of the records from the 10 m height band being assumed to be at PCH).
- 13 The variability about the percentage of flights estimated at PCH by the site-specific data was calculated for both gannet and kittiwake, and compared with the estimates from the generic data. This was not undertaken for herring gull because of the relatively small number of flights of this species recorded during the 'at-sea' surveys, whilst the difference in the collision estimates between options 1 and 2 of the CRM were less marked for this species than for either gannet or kittiwake see below).
- 14 Variability in the site-specific estimates was calculated by making the number of flights recorded at PCH during each survey the dependent variable in a regression with a quasibinomial error structure and logit link function, and with the total number of birds recorded in flight during the survey made the binomial denominator (Crawley 2007). By fitting the null

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model (i.e. with no covariates or factors included), the resulting parameter estimate equates to the logit transformed mean value for the dependent variable divided by the total number of birds in flight. The 95 per cent confidence limits for this mean value were calculated, so that the back transformed values gave the estimated proportion of flights at PCH together with the associated upper and lower 95 per cent confidence limits. This calculation was undertaken separately for each seasonal period for both species. A quasi-binomial error structure was used instead of a binomial error structure to account for over-dispersion in some of the models (i.e. where the residual deviance over the residual degrees of freedom exceeds one). The use of a quasi-binomial error is more conservative in that it estimates greater variation about the mean. These calculations were undertaken in the R statistical software (R Development Core Team, 2012).

15 The generic flight height data are available as estimates of the percentage of flights occurring at one metre intervals from 0 - 1 m to 299 - 300 m, with lower and upper 95 per cent confidence limits for each estimate¹. For the purposes of comparisons with the site-specific flight estimates, these estimates and their confidence limits were summed across the one metre height intervals encompassed by the rotor swept heights.

11C.2.3 Other species-specific parameters

16 In addition to the estimates of density and flight height, the input parameters for the CRM include data on a number of other attributes of the species for which collision risk is being estimated. These are detailed below for the three species on which CRMs were undertaken for the current assessment (*Table 11C.3*).

Species	Parameter					
	Bird length (m) ¹	Wingspan (m) ¹	Flight speed (m.s ⁻¹) ²	Flight type	Nocturnal activity ³	
Gannet	0.94	1.73	14.9	flapping	1 (=0%)	
Kittiwake	0.39	1.08	13.1	flapping	2 (=25%)	
Herring gull	0.60	1.44	12.8	flapping	2 (=25%)	
¹ From BTO Birdfacts (<u>https://www.bto.org/about-birds/birdfacts</u>) [Accessed 10/05/2018].						
² From Pennycuik (1997) for gannet and Alerstam <i>et al.</i> (2007) for kittiwake and herring gull.						
³ Following the advice of the Scoping Opinion.						

Table 11C.3 Details of species-specific parameters used as in the C	RMs
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¹ <u>https://www.bto.org/science/wetland-and-marine/soss/projects</u> [Accessed 10/05/2018]

11C.3.1 Design options

17 In relation to collision risk, two design options are considered for the Development (both with a total rotor swept area of 87,000 m² below 50 m above Mean Sea Level (MSL). These differ in the number of Wind Turbine Generators (WTGs), the WTG hub height and rotor blade diameter, as well as in the maximum rotor blade width and estimated rotor speed (Table 11C.4). For both designs, there are fewer WTGs than for the 2014 design on which the previous Appropriate Assessment was undertaken (MS-LOT 2014), whilst the greater hub heights result in greater clearance above the sea surface (despite the larger rotor diameters associated with these designs).

 Table 11C.4 Wind farm parameters used in the CRMs for the two design options considered

 (together with the parameters used in the 2014 design presented for comparison)

Parameter	2014	2017 designs		
	Appropriate Assessment design	40 WTG	72 WTG	
Number of WTGs	110	40	72	
Hub height (relative to MSL) (m) ^{1,2}	110.97	152.6	116.1	
Rotor diameter (m)	172	250	167	
Height to upper blade tip (relative to MSL) (m) 1,2	196.97	277.6	199.6	
Height to lower blade tip (relative to MSL) (m) 1,2	24.97	27.6	32.6	
Maximum blade width (m)	6.0	7.8	6.0	
Rotor speed (rpm) ³	7.39	5.72	8.72	
Pitch (°)	10	10	10	
Monthly percentage of time operational (%) ³	91	80	80	

¹Values are given relative to MSL because the CRM is calculated using MSL. MSL is 2.9m above LAT for the Development Area.

²Values represent the average heights above MSL. Heights vary because of changes in water depth across the site. Turbine parameters will not exceed those as detailed in *Chapter 7: Description of Development* and will be such that the CRM estimates do not exceed those calculated for the assessment (on the basis of the data, methods and assumptions used here).

³Values are estimated on a monthly basis with the annual mean for all months presented. The CRM uses the mean values from across the months comprising the relevant seasonal periods (see below). The values used in each CRM can be obtained from *Annex 11C.1*.

11C.3.2 Collision estimates

Differences between designs

- 18 Collision estimates for gannet and kittiwake were lower for the 72 WTG design than for the 40 WTG design, (almost) irrespective of seasonal period and model option (*Table 11C.5*). The only exceptions were for the option 2 autumn and spring passage estimates for gannet, which were the same for both designs. This finding may appear counter-intuitive, given that the collision estimates will increase in direct proportion to WTG number (all else being equal). However, the 'air gap' (i.e. distance from sea surface to lower rotor blade height) for the 72 WTG is five metres higher than for the 40 WTG design (*Table 11C.4*) and this more than compensates for the greater number of WTGs in terms of reducing the collision estimates, with a smaller percentage of birds at PCH for the 72 WTG design (*Table 11C.6*). Overall, the differences between the two designs were relatively small for both of these species, which is expected given that the two designs had the same rotor swept area below 50 m MSL.
- 19 Collision estimates for herring gull were low, with a maximum of one and three collisions estimated for the breeding and non-breeding periods, respectively. These estimates were lower than for either gannet or kittiwake, except for the option 1 breeding season estimates for kittiwake, which were the same as for herring gull. Given the very low number of estimated collisions for herring gull, the differences between the two designs were minor. The 72 WTG design gave lower estimates during the breeding season for option 1 but higher estimates during the non-breeding season for both options 2 and 3, and represented the worst-case for this species overall. However, in all cases the differences between the two designs equated to a single collision (*Table 11C.5*).

Species	Design	Seasonal period	Estimated number of collisions (range with ±2 SD applied to avoidance rate) ¹				
			Option 1	Option 2	Option 3		
Gannet	72 WTG	Breeding (mid-Mar – Sep)	32 (26 – 38)	96 (79 – 113)	N/A		
		Autumn passage (Oct – Nov)	0 (0 - 0)	5 (4 - 6)	N/A		
		Spring passage (Dec – mid-Mar)	0 (0 – 0)	4 (3 – 5)	N/A		
	40 WTG	Breeding (mid-Mar – Sep)	46 (38 – 54)	108 (88 – 128)	N/A		

Table 11C.5 Collision estimates according to wind farm design and CRM option

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Species	Design	Seasonal period	Estimated number of collisions (range with ±2 SD applied to avoidance rate) ¹				
			Option 1	Option 2	Option 3		
		Autumn passage (Oct – Nov)	1 (0.8 – 1.2)	5 (4 – 6)	N/A		
		Spring passage (Dec – mid-Mar)	1 (0.8 – 1.2)	4 (3 – 5)	N/A		
Kittiwake	72 WTG	Breeding (mid-Apr – Aug)	0 (0 - 0)	36 (29 – 43)	N/A		
		Autumn passage (Sep – Dec)	7 (6 – 8)	23 (19 – 27)	N/A		
		Spring passage (Jan – mid-Apr)	1 (0.8 – 1.2)	5 (4 – 6)	N/A		
	40 WTG	Breeding (mid-Apr – Aug)	1 (0.8 – 1.2)	40 (33 – 47)	N/A		
		Autumn passage (Sep – Dec)	19 (16 – 23)	26 (21 – 31)	N/A		
		Spring passage (Jan – mid-Apr)	3 (2 - 4)	6 (5 – 7)	N/A		
Herring gull	72 WTG	Breeding (Apr – Aug)	0 (0 - 0)	1 (0.8 – 1.2)	1 (0.8 – 1.2)		
		Non-breeding (Sep – Mar)	1 (0.8 – 1.2)	3 (2 - 4)	2 (1.6 – 2.4)		
	40 WTG	Breeding (Apr – Aug)	1 (0.8 – 1.2)	1 (0.8 – 1.2)	1 (0.8 – 1.2)		
		Non-breeding (Sep – Mar)	1 (0.8 – 1.2)	2 (1.6 – 2.4)	1 (0.8 – 1.2)		

Ι

¹Avoidance rates applied to each combination of species and model option are as given in *Table 11C.1*, as are the values for the SD about the estimated avoidance rate.

Differences between model options

20 For both gannet and kittiwake, the option 1 collision estimates were considerably lower than the option 2 estimates (Table 11C.5). These differences were most marked for kittiwake,

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particularly during the breeding period (with the option 1 estimates being zero and one collisions for the 72 and 40 WTG designs, respectively), but were also substantial for gannet (with the option 2 estimates for the breeding period being three and two and half times greater than for option 1 for the 72 and 40 WTG designs, respectively).

21 These differences are due to the lower percentage of flights estimated to occur at PCH by the site-specific flight height data than by the generic flight height data (*Table 11C.6, Appendix 11A*). Consideration of the statistical variability associated with these estimates demonstrates that for gannet and kittiwake the estimates for flights at PCH using the generic data exceeds the upper 95 per cent confidence limit for the site-specific estimates in all but two instances (i.e. kittiwake spring passage for the 72 WTG design and kittiwake autumn passage for the 40 WTG design). Also, there is no overlap in the 95 per cent confidence intervals for the respective generic and site-specific estimates in five of the 12 comparisons for gannet and kittiwake (most notably for kittiwake during the breeding period - *Table 11C.6*). Thus, there is relatively strong statistical support for the observed differences in the site-specific and generic flight height estimates.

Species	Design	Seasonal period	CRM option	
			1	2
Gannet	72 WTG	Breeding	1.1 (0.5 – 2.3)	3.3 (1.1 – 7.4)
		Autumn passage	0.2 (0.1 – 0.4)	3.3 (1.1 – 7.4)
		Spring passage	0.0 (0.0 – 0.0)	3.3 (1.1 – 7.4)
	40 WTG	Breeding	2.4 (1.1 – 4.5)	5.6 (2.1 – 11.0)
		Autumn passage	1.2 (0.5 – 2.3)	5.6 (2.1 – 11.0)
		Spring passage	0.6 (0.0 – 1.9)	5.6 (2.1 – 11.0)
Kittiwake	72 WTG	Breeding	0.0 (0.0 – 0.0)	4.3 (3.0 – 5.8)
		Autumn passage	1.3 (0.2 – 3.8)	4.3 (3.0 – 5.8)
		Spring passage	0.8 (0.0 – 5.0)	4.3 (3.0 – 5.8)
	40 WTG	Breeding	0.2 (0.0 – 0.37)	7.1 (5.1 – 9.1)
		Autumn passage	5.2 (2.6 – 8.2)	7.1 (5.1 – 9.1)
		Spring passage	3.0 (0.3 – 5.1)	7.1 (5.1 – 9.1)
Herring gull	72 WTG	Breeding	5.0	15.1 (10.5 – 25.6)

Table 11C.6 Percentage of flights estimated to occur at PCH (with 95 per cent confidence
limits ¹) on the basis of the site-specific and generic flight height data for the two design
options

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Species	Design	Seasonal period	CRM option				
			1 2				
		Non-breeding	3.6	15.1 (10.5 – 25.6)			
	40 WTG	Breeding	9.6	20.3 (14.8 – 31.7)			
		Non-breeding	9.8	20.3 (14.8 – 31.7)			
¹ Confidence limits not calculated for the herring gull site-specific estimates because these are based on relatively small sample of flights (see text).							

- 22 Such differences in the estimated percentage of birds at PCH between the site-specific and generic flight height data are not particularly surprising, given that for both gannet and kittiwake the analyses of the generic flight height data suggest high between-site variability for these two species and a low confidence in the applicability of the estimated flight heights to new sites (Johnston *et al.* 2014a, b). At least some of these differences for kittiwake may be associated with seasonal effects (Johnston and Cook, 2016). Furthermore, a high proportion of the sites which contribute to the generic flight heights are in more southerly locations than the Development Area and relatively far from major breeding colonies of both gannet and kittiwake. Therefore, the generic flight heights for gannet and kittiwake may be biased towards passage or wintering birds (which for kittiwake, at least, fits with the closer match to the autumn and spring passage site-specific flight heights).
- The reliability of seabird flight height estimates derived from subjective 'by eye' estimation during boat-based surveys (as undertaken to collect the current site-specific flight heights and the majority of the generic flight heights also *Appendix 11A*, Johnston *et al.* 2014a, b) has been questioned (Cleasby et al. 2015, Green et al. 2016). However, although it is likely that there will be error about the estimates that are generated by this method, there appears to be no evidence to suggest any inherent systematic bias in the method (or in the resulting estimates).
- 24 Considering the site-specific flight estimates for gannet and kittiwake, it is clear that any systematic bias towards underestimating flight height would have to be substantial to account for the observed differences between these and the generic flight heights. This is most readily apparent for kittiwake. Using the data for the breeding period (for which sample size is largest, and the collision estimates from option 2 highest), the site-specific data estimate 10.4 per cent of kittiwake flights to be above 10 m, 0.6 per cent to be above 20 m and no flights above 30 m (*Appendix 11A*). Therefore, the heights of almost 70 per cent of the flights estimated to be above 10 m would have to be underestimated by at least 8 to 18 m to match the 7.1 per cent of flights estimated to be at PCH by the generic flight data for the 40 WTG design (for which the 'air gap' is 28 m, relative to MSL). For the 72 WTG design (for which the 'air gap' is 23 m relative to MSL), the equivalent comparison suggests that over 40 per cent of flight heights estimated to be above 10 m would have to be underestimated by at least 13 to 23 m to match the 4.3 per cent of kittiwakes estimated to be at PCH by the generic flight height data.

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Estimating Development-alone collisions according to population age classes

25 Age distributions for gannet, kittiwake and herring gull were derived from plumage characteristics of birds recorded during the ESAS-type surveys of the Development Area and four kilometre buffer (*Appendix 11A*). The breakdown of age classes for each species in each seasonal period according to these data is summarised in *Table 11C.7*.

Table 11C.7 Species age distributions by seasonal period in the Development Area and four
kilometre buffer as estimated on the basis of plumage characteristics during the ESAS-type
baseline surveys.

Species	Seasonal period	Age class				
		Adults	Immatures	Juveniles		
Gannet	Breeding	97%	2%	1%		
	Autumn passage	94%	2%	4%		
	Spring passage	98%	2%	0%		
Kittiwake	Breeding	93%	3%	4%		
	Autumn passage	59%	<1%	40%		
	Spring passage	83%	5%	12%		
Herring gull	Breeding	79%	21%	0%		
20	Non-breeding	55%	28%	17%		

26 Applying these age distributions to the Development-alone collision estimates for the 40 WTG design for gannet and kittiwake and the 72 WTG design for herring gull (i.e. the worst case for each species), suggests that there would be 105, 37 and 1 collisions to adult gannets, kittiwakes and herring gulls, respectively, during the breeding period based upon the option 2 CRMs for the former two species and the option 3 CRM for the latter. For the option 1 CRMs, the equivalent estimates of breeding period collisions to adult birds are 45, 1 and 0 for gannets, kittiwakes and herring gulls, respectively. However, the Scoping Opinion advised that 10 per cent of adult gannets and adult kittiwakes, and 35 per cent of adult herring gulls should be assumed to be sabbatical birds, so that the estimated collisions to the breeding adults from the regional population are correspondingly lower (*Table 11C.8*). For gannet and kittiwake, no correction was made for assumed sabbatical birds within the passage period collision estimates due to the different approach taken to the apportioning of these estimates to different colony populations (see *Appendix 11B*).

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Table 11C.8 Development-alone collision estimates for the 40 WTG design for gannet and kittiwake and the 72 WTG for herring gull, apportioned to age classes and accounting for the assumed occurrence of sabbatical birds amongst the adult age class¹

Species	Seasonal	Estimated number of collisions ²						
	period		Option 1		Option 2 or 3 ³			
		Adults	Immatures	Juveniles	Adults	Immatures	Juveniles	
Gannet	Breeding	40.2	0.9	0.5	94.3	2.1	1.1	
	Autumn passage	0.9	0.0	0.0	4.7	0.1	0.2	
	Spring passage	1.0	0.0	0.0	3.9	0.1	0.0	
Kittiwake	Breeding	0.8	0.0	0.0	33.5	1.2	1.6	
	Autumn passage	11.2	0.2	7.6	15.3	0.0	10.4	
	Spring passage	2.5	0.1	0.4	5.0	0.3	0.7	
Herring	Breeding	0.0	0.0	0.0	0.5	0.2	0.0	
2011	Non- breeding	0.2	0.3	0.2	0.7	0.6	0.3	

¹The collision estimates for the adult age class have been reduced by 10 % for gannet and kittiwake and by 35 % for herring gull to take account of sabbatical birds (with these percentages as advised in the Scoping Opinion), although for gannet and kittiwake this reduction is only applied to the breeding period estimates and not to those for the passage periods due the different apportioning method used.

²Collision estimates are presented to 1 decimal place due to the small numbers involved for some CRM options and age classes.

³Option 2 estimates are presented for gannet and kittiwake, and option 3 estimates for herring gull.

11C.3.3 Effects of variable WTG heights

As indicated in *Table 11C.4*, the WTG hub heights available for both the 72 WTG and 40 WTG designs are average values taken from across the Development Area because of the variation in water depth across the site. This could result in underestimating collision risk if the increase in the estimated percentage of birds at PCH that arises from a reduction in hub height is greater than the concomitant decrease resulting from an equivalent increase in hub height. However, ICOL will commit to ensuring that the range of hub heights used within the Wind Farm will be such as to give collision estimates (on the basis of the data, methods and assumptions used here) which do not exceed the worst case presented in *Table 11C.5* for gannet, kittiwake or herring gull.

11C.4 Cumulative collision estimates for the Forth and Tay wind farms

11C.4.1 Collision estimates for the other Forth and Tay wind farms

- 28 To estimate the cumulative impacts of collisions from the Wind Farm with the other three Forth and Tay wind farms, CRMs were also undertaken for Neart na Gaoithe and the Seagreen Alpha and Bravo proposed developments. These were undertaken for both the consented 2014 designs as well as for the 2017 designs (to the extent that was possible from the available information on the 2017 designs).
- 29 The CRM spreadsheets for these proposed developments, as used for the purposes of the 2014 Appropriate Assessment (MS-LOT 2014), were supplied by the respective developers. For the purposes of estimating collisions for the 2014 designs, the input parameters were amended only to reflect the revised seasonal periods (as advised in the Scoping Opinion) and the species-specific nocturnal activity scores advised in the Scoping Opinion (*Table 11C.3*). The information available on the respective 2017 designs for each of the proposed developments was used to amend the relevant CRM input parameters and provide collision estimates for these designs. Information on the site-specific flight height data was not available for all these proposed developments, so that these CRMs used only option 2 (for all three species) and option 3 (for herring gull). The avoidance rates (and associated SDs) were as used in the CRMs for the Wind Farm (*Table 11C.1*). Details of the wind farm parameters used for the 2014 and 2017 designs for Neart na Gaoithe and Seagreen Alpha and Bravo are presented in *Table 11C.9*, with the associated collision estimates presented in *Table 11C.9*.

Parameter	Neart na Gaoithe		Seagreen Alpha		Seagreen Bravo	
	2014	2017	2014	2017	2014	2017
Number of WTGs	75	54	75	60	75	60
Hub height (relative to MSL) (m) ¹	104.5	118.5	111.0	136.8	111.0	136.8
Rotor diameter (m)	154	167	167	220	167	220
Height to upper blade tip (relative to MSL) (m) ¹	181.5	202.0	194.5	246.8	194.5	246.8
Height to lower blade tip (relative to MSL) (m) ¹	27.5	35.0	27.5	26.8	27.5	26.8
Maximum blade width (m)	5.0	5.0	5.4	5.4	5.4	5.4
Rotor speed (rpm) ²	8.00	8.00	10.64	10.64	10.64	10.64
Pitch (°)	15	15	10	10	10	10

Table 11C.9 Wind farm parameters used in the CRMs for the 2014 and 2017 designs for the other Forth and Tay proposed developments

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Parameter	Neart na Gaoithe		Seagreen Alpha		Seagreen Bravo		
	2014	2017	2014	2017	2014	2017	
Monthly percentage of time operational (%) ²	86	86	88	88	88	88	
¹ Values were provided in relation to LAT but are presented relative to MSL because the CRM is calculated using MSL. MSL is taken to be 2.65 m above LAT for Neart na Gaoithe (based on the tidal offset value used in the 2014 CRM sheets for this wind farm), and 2.9 m above LAT for Seagreen (based on the value for Inch Cape). ² For Seagreen Alpha and Bravo values are estimated on a monthly basis with the annual mean for all months presented. The CRM uses the mean values from across the months comprising the relevant seasonal periods (see below). The values used in each CRM can be obtained from <i>Annex 11C.1</i> .							

Table 11C.10 Collision estimates for the other Forth and Tay proposed developments according to the 2014 and 2017 designs. (Seasonal periods are as defined in *Table 11C.5*).

Development	Species	Seasonal period	Estimated number of collisions (range with ±2 SD applied to avoidance rate) ¹				
			201	4	2017		
			Option 2	Option 3	Option 2	Option 3	
Neart na Gaoithe	Gannet	Breeding	196 (160 – 232)	N/A	69 (56 – 82)	N/A	
		Autumn passage	14 (11 – 17)	N/A	5 (4 – 6)	N/A	
		Spring passage	14 (11 – 17)	N/A	5 (4 – 6)	N/A	
	Kittiwake	Breeding	18 (15 – 21)	N/A	7 (6 – 8)	N/A	
		Autumn passage	33 (27 – 39)	N/A	12 (10 – 14)	N/A	
		Spring passage	3 (2 – 4)	N/A	1 (0.8 – 1.2)	N/A	
	Herring gull	Breeding	3 (2 – 4)	3 (2 – 4)	2 (1.6 – 2.4)	1 (0.8 – 1.2)	
		Non-breeding	6 (5 – 7)	5 (4 – 6)	3 (2 – 4)	2 (1.6 – 2.4)	
Seagreen Alpha	Gannet	Breeding	279 (228 – 330)	N/A	278 (227 – 329)	N/A	
		Autumn passage	11 (9 – 13)	N/A	11 (9 – 13)	N/A	

OGICAL ENVIRONMENT fumulative Collision Risk	11C
collisions	

Development	Species	Seasonal period	Estimated number of collisions (range with ±2 SD applied to avoidance rate) ¹				
			201	.4	2017		
			Option 2 Option 3		Option 2	Option 3	
		Spring passage	12 (10-14)	N/A	12 (10 – 14)	N/A	
	Kittiwake	Breeding	78 (64 – 92)	N/A	74 (61 – 87)	N/A	
		Autumn passage	116 (95 – 137)	N/A	112 (92 – 132)	N/A	
		Spring passage	43 (35 – 51)	N/A	42 (34 – 50)	N/A	
	Herring gull	Breeding	4 (3 – 5)	3 (2 - 4)	4 (3 – 5)	3 (2 – 4)	
		Non-breeding	7 (6 – 8)	5 (4 – 6)	6 (5 – 7)	5 (4 – 6)	
Seagreen Bravo	Gannet	Breeding	176 (144 – 208)	N/A	175 (143 – 207)	N/A	
		Autumn passage	13 (11 – 15)	N/A	13 (11 – 15)	N/A	
		Spring passage	13 (11 – 15)	N/A	13 (11 – 15)	N/A	
	Kittiwake	Breeding	84 (69 – 99)	N/A	80 (65 – 95)	N/A	
		Autumn passage	64 (52 – 76)	N/A	62 (51 – 73)	N/A	
		Spring passage	56 (46 – 66)	N/A	54 (44 – 64)	N/A	
	Herring gull	Breeding	3 (2 – 4)	2 (1.6 – 2.4)	3 (2 – 4)	2 (1.6 – 2.4)	
		Non-breeding	5 (4 – 6)	4 (3 – 5)	5 (4 – 6)	4 (3 – 5)	

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11C.4.2 Estimating cumulative collisions for the Forth and Tay wind farms according to population age classes

30 Age distributions for gannet, kittiwake and herring gull, as based on boat-based survey data from the respective proposed wind farms, were available for Neart na Gaoithe and Seagreen Alpha and Bravo. These age distributions were supplied by the respective developer for Neart na Gaoithe and extracted from the Seagreen ES (Seagreen 2012), and were available only as adults and sub-adults², with immatures and juveniles not distinguished (*Table 11C.11*).

Table 11C.11 Percentage of adults by seasonal period in the counts of each species on the proposed development areas for Neart na Gaoithe, Seagreen Alpha and Seagreen Bravo (as determined from plumage characteristics)

Proposed development	Species	Seasonal period	Percentage of adults (%)
Neart na Gaoithe	Gannet	Breeding	97
		Autumn passage	94
		Spring passage	98
	Kittiwake	Breeding	93
		Autumn passage	57
		Spring passage	79
	Herring gull	Breeding	77
		Non-breeding	69
Seagreen Alpha	Gannet	Breeding	97
		Autumn passage	89
		Spring passage	98
	Kittiwake	Breeding	93
		Autumn passage	67
		Spring passage	87
	Herring gull	Breeding	64
		Non-breeding	48
Seagreen Bravo	Gannet	Breeding	98

² The term sub-adult is used where no distinction is made between immatures and juveniles.

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Proposed development	Species	Seasonal period	Percentage of adults (%)
		Autumn passage	97
		Spring passage	99
	Kittiwake	Breeding	95
		Autumn passage	72
		Spring passage	83
	Herring gull	Breeding	78
		Non-breeding	50

31 The age distributions in Table 11C.11 were applied to the collision estimates for the 2014 and 2017 designs of the respective proposed developments (Table 11C.10) to provide the breakdown of collisions by population age class. As for the Development-alone, the collision estimates for adults were amended to account for assumed sabbatical birds (using the percentages advised in the Scoping Opinion, but noting that this was not applied to the passage period collision estimates for gannet or kittiwake - see above). The cumulative collision estimates for the breeding adult and sub-adult age classes for the Development together with the other three Forth and Tay developments were then calculated using the CRM option 2 estimates for gannet and kittiwake, and the option 3 estimates for herring gull (again as derived for the 40 WTG design for the Development). These cumulative collision estimates are presented in Table 11C.12 below.

Table 11C.12 Cumulative collision estimates for the Wind Farm together with the other Forth and Tay proposed wind farms apportioned to age classes, and accounting for the assumed occurrence of sabbatical birds amongst the adult age class¹. Estimates are based upon the 40 WTG design for the Wind Farm.

Species	Seasonal period	Estimated number of collisions by option 2 (gan and kittiwake) and option 3 (herring gull)				
		2014 design for other developments		-	gn for other opments	
		Adults	Sub- adults	Adults	Sub-adults	
Gannet	Breeding	664	21	552	17	
	Autumn passage	40	3	32	2	
	Spring passage	42	1	33	1	
Kittiwake	Breeding	186	14	170	12	

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Species	Seasonal period			ollisions by opt d option 3 (her	
		2014 desigi develop		-	gn for other pments
		Adults	Sub- adults	Adults	Sub-adults
	Autumn passage	158	81	142	70
	Spring passage	91	17	87	16
Herring gull	Breeding	4	2	3	2
	Non-breeding	6	7	4	6

¹The collision estimates for the adult age class have been reduced by 10 % for gannet and kittiwake and by 35 % for herring gull to take account of sabbatical birds (with these percentages as advised in the Scoping Opinion) although for gannet and kittiwake this reduction is only applied to the breeding period estimates and not to those for the passage periods due to the different apportioning method used.

References

Alerstam, T., Rosen, M., Backman, J., Ericson, P.G.P. and Hellgren, O. (2007). Flight speeds among bird species: Allometric and phylogenetic effects. *PLoS Biology* 5: 1656-1662.

Band, W. (2012). Using a collision risk model to assess bird collision risks for offshore wind farms. Available <u>http://www.bto.org/sites/default/files/u28/downloads/Projects/Final_Report_SOSS02_Band1Model</u> <u>Guidance.pdf</u> [Accessed 10/05/2018]

Camphuysen, C. J., Fox, A. D. and Leopold, M. F. (2004). Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K: A comparison of ship and aerial sampling for marine birds, and their applicability to offshore wind farm assessments. *Report commissioned by COWRIE*.

Cleasby, I.R., Wakefield, E.D., Bearhop, S., Bodey, T.W., Votier, S.C. and Hamer, K.C. (2015). Threedimensional tracking of a wide-ranging marine predator: flight heights and vulnerability to offshore wind farms. *Journal of Applied Ecology*, 52: 1474-1482.

Cook, A.S.C.P., Humphreys, E.M., Masden, E.A. and Burton, N.H.K. (2014). The avoidance rates of collision between birds and offshore turbines. *BTO Research Report* no. 656.

Crawley, M.J. (2007). The R Book. John Wiley & Sons Ltd, Chichester.

Green, R.E., Langston, R.H.W., McCluskie, A., Sutherland, R. and Wilson, J.D. (2016). Lack of sound science in assessing wind-farm impacts on seabirds. *Journal of Applied Ecology* 53: 1635-1641.

ICOL (2013). Offshore Environmental Statement: Offshore Ornithology Technical Report. Appendix 15A. Volume 2F.

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

Johnston, A., Cook, A.S.C.P., Wright, L.J., Humphreys, E.M. and Burton, N.H.K. (2014b). Corrigendum. *Journal of Applied Ecology* 51: 1126-1130.

Johnston, A. and Cook, A.S.C.P. (2016). How high do birds fly? Development of methods and analysis of digital aerial data of seabird flight heights. *BTO Research Report*, no. 676. BTO, Thetford.

Maclean, I. M. D., Wright, L. J., Showler, D. A. and Rehfisch, M. M. (2009). A review of assessment methodologies for offshore wind farms. *British Trust for Ornithology Report* Commissioned by COWRIE.

MS-LOT (2014). Appropriate Assessment for the Forth and Tay wind farms. Available at: <u>http://www.gov.scot/Resource/0046/00460542.pdf</u> [Accessed 10/05/2018].

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Pennycuick, J. (1997). Actual and 'optimum' flight speeds: field data reassessed. *The Journal of Experimental Biology* 200: 2355–2361.

R Development Core Team (2012). R: A language and environment for statistical computing. *R Foundation for Statistical Computing*, Vienna, Austria. <u>http://www.R-project.org</u>

Seagreen (2012). Firth of Forth Environmental Statement. Seagreen Wind Energy Limited.

SNCBs (2014). Joint response from the Statutory Nature Conservation Bodies to the Marine Scotland Science avoidance rate review.

ANNEX 11C.1: Excel worksheets showing the input parameters used for the different collision risk models

Development CRMs – 72 WTG design

Gannet

COLLISION RISK ASSESSMENT			used in ove	rall collision	risk sheet								used in av	ailable hou	rs sheet						
Sheet 1 - Input data			used in mig	rant collision	n risk sheet								used in lar	ge array co	orrection	sheet					
			used in sin	, gle transit co	llision risk s	neet or exter	nded model	1					not used ir				eference	Э			
	Units	Value		Data source	ces																
Bird data																					
Species name		Gannet																			
Bird length	m	0.94																	Murray G		
Vingspan	m	1.73																	For 2017	rant: advised seas	onal periods,
Flight speed	m/sec	14.9																	values sho		onai penous,
Nocturnal activity factor (1-5)		1																	Breeding s		%
light type, flapping or gliding		flapping																	Aut pass -		
				Data source	ces														Spr pass -	0.0%	
Bird survey data			Jan	Feb	Mar	Apr	May	Jun		Jul	Aug		Sep	Oct	Nov		Dec				
Daytime bird density	birds/sq km		0.150	0.55	6 0.578			.328	3.7765	3.62		5.134	1.51		355	0.193		0	٦		
Proportion at rotor height	%	1.1%																			
Proportion of flights upwind	%	50.0%																Ĩ			
				Data source	es																
Birds on migration data																					
Aigration passages	birds) (0	0	0	0	0		0	0	200	0 4	000	0		0			i i
Width of migration corridor	km																				
Proportion at rotor height	%																				
Proportion of flights upwind	%	50.0%																			
	Units	Value		Data source	es																
Vindfarm data											_										
Name of windfarm site		IC - Large																			
_atitude	degrees	56.49																			
Number of turbines	augrooo	72									_								Murray	Grant:	
Vidth of windfarm	km	6.774																			e unique for
	m																				od as follows:
	Units	Value		Data source	es			_			_			_						ig - 7.89	
Furbine data	•	Turuo		Data court			-			-	-								Aut pas	s - 9.68 pass - 9.93	
Furbine model											_								Spring i	pass - 9.93	
No of blades		2	Jan	Feb	Mar	Apr	May	Jun		Jul	Aug		Sep	Oct	Nov		Dec		-		
Rotation speed	rpm	7.89						7.66	7.15	5ui 6.		7.19	3ep 8.4		9.41	9.96		0.12			-
Rotor radius	m	83.5		5 9.0	, 9.0	0.		1.50	7.13	0.	-	1.19	0.4		J71	3.30	- · · ·	0.12			
Hub height	m	116.1		Feb	Mar	Apr	May	Jun		Jul	Aug		Sep	Oct	Nov		Dec			-	
Monthly proportion of time operational	%	110.1	Jan 89%					74%	71%	5ui 69		72%	3ep 789		36%	87%		88%			
Max blade width	m	6.000		5 057	0 00	11	/0	1 - 1 / 0	7170	03	/0	1 2 /0	10	/0 0	0/0	0770		0070			-
Pitch	degrees	10					_														-

<u>Kittiwake</u>

COLLISION RISK ASSESSMENT			used in a	overall col	lision risk	sheet					used in	available l	hours she	et					
Sheet 1 - Input data			used in I	migrant co	ollision ris	k sheet					used in	large arra	y correcti	on sheet					
			used in s	single trar	nsit collisi	on risk sł	neet or ex	tended m	odel		not used	d in calcul	ation but	stated for r	eference				
	Units	Value		Data so	urces														
Bird data																			
Species name		Ki																	
Bird length	m	0.39																	
Wingspan	m	1.08																	
Flight speed	m/sec	13.1																	
Nocturnal activity factor (1-5)		2													m	rray.grant	:		
Flight type, flapping or gliding		flapping															ed seasonal p	periods,	
				Data sou	urces											ues should b			
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		eding seaso			
Daytime bird density	birds/sq km		0.2	0.048										0.347		t pass - 1.32			
Proportion at rotor height	%	0.80%	4												Spi	pass - 0.8%	70		
Proportion of flights upwind	%	50.0%																	
				Data so	urces														
Birds on migration data																			
Migration passages	birds		0) 0	0	4000	2000	0) 0	0	2000	4000) 0					
Width of migration corridor	km	8		, 0	U	1000	2000		, 0		2000		, c	, 0			_		
Proportion at rotor height	%	75%															_		
Proportion of flights upwind	%	50.0%																	
	Units	Value		Data so	Ircas								-						
Windfarm data	Units	Value		Data Sol	uices														
Name of windfarm site		Inch Cape																	
Latitude	degrees	56.49																	
Number of turbines	uegrees	72																	
Width of windfarm	km	6.774														murray.g			
Tidal offset	m	0.774																e on seasons	· –
Ildai oliset	Units	Value		Data an												Aut pass	season = 7.4	2	
Turking data	Units	vaiue		Data so	urces											Spr pass			
Turbine data																Spi pass	- 5.50		
Turbine model	La	arge turbine		-							-	-		_					
No of blades			Jan		Mar	Apr		Jun	Jul	Aug	Sep	Oct	Nov	Dec					
Rotation speed	rpm	7.42		9.67	9.68	8.38	7.66	7.15	6.72	7.19	8.45	9.41	9.96	5 10.12					
Rotor radius	m	83.5										-							
Hub height	m	116.1		Feb	Mar	Apr		Jun	Jul	Aug	Sep	Oct	Nov	Dec					
Monthly proportion of time operational	%		89%	85%	86%	77%	74%	71%	69%	72%	78%	86%	87%	88%					
Max blade width	m	6.000																	
Pitch	degrees	10																	

Appendix 11C

<u>Herring gull</u>

COLLISION RISK ASSESSMENT			used in over	rall collision r	isk sheet							used in	n availat	le hours s	heet						
Sheet 1 - Input data			used in mig	rant collision	risk sheet							used in	large a	rray correct	ction sheet						
·			used in sing	le transit col	lision risk sh	eet or extend	ded model					not use	ed in ca	culation b	ut stated for	reference					
	Units	Value		Data sourc	es																
Bird data																					
Species name	н	lerring gull																			
Bird length	m	0.60															Murro	y Grant:			
Wingspan	m	1.44															% at P				
Flight speed	m/sec	12.8																ng - 5.0%			
Nocturnal activity factor (1-5)		2																eed - 3.6%			
Flight type, flapping or gliding		flapping																			
				Data sourc	es																
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul		Aug	Sep	C	ct	Nov	Dec					
Daytime bird density	birds/sq km		0.1001021	0.0484165	5 ()	0 0.024473	0.1218	324		0.024260	1	0	0.0252525	0.048309	2 0.14729	15				
Proportion at rotor height	%	5.0%																			
Proportion of flights upwind	%	50.0%																			
				Data sourc	es																
Birds on migration data																					
Aigration passages	birds		0) () ()	0	0	0	0	()	2000	4000		0	0				_
Vidth of migration corridor	km								-							-					
Proportion at rotor height	%																				
Proportion of flights upwind	%	50.0%																			
	Units	Value		Data sourc	es																
Windfarm data																					
Name of windfarm site		IC - Large											1								
_atitude	degrees	56.49											1								
Number of turbines		72											1								
Width of windfarm	km	6.774											1								
Fidal offset	m	0.771											1					Murray Gran			
	Units	Value		Data sourc	es													For herring g		sed	-
Furbine data	0	Fulue		Duia couro														seasons, roto			-
Furbine model																		Breeding - 7.			-
No of blades		3	Jan	Feb	Mar	Apr	May	Jun	Jul		Aug	Sep	0	ct	Nov	Dec		Non-breed -	9.65		-
Rotation speed	rpm	7.42	4						.15	6.72			8.45	9.41			2		-	_	+
Rotor radius	m n	83.5		9.07	9.00	0.3	J 7.0	10 1	. 13	0.72	7.18	2	0.40	5.41	9.9	0 10.	-				
Hub height	m	116.1		Feb	Mar	Apr	May	Jun	Jul		Aug	Sep	C	ct	Nov	Dec			-		
Monthly proportion of time operational	%	110.1	3an 89%						1%	69%	72%		78%	86%			24		-		
Monthly proportion of time operational	m	6.000		00%	00%	117	0 74	/0 /	1 /0	05%	12%	,	10/0	00%	0/7	0 00	/0				
Pitch	degrees	0.000						-	-												
- 11011	degrees	10																			

Development CRMs – 40 WTG design

Gannet

COLLISION RISK ASSESSMENT			used in ove	erall collisior	n risk sheet									used	in avail	lable hour	s shee	t						
Sheet 1 - Input data			used in mig	grant collisio	on risk shee	et								used	in large	e array co	rrectior	n sheet						
			used in sin	gle transit c	ollision risk	sheet	or extende	ed model						not u	sed in a	calculatio	n but si	tated for	referenc	e				
	Units	Value		Data sou	rces																			
Bird data									_															
Species name		Gannet							_															
Bird length	m	0.94							_												Murra	y Grant:		<u>–</u> 1–
Wingspan	m	1.73							_														seasonal period	s,
Flight speed	m/sec	14.9																				should be:		<u> </u>
Nocturnal activity factor (1-5)		1										-										ng season	2.4%	
Flight type, flapping or gliding		flapping																				iss - 1.2%		
				Data sou	rces																Spr page	ss - 0.6%		
Bird survey data			Jan	Feb	Mar	Ap	or	May	Jun		Jul	A	ug	Sep		Oct	No	v	Dec					
Daytime bird density	birds/sq km		0.150	5 0.5	56 0.5	5785	2.1745	4.32	28	3.7765	3	3.6285	5.13	34	1.512	1.0	355	0.193	3	0	L			_
Proportion at rotor height	%	2.4%																						
Proportion of flights upwind	%	50.0%																						
				Data sou	rces																			
Birds on migration data																								
Migration passages	birds			0	0	0	0		0	0		0		0	2000	4	000	()	0				-
Nidth of migration corridor	km																							-
Proportion at rotor height	%																							_
Proportion of flights upwind	%	50.0%																						
	Units	Value		Data sou	rces																			_
Windfarm data																Î.								_
Name of windfarm site		IC - Large																						_
_atitude	degrees	56.49																						_
Number of turbines	uogiooo	40												_							Mu	rray Grant	:	
Width of windfarm	km	6.774																			Rota	ation speed	ls are unique fo	
Tidal offset	m																						period as follow:	s:
	Units	Value		Data sou	rces	_					-	_										eding - 5.1		
Turbine data	2							-														pass - 6.3 ing pass - 6		
Turbine model					-																spn	ing pass - c	.51	
No of blades		3	Jan	Feb	Mar	Ap	vr	May	Jun		Jul	Δ	uq	Sep		Oct	No	v	Dec					_
Rotation speed	rpm	5.18				6.35	5.50			4.69	oui	4.41	ug 4.1		5.54		.17	v 6.53		6.64				
Rotor radius	m	125		0		0.00	5.50	0.0		4.03		4.41			0.04			0.00	,	0.04				
Hub height	m	152.6		Feb	Mar	Ap	vr	May	Jun		Jul	Δ	ug	Sep		Oct	No	v	Dec					
Monthly proportion of time operational	%	152.0	- Jan 89%			36%	77%	74 ⁰		71%	oui	69%	uy 72		78%		6%	v 87%		88%				
Max blade width	m	7.800		0 00	//	5070	11/0	/4	/0	11/0		0370	12	/0	1070	0	070	01/0	,	00 /0				
	degrees	7.800																						
Pitch																								

<u>Kittiwake</u>

COLLISION RISK ASSESSMENT			used in o	verall coll	ision risk	sheet					used in	available I	hours she	et				
Sheet 1 - Input data			used in m	nigrant co	llision ris	k sheet					used in	large arra	y correction	on sheet				
			used in si	ingle tran	sit collisi	on risk sh	eet or ext	ended mo	odel		not used	in calcul	ation but	stated for	reference			
	Units	Value																
-	Units	value		Data sou	irces							-						
Bird data																		
Species name		Ki																
Bird length	m	0.39																
Wingspan	m	1.08																
Flight speed	m/sec	13.1																
Nocturnal activity factor (1-5)		2														rray.grant:		
Flight type, flapping or gliding		flapping															d seasonal pe	eriods, values
				Data sou												uld be:	0.20/	
Bird survey data			Jan	Feb	Mar		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		eding seasor pass - 5.24		
Daytime bird density	birds/sq km			0.048	0.569	0.612	0.839	1.998	3.682	0.487	2.495	5 1.591	0.628	0.347		pass - 5.24 pass - 3.0%		
Proportion at rotor height	%	0.20%													Spi	puss - 5.0%	,	
Proportion of flights upwind	%	50.0%																
				Data sou	irces													
Birds on migration data	i i																	
Migration passages	birds		0	0	0	4000	2000	0	0	C	2000	4000) 0	0				
Width of migration corridor	km	8																
Proportion at rotor height	%	75%																
Proportion of flights upwind	%	50.0%																
	Units	Value		Data sou	irces							-	-	-				
Windfarm data	•			2414 001								1						
Name of windfarm site	1	Inch Cape										1						
Latitude	degrees	56.49										1						
Number of turbines	degrees	40														-		
Width of windfarm	km	6.774														murray.g		
Tidal offset	m	0.774																on seasons:
	Units	Value		Data sou	ILCOS							-				Aut pass =	eason =4.87	
Turbine data	01113	Value		Data Sot	1003						-			-		Spr pass =		
Turbine model	12	arge turbine																
No of blades		-		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec				
Rotation speed	mm	4.87		6.34														
Rotor radius	rpm m	4.07		0.34	0.35	5.50	5.05	4.09	4.41	4./1	5.54	. 0.17	0.00	0.04				
Hub height	m	152.6		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec				
		152.0		гер 85%	86%					Aug 72%								
Monthly proportion of time operational Max blade width	%	7.800	89%	80%	00%	11%	74%	/1%	09%	12%	/8%	00%	0 01%	00%				
	m																	
Pitch	degrees	10																

<u>Herring gull</u>

Dec 0.1472915	Murray Gra % at PCH: Breeding - 9 Non-breed -	9.6%
Dec	% at PCH: Breeding - 9	9.6%
	% at PCH: Breeding - 9	9.6%
	% at PCH: Breeding - 9	9.6%
	% at PCH: Breeding - 9	9.6%
	% at PCH: Breeding - 9	9.6%
	% at PCH: Breeding - 9	9.6%
	% at PCH: Breeding - 9	9.6%
	Breeding - 9	
0.1472915		
0		
0		
0		
0		
0		
-		
Ì		
	M	ray Grant:
		nerring gull 2017 advised
i		ons, rotor speeds as follow:
	Breed	ding - 4.87
Dec	Non-I	breed - 6.33
	L	
0.04		
Dec		
00 /0		
	6.64	ec For t

Neart na Gaoithe – 2014 design

Gannet

COLLISION RISK ASSESSMENT			used in over	all collision	risk she	et								use	ed in avai	lable ho	urs she	eet		
Sheet 1 - Input data			used in mig	rant collisior	n risk sh	eet								use	ed in larg	e array o	correcti	ion sheet		
			used in sing				t or extend	ed mod	el									stated for	reference	
	Units	Value		Data source	ces															
Bird data																				
Species name		Gannet																		
Bird length	m	0.94																		
Wingspan	m	1.73																		
Flight speed	m/sec	14.9																		
Nocturnal activity factor (1-5)		1																		
Flight type, flapping or gliding		flapping																		
				Data source	ces															
Bird survey data			Jan	Feb	Mar	ŀ	\pr	May		Jun		Jul	Aug	Se	р	Oct	١	Vov	Dec	
Daytime bird density	birds/sq km		0.084	1.32	8	2.358	1.24	L L	4.412		3.419	5.1	2 4.	175	4.742	2 2	2.272	0.287	0.0	31
Proportion at rotor height	%	7.3%																		
Proportion of flights upwind	%	50.0%																		
				Data source	ces															
Birds on migration data																				
Vigration passages	birds		0		0	0	C)	0		0)	0	2000)	4000	()	0
Width of migration corridor	km																			
Proportion at rotor height	%																			
Proportion of flights upwind	%	50.0%																		
	Units	Value		Data source	ces															
Windfarm data	i i															1				
Name of windfarm site		NNG - 12																0.063	3	
Latitude	degrees	56.27																		
Number of turbines		75																		
Width of windfarm	km	8.22																		
Tidal offset	m	2.65																		
	Units	Value		Data source	ces															
Turbine data																				
Turbine model	61	W turbine																		
No of blades		3																		
Rotation speed	rpm	8																		
Rotor radius	'n	77																		
Hub height	m	101.85		Feb	Mar	ŀ	\pr	May		Jun		Jul	Aug	Se	р	Oct	١	Nov	Dec	
Monthly proportion of time operational			89%	86%	6	87%	85%		86%		85%	84%		2%	86%		87%	89%		%
Max blade width	m	5.000																		
Pitch	degrees	15																		

<u>Kittiwake</u>

COLLISION RISK ASSESSMENT			used in ove	rall collision r	isk she	et								used i	n avail	able ho	ours sh	ieet			
Sheet 1 - Input data			used in mig	grant collision	risk sh	neet								used i	n large	e array	correc	tion she	eet		
-				gle transit col			t or extend	led model						not us	ed in o	calcula	tion bu	t stated	d for re	ference	
	Units	Value		Data sourc	es																
Bird data																					
Species name		Kittiwake																			
Bird length	m	0.39																			
Wingspan	m	1.08																			
Flight speed	m/sec	13.1																			
Nocturnal activity factor (1-5)		2																			
Flight type, flapping or gliding		flapping																			
				Data sourc	es																
Bird survey data			Jan	Feb	Mar	A	Apr	May	Ju	un	Jul	A	ug	Sep		Oct		Nov	1	Dec	
Daytime bird density	birds/sq km		0.14	7 0.044	1	0.189	0.214	4 0.	616	0.23	4 0.9	43	0.171		0.653		0.803	().764	3.3	64
Proportion at rotor height	%	6.5%																			
Proportion of flights upwind	%	50.0%																			
				Data sourc	es																
Birds on migration data																					
Migration passages	birds			0 C)	0	()	0		D	0	0		2000		4000		0		0
Width of migration corridor	km																				
Proportion at rotor height	%																				
Proportion of flights upwind	%	50.0%																			
	Units	Value		Data sourc	es																
Windfarm data																					
Name of windfarm site		NNG - 12																(0.063		
Latitude	degrees	56.27																			_
Number of turbines		75																			
Width of windfarm	km	8.22																			
Tidal offset	m	2.65																			
	Units	Value		Data sourc	es	_															
Turbine data	00				1																
Turbine model	61	MW turbine																			
No of blades		3																			
Rotation speed	rpm	8																			
Rotor radius	m	77																			
Hub height	m	101.85		Feb	Mar	1	Apr	May	Ju	ın	Jul	Δ	ug	Sep		Oct		Nov		Dec	
Monthly proportion of time operational	%	101.00	89%			87%	יקר 85%		6%	85%		1%	82%		86%		87%		89%	86	%
Max blade width	m	5.000		0070		01/0	00/	, 0	0 /0	007	0-	170	02/0		0070		51 /0		0070	00	/5
Pitch	degrees	5.000										-									
	uegiees	15			-																_

<u>Herring gull</u>

COLLISION RISK ASSESSMENT			used in ove	rall collision r	isk shee	t							used	l in avai	lable ho	ours sh	eet		
Sheet 1 - Input data			used in mic	rant collision	risk she	et							used	l in larg	e array	correct	ion sheet		
·			used in sing	, gle transit col	lision risl	k sheet o	r extend	ed model									stated fo	referend	e
	Units	Value		Data sourc	es														
Bird data																			
Species name	H	lerring gull																	
Bird length	m	0.61																	
Wingspan	m	1.44																	
Flight speed	m/sec	12.8																	
Nocturnal activity factor (1-5)		2																	
Flight type, flapping or gliding		flapping																	
				Data sourc	es														
Bird survey data			Jan	Feb	Mar	Apr		May	Ju	n	Jul	Aug	Sep		Oct	1	Nov	Dec	
Daytime bird density	birds/sq km		0.23		5 C).118	0.043		085	0.086			0	0		0	0.09	6	0.159
Proportion at rotor height	%	35.6%																	
Proportion of flights upwind	%	50.0%																	
				Data sourc	es			1							1				
Birds on migration data					1										1				
Migration passages	birds		()	0	0)	0	C)	0	0	2000		4000		0	0
Width of migration corridor	km																		-
Proportion at rotor height	%																		
Proportion of flights upwind	%	50.0%																	
	Units	Value		Data sourc	<u>AS</u>														
Windfarm data	onita	Value		Data Sourc											1			-	
Name of windfarm site		NNG - 12															0.06	2	
Latitude	degrees	56.27															0.00	15	
Number of turbines	uegrees	75																-	
Width of windfarm	km	8.22																	
Tidal offset	m	2.65																	
ndar onoot	Units	Value	-	Data sourc	AS													-	
Turbine data	Gillta	Value		Data Sourc															
Turbine model	6	W turbine																	
No of blades	U	3																	
Rotation speed	rom	3																	
Rotor radius	rpm m	° 77																_	
Hub height		101.85		Feb	Mar	۸		Mov	Ju	•	Jul	Aug	Sep		Oct		Nov	Dec	
Hub neight Monthly proportion of time operational	m %	101.85	Jan 89%			Apr 87%	85%	May	Ju 6%	n 85%		Aug	Sep 32%	86%		87%	۷0۷ 89'		86%
		E 000		• 86%		81%	85%	5	0%	85%	84	/o E	5∠%	86%		81%	89	/o	86%
Max blade width Pitch	m degrees	5.000																	
Puch	nenrees	15																	

Seagreen Alpha – 2014 design

Gannet

y Grant: In speeds are unique fo
al period as follows:
ng - 10.37
ss - 11.05
pass - 10.95

<u>Kittiwake</u>

COLLISION RISK ASSESSMENT			used in over	all collision ri	isk sheet							us	ed in avai	lable hours s	sheet					
Sheet 1 - Input data			used in mig	rant collision	risk sheet							us	ed in larg	e array corre	ction sh	neet				
-			used in sing	le transit coll	lision risk sh	eet or exte	nded mode	1				nc	ot used in	calculation b	out state	d for re	eference			
						_														
	Units	Value		Data source	es	_														
Bird data																				
Species name		Kittiwake																		
Bird length	m	0.39																		
Wingspan	m	1.08																		
Flight speed	m/sec	13.1																		
Nocturnal activity factor (1-5)		2																		
Flight type, flapping or gliding		flapping																		
				Data source																
Bird survey data				Feb	Mar	Apr	May	Jur		Jul	Aug	Se		Oct	Nov		Dec			
Daytime bird density	birds/sq km			0.5555556	2.5343344	2.	056 1.125	5333	3.125244	1.8746994	0.519	5335 3	3.3860351	2.3191904	4 9.61	60419	0.5796056			
Proportion at rotor height	%	10.3%																		
Proportion of flights upwind	%	50.0%																		
				Data source	es															
Birds on migration data																				
Migration passages	birds		0	0	Ú C)	0	0	0	()	0	2000	4000	C	0	0			
Width of migration corridor	km																			
Proportion at rotor height	%																			
Proportion of flights upwind	%	50.0%																		
	Units	Value		Data source	es															
Windfarm data														1						
Name of windfarm site		SG - A																		
Latitude	degrees	56.37																Murray Grant		
Number of turbines	J	75																To fit with 201	7 advice or	seasons:
Width of windfarm	km											_						Breeding: 10.2		
Tidal offset	m																	Aut passage: 1		
	Units	Value		Data source	es			_										Spr passage:10	.85	
Turbine data						-														
Turbine model		7MW																		
No of blades			Jan	Feb	Mar	Apr	May	Jur	h	Jul	Aug	Se	an	Oct	Nov		Dec	l		
Rotation speed	rpm	10.22						10.2	10.3			10	э р 10.7			11.1	10.9			
Rotor radius	m n	83.5		. 10.9	10.0	, 1	0.0	10.2	10.3	10.		10	10.7		•	11.1	10.9			
Hub height	m			Feb	Mar	Apr	May	Jur	h	Jul	Aug	Se	an	Oct	Nov		Dec			
Monthly proportion of time operational	%	(11	3an 88%					301 88%	88%	3ui 88%		88%	ч- 88%			88%	88%			
Max blade width	m	5.400		00 %	00%	0	570	0070	00%	0070	,	0070	00%	0070	0	0070	0070			
Pitch	degrees	5.400 10																		
r iton	uegrees	10																		

<u>Herring gull</u>

COLLISION RISK ASSESSMENT			used in over	all collision r	isk sheet						used in av	ailable hours	sheet		
Sheet 1 - Input data			used in migr	ant collision	risk sheet						used in la	ge array corre	ection sheet		
· · ·			used in sing	le transit col	lision risk sh	eet or extend	ed model				not used i	n calculation b	out stated for	reference	
	Units	Value		Data sourc	es										
Bird data															
Species name	H	lerring gull													
Bird length	m	0.61													
Wingspan	m	1.44													
Flight speed	m/sec	12.8													
Nocturnal activity factor (1-5)		2													
Flight type, flapping or gliding		flapping													
				Data sourc	es										
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daytime bird density	birds/sq km		0.1019258	0.1031593	0.1586145	0.0350926	0.1062241	0.08596	6 0.036023	9	0 0.017870	0.0730842	2 0.0338732	0.1252648	
Proportion at rotor height	%	22.7%													
Proportion of flights upwind	%	50.0%													
				Data sourc	es										
Birds on migration data															
Migration passages	birds		0	C) () () C)	0	0	0 200	0 400	0 (0 0	
Width of migration corridor	km														
Proportion at rotor height	%														
Proportion of flights upwind	%	50.0%													
	Units	Value		Data sourc	es										
Windfarm data															
Name of windfarm site		SG - A													
Latitude	degrees	56.37													
Number of turbines	Ĩ	75													
Width of windfarm	km														Murray Grant:
Tidal offset	m														breeding period = 10.2
	Units	Value		Data sourc	es										non-breeding period =
Turbine data															10.94
Turbine model		7MW													
No of blades		3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Rotation speed	rpm	10.22							• •		10 10				
Rotor radius	m	83.5									, 10				
Hub height	m		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly proportion of time operational	%		88%								88% 88				
Max blade width	m	5.400													
Pitch	degrees	10													
		10						-							

Seagreen Bravo – 2014 design

Gannet

COLLISION RISK ASSESSMENT			used in over	all collision ri	sk sheet							used in av	ailable hours	sheet						
Sheet 1 - Input data			used in mig	rant collision	risk sheet							used in la	ge array cor	rection sl	neet					
· · · · · · · · · · · · · · · · · · ·			used in sing	le transit coll	ision risk she	eet or exter	nded model					not used i	n calculation	but state	ed for re	ference				
	Units	Value		Data source	es															
Bird data												1								
Species name		Gannet																		
Bird length	m	0.94																		
Wingspan	m	1.73																		
Flight speed	m/sec	14.9																		
Nocturnal activity factor (1-5)		1																		
Flight type, flapping or gliding		flapping																		
				Data source	es															
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul		Aug	Sep	Oct	Nov	[Dec				
Daytime bird density	birds/sq km		0.3153314	0.7838746			96 3.09584	36 3.80674					1.40867	77 0.59	46467	0.0808	181			
Proportion at rotor height	%	5.1%																		
Proportion of flights upwind	%	50.0%																		
<u> </u>				Data source	es															
Birds on migration data	1													-						
Aigration passages	birds		0	0	0)	0	0	0	0	(0 200	0 40	00	0		0			
Vidth of migration corridor	km						Ŭ						.0 .0		Ŭ		Ŭ			
Proportion at rotor height	%																			
Proportion of flights upwind	%	50.0%																		
	Units	Value		Data source	s															
Windfarm data						-														
Name of windfarm site		SG - A															Murr	ay Grant:	-	
_atitude	degrees	56.37																ion speeds are	e unique for	each
Number of turbines	abgroot	75							_									nal period as f		cuen
Nidth of windfarm	km												i					ling - 10.37		
Fidal offset	m												i					ass - 11.05		
	Units	Value		Data source	s		-						_				Spring	g pass - 10.95		
furbine data					-	-								_			A 6 62	culated in CRI	M choot for 6	C A
Furbine model		7MW		-													AS Ca		in sileet for S	ADGA
No of blades			Jan	Feb	Mar	Apr	May	Jun	Jul		Aua	Sep	Oct	Nov	ſ	Dec				
Rotation speed	rpm	10.37).5 10			10.1	-ug 1(11	11.1		10.9			
Rotor radius	m	83.5		10.9	10.0	, 10		1		10.1		10	.,		11.1		10.0			
Hub height	m	111		Feb	Mar	Apr	May	Jun	Jul		Aug	Sep	Oct	Nov	r	Dec				
Monthly proportion of time operational	%		3an 88%							88%	-uy 88%				88%		38%			
Monthly proportion of time operational	m	5.400		00%	0070	, 00	.,	/0 00		0070	007	0 00	/0 00	/0	0070	,	10 /0			-
Pitch	degrees	3.400 10				-														-
iteri	uegrees	10				-														
																			-	

<u>Kittiwake</u>

COLLISION RISK ASSESSMENT			used in over	rall collision ri	sk sheet						used in avai	lable hours s	heet				
Sheet 1 - Input data				rant collision								e array correc					
			used in sing	gle transit coll	ision risk she	eet or extend	led model				not used in	calculation b	ut stated for	reference			
	Units	Value		Data source	es												
Bird data																	
Species name		Kittiwake															
Bird length	m	0.39															
Wingspan	m	1.08															
Flight speed	m/sec	13.1															
Nocturnal activity factor (1-5)		2															
Flight type, flapping or gliding		flapping															
				Data source	es												
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Daytime bird density	birds/sq km		2.3364019	2.0476724	2.4573382			3.159349	1.3376954		3 0.3860366	1.4617893	6.682772	0.6867475			
Proportion at rotor height	%	10.3%															
Proportion of flights upwind	%	50.0%															
· · ·				Data source	es					1		1					
Birds on migration data							1					1		1			
Aigration passages	birds		0) 0	0	() (0	0)	0 2000	4000		o c			
Nidth of migration corridor	km																
Proportion at rotor height	%																
Proportion of flights upwind	%	50.0%															
	Units	Value		Data source	es												
Windfarm data												1					
Name of windfarm site		SG - B															
Latitude	degrees	56.37													1		
Number of turbines	acgreec	75													Murray Gran	11: 017 advice on	
Width of windfarm	km														seasons:		
Tidal offset	m														Breeding sea	on =10.22	
	Units	Value		Data source	es										Aut pass = 1		
Turbine data															Spr pass = 10	0.85	
Turbine model		7MW															
No of blades			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			_
Rotation speed	rpm	10.22															
Rotor radius	m	83.5			10.0	10.,	. 10.2	10.0	10.1		- 10.7			. 10.5			
Hub height	m		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Monthly proportion of time operational	%		3an 88%														
Max blade width	m	5.400		, 00 /8	0070	007	. 00/0	0076	0070	, 307	0 00/0	, 00 /8	007	00%			
Pitch	degrees	10												-			
iion	uegrees	10															
														-			

<u>Herring gull</u>

COLLISION RISK ASSESSMENT			used in over	all collision ri	sk sheet								used in av	ailable hour	s shee	t			
Sheet 1 - Input data			used in mig	rant collision	risk sheet								used in lar	ge array co	rrection	n sheet			
			used in sing	le transit coll	ision risk sh	eet or exte	ended mod	del					not used i	n calculatio	n but s	tated for	reference	Э	
	Units	Value		Data source	es														
Bird data																			
Species name		Herring gull																	
Bird length	m	0.61																	
Wingspan	m	1.44	L .																
Flight speed	m/sec	12.8	s																
Nocturnal activity factor (1-5)		2	2																
Flight type, flapping or gliding		flapping	1																
				Data source	es														
Bird survey data			Jan	Feb	Mar	Apr	May		Jun	Jul	Au	ıg	Sep	Oct	No	v	Dec		
Daytime bird density	birds/sq km		0.0628627	0.0415933	0.1024429)	0 0.	04095	0.1466796	;	0	(0.022671	8 0.021	952	(0 0.214	5828	
Proportion at rotor height	%	22.7%																	
Proportion of flights upwind	%	50.0%																	
				Data source	es														
Birds on migration data																			
Migration passages	birds		0	0	()	0	0	C		0	(200	0 4	000		0	0	
Width of migration corridor	km																		
Proportion at rotor height	%																		
Proportion of flights upwind	%	50.0%																	
	Units	Value	1	Data source	es														
Windfarm data														Ì					
Name of windfarm site		SG - B																	
Latitude	degrees	56.37																	
Number of turbines	Ŭ	75	5																
Width of windfarm	km																		
Tidal offset	m																		
	Units	Value		Data source	es														
Turbine data																			
Turbine model		7MW	1																Murray Grant:
No of blades		3	Jan	Feb	Mar	Apr	May		Jun	Jul	Au	a	Sep	Oct	No	v	Dec		breeding period = 10.
Rotation speed	rpm						0.5	10.2			10.1	10			11	. 11.		10.9	Non-breeding period =10.94
Rotor radius	m						-												-10.94
Hub height	m		Jan	Feb	Mar	Apr	May		Jun	Jul	Au	a	Sep	Oct	No	v	Dec		
Monthly proportion of time operational	%		88%				8%	88%	88%		88%	.9 88%			8%	. 88%		88%	
Max blade width	m	5.400			507				2070			20/				207			
Pitch	degrees																		
																	-		

Neart na Gaoithe – 2017 design

Gannet

COLLISION RISK ASSESSMENT			used in over	rall collision	risk sh	eet								used	in avai	able hours	sheet			
Sheet 1 - Input data			used in mig	rant collisio	n risk s	heet								used	in large	e array cor	rection	sheet		
•			used in sing	gle transit co	ollision	risk she	et or exte	nded mo	odel							calculation			eference	
	Units	Value		Data sour	ces															
Bird data																				
Species name		Gannet																		
Bird length	m	0.94																		
Wingspan	m	1.73																		
Flight speed	m/sec	14.9																		
Nocturnal activity factor (1-5)		1																		
Flight type, flapping or gliding		flapping																		
				Data sour	ces															
Bird survey data			Jan	Feb	Mar		Apr	May		Jun		Jul	Aug	Sep		Oct	No	v	Dec	
Daytime bird density	birds/sq km		0.084	1.32	28	2.358		24	4.412	3.	.419	5.12			4.742	2.2	.72	0.287	0	.031
Proportion at rotor height	%	7.3%																		
Proportion of flights upwind	%	50.0%																		
				Data sour	ces															
Birds on migration data																				
Migration passages	birds		C)	0	0		0	0		0	0		0	2000	40	000	0		0
Width of migration corridor	km																			
Proportion at rotor height	%																			
Proportion of flights upwind	%	50.0%																		
	Units	Value		Data sour	ces															
Windfarm data																1				
Name of windfarm site		NNG - 12																		
Latitude	degrees	56.27															_			
Number of turbines	aogrooo	54																		
Width of windfarm	km	8.22															_			
Tidal offset	m	2.65																		
	Units	Value		Data sour	ces								-				_			
Turbine data	0												-							
Turbine model	6N	IW turbine																		
No of blades		3																	-	
Rotation speed	rpm	8																		
Rotor radius	m	83.5			_			_						_						
Hub height	m	115.5		Feb	Mar		Apr	May		Jun		Jul	Aug	Sep		Oct	Nov		Dec	
Monthly proportion of time operational	%	113.5	Jan 89%			87%	Api 85		86%		85%	3ui 84%	Aug 82		86%		7%	v 89%		36%
Max blade width		5.000		00	/0	01 %	00	70	00%	(00 /0	0470	02	/0	00%	01	/0	09%		50 /0
	m	5.000																		
Pitch	degrees	15																		

<u>Kittiwake</u>

COLLISION RISK ASSESSMENT			used in ov	erall collision r	isk shee	t							used in ava	ailable ho	urs she	et		
Sheet 1 - Input data			used in mi	grant collision	risk she	et							used in lar	ge array o	correction	on sheet		
			used in sir	ngle transit col	lision risl	k sheet o	or extend	ed model					not used ir	n calculat	ion but	stated for	reference	
	Units	Value		Data sourc	es									_				
Bird data																		
Species name		Kittiwake																
Bird length	m	0.39																
Wingspan	m	1.08																
Flight speed	m/sec	13.1																
Nocturnal activity factor (1-5)		2																
Flight type, flapping or gliding		flapping																
				Data sourc	es													
Bird survey data			Jan	Feb	Mar	Ap		May	Jur		Jul	Aug	Sep	Oct		lov	Dec	
Daytime bird density	birds/sq km		0.14	17 0.044	4 C	.189	0.214	0.6	16	0.234	0.943	3 0.17	1 0.65	3 (0.803	0.764	3.36	4
Proportion at rotor height	%	6.5%																
Proportion of flights upwind	%	50.0%																
				Data sourc	es													
Birds on migration data																		
Migration passages	birds			0 0)	0	0		0	0) () (200	0	4000	C	ĺ	0
Width of migration corridor	km																	
Proportion at rotor height	%																	
Proportion of flights upwind	%	50.0%																
	Units	Value		Data sourc	es													
Windfarm data																		
Name of windfarm site		NNG - 12																
Latitude	degrees	56.27																
Number of turbines		54																
Width of windfarm	km	8.22																
Tidal offset	m	2.65																
	Units	Value		Data sourc	es													
Turbine data																		
Turbine model	6N	IW turbine																
No of blades		3																
Rotation speed	rpm	8																
Rotor radius	m	83.5																
Hub height	m	115.5		Feb	Mar	Ap	r	May	Jur	า	Jul	Aug	Sep	Oct	N	lov	Dec	
Monthly proportion of time operational	%		89			87%	85%			85%					87%	89%	86%	6
Max blade width	m	5.000																
Pitch	degrees	15																
																		1
																		_

<u>Herring gull</u>

Species name Bird length Bird length Bird length Wingspan Flight speed Nocturnal activity factor (1-5) Flight type, flapping or gliding Bird survey data Bird survey data Daytime bird density birds Proportion at rotor height Birds on migration data Migration passages Width of migration corridor Proportion of flights upwind Proportion of flights upwind Width of migration corridor Proportion of flights upwind Windfarm data Mindfarm data	Units Me m m/sec s/sq km % %	Value erring gull 0.61 1.44 12.8 2 flapping	used in sing Jan 0.231	Data sourc	Ilision ces Ces Mar 5	risk she	Apr 0.04	May 3 (lun 0.086	Jul 0.04.	Aug		sed in c	Oct	on but	Nov	Dec	
Species name Image: Species name Bird length Vingspan Wingspan Image: Species name Flight speed Image: Species name Nocturnal activity factor (1-5) Image: Species name Flight type, flapping or gliding Image: Species name Bird survey data Image: Species name Daytime bird density birds Proportion at rotor height Image: Species name Birds on migration data Image: Species name Wigration passages Image: Species name Proportion at rotor height Image: Species name Proportion of flights upwind Image: Species name Image: Species name Image: Species name Midth of migration corridor Image: Species name Proportion at rotor height Image: Species name Image: Species name Image: Species n	He m m/sec s/sq km % % birds km %	Value erring gull 0.61 1.44 12.8 2 flapping 35.6%	Jan 0.231	Data source Data source Feb 1 0.065 Data source	ces Mar 5 ces	0.118	Apr 0.04	May 3 (J				Sep		Oct	1	Nov		c
Species name Bird length Bird length Bird length Wingspan Flight speed Nocturnal activity factor (1-5) Flight type, flapping or gliding Bird survey data Bird survey data Daytime bird density birds Proportion at rotor height Birds on migration data Migration passages Width of migration corridor Proportion of flights upwind Proportion of flights upwind Width of migration corridor Proportion of flights upwind Windfarm data Mindfarm data	He m m/sec s/sq km % % birds km %	erring gull 0.61 1.44 12.8 2 flapping 35.6%	Jan 0.231	Data source Feb 1 0.069 Data source	bes Mar 5 ces	0.118	0.04	3 (
Bird data Species name Bird length Wingspan Flight speed Nocturnal activity factor (1-5) Flight type, flapping or gliding Bird survey data Daytime bird density Proportion at rotor height Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion of flights upwind Windfarm data Name of windfarm site	He m m/sec s/sq km % % birds km %	erring gull 0.61 1.44 12.8 2 flapping 35.6%	Jan 0.231	Data source Feb 1 0.069 Data source	bes Mar 5 ces	0.118	0.04	3 (
Species name Bird length Bird length Wingspan Flight speed Flight speed Nocturnal activity factor (1-5) Flight type, flapping or gliding Bird survey data Bird survey data Daytime bird density birds Proportion at rotor height Birds on migration data Migration passages Width of migration corridor Proportion of flights upwind Birds on migration corridor Width of migration corridor Proportion of flights upwind Width of migration data Migration data Windfarm data Mindfarm data	m m/sec s/sq km % % birds km %	0.61 1.44 12.8 2 flapping 35.6%	Jan 0.231	Feb 1 0.065 Data source	Mar 5 ces	0.118	0.04	3 (
Bird length Wingspan Flight speed Nocturnal activity factor (1-5) Flight type, flapping or gliding Bird survey data Daytime bird density Proportion at rotor height Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion of flights upwind Windfarm data Windfarm data	m m/sec s/sq km % % birds km %	0.61 1.44 12.8 2 flapping 35.6%	Jan 0.231	Feb 1 0.065 Data source	Mar 5 ces	0.118	0.04	3 (
Wingspan Image: Constraint of the speed Flight speed Image: Constraint of the speed Nocturnal activity factor (1-5) Image: Constraint of the speed Flight type, flapping or gliding Image: Constraint of the speed Bird survey data Image: Constraint of the speed Daytime bird density birds Proportion at rotor height Image: Constraint of the speed Birds on migration data Image: Constraint of the speed Migration passages Image: Constraint of the speed Width of migration corridor Image: Constraint of the speed Proportion of flights upwind Image: Constraint of the speed Windfarm data Image: Constraint of the speed	m m/sec s/sq km % % birds km %	1.44 12.8 2 flapping 35.6%	Jan 0.231	Feb 1 0.065 Data source	Mar 5 ces	0.118	0.04	3 (
Flight speed Nocturnal activity factor (1-5) Flight type, flapping or gliding Bird survey data Daytime bird density birds Proportion at rotor height Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion of flights upwind Optimities Proportion of flights upwind	m/sec s/sq km % % birds km %	12.8 2 flapping 35.6%	Jan 0.231	Feb 1 0.065 Data source	Mar 5 ces	0.118	0.04	3 (
Nocturnal activity factor (1-5) Flight type, flapping or gliding Bird survey data Daytime bird density birds Proportion at rotor height Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	s/sq km % % birds km %	2 flapping 35.6%	Jan 0.231	Feb 1 0.065 Data source	Mar 5 ces	0.118	0.04	3 (
Flight type, flapping or gliding Bird survey data Daytime bird density Diaptime bird density Proportion at rotor height Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Width of migration corridor Proportion of flights upwind Windfarm data	% % birds km %	flapping 35.6%	Jan 0.231	Feb 1 0.065 Data source	Mar 5 ces	0.118	0.04	3 (
Bird survey data Daytime bird density birds Proportion at rotor height Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	% % birds km %	35.6%	Jan 0.231	Feb 1 0.065 Data source	Mar 5 ces	0.118	0.04	3 (
Daytime bird density birds Proportion at rotor height Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	% % birds km %	35.6%	0.231	Feb 1 0.065 Data source	Mar 5 ces	0.118	0.04	3 (
Daytime bird density birds Proportion at rotor height Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	% % birds km %	35.6%	0.231	1 0.06	5 ces	0.118	0.04	3 (
Proportion at rotor height Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	% % birds km %			Data sourc	ces				.085	0.086	0.04		0	0		0	0.0	96	0.159
Proportion of flights upwind Birds on migration data Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	birds km %					0													
Birds on migration data Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	birds km %	50.0%				0							_					_	
Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	km %		(0													
Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	km %		(0 (0	0							- 1						
Migration passages Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	km %		(0 (0	0		~											
Width of migration corridor Proportion at rotor height Proportion of flights upwind Windfarm data	%							0	0	0	, i i)	0	2000		4000		0	0
Proportion of flights upwind Windfarm data																			
Windfarm data	%																		
	/0	50.0%																	
	Units	Value		Data source	ces														
Name of windfarm site																			
		NNG - 12																	
Latitude d	degrees	56.27																	
Number of turbines		54																	
Width of windfarm	km	8.22																	
Tidal offset m		2.65																	
	Units	Value		Data source	ces														
Turbine data																			
Turbine model	6M	W turbine																	
No of blades		3																	
Rotation speed	rpm	8																	
Rotor radius	m	83.5																	
Hub height	m	115.5		Feb	Mar		Apr	May	J	lun	Jul	Aug	Sep		Oct	1	Nov	Dee	с
Monthly proportion of time operational	%		89%	6 86%	6	87%			36%	85%	84%			86%		87%	89	9%	86%
Max blade width	m	5.000																	
Pitch d	degrees	15																	

Seagreen Alpha – 2017 design

Gannet

COLLISION RISK ASSESSMENT			used in over	rall collision ri	sk sheet						used in avai	lable hours s	heet			
Sheet 1 - Input data			used in mig	rant collision	risk sheet						used in larg	e array correc	ction sheet			
				gle transit coll		eet or exte	nded model					calculation b		reference		
	Units	Value	•	Data source	es											
Bird data																
Species name		Gannet														
Bird length	m	0.94	ŧ.													
Wingspan	m	1.73	5													
Flight speed	m/sec	14.9)													
Nocturnal activity factor (1-5)		1														
Flight type, flapping or gliding		flapping	1													
				Data source	es											
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Daytime bird density	birds/sq km		0.2882982	0.4169353	1.9670819	9 1.1	53 7.663835	9 8.819292	5 1.3649668		3 2.4171735	1.1937633	0.445199	0.08189	3	
Proportion at rotor height	%	5.1%														
Proportion of flights upwind	%	50.0%														
· · · · · · · · · · · · · · · · · · ·				Data source	es											
Birds on migration data												1			1	
Migration passages	birds		C) 0	()	0	0 0) () (2000	4000	, I	0)	
Width of migration corridor	km															
Proportion at rotor height	%															
Proportion of flights upwind	%	50.0%														
	Units	Value		Data source	25											
Windfarm data															-	
Name of windfarm site		SG - A													Murray Grant:	
Latitude	degrees	56.37													Rotation speeds	r each
Number of turbines	uogioco	60													seasonal period a Breeding - 10.37	
Width of windfarm	km														Aut pass - 11.05	
Tidal offset	m														Spring pass - 10.9	
	Units	Value		Data source	es											
Turbine data															Ì	
Turbine model		7MW	r	-												
No of blades			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Rotation speed	rpm	10.37).5 10.			0						
Rotor radius	m	110		- 10.9	10.0	, 10		- 10.	, 10.		, 10.7	1	11		1	
Hub height	m	136.8		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Monthly proportion of time operational	%	100.0	88%													
Max blade width	m	5.400		, 00%	0070	, 00	00	0 00%	. 007	007	, 00%	0076	00	/0 00 /		
Pitch	degrees	5.400 10														
non	uegrees	10														
												1	1			

<u>Kittiwake</u>

COLLISION RISK ASSESSMENT			used in over	all collision r	isk sheet							used in avai	lable hours	sheet		
Sheet 1 - Input data			used in mig	rant collision	risk sheet							used in larg	e array corre	ection sheet		
			used in sing	le transit col	lision risk sh	eet or exte	nded model					not used in	calculation b	out stated for	reference	
	Units	Value		Data sourc	es											
Bird data																
Species name		Kittiwake														
Bird length	m	0.39														
Wingspan	m	1.08														
Flight speed	m/sec	13.1														
Nocturnal activity factor (1-5)		2														
Flight type, flapping or gliding		flapping														
				Data sourc	es											
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	J	lul	Aug	Sep	Oct	Nov	Dec	
Daytime bird density	birds/sq km		1.3135025	0.5555556	2.534334	4 2.0	56 1.12553	33 3.1	25244			3.3860351	2.319190	4 9.616041	9 0.5796056	ŝ
Proportion at rotor height	%	10.3%														
Proportion of flights upwind	%	50.0%														
· • • •				Data sourc	es							1				
Birds on migration data																
Vigration passages	birds		0	C)	0	0	0	0	0	C	2000	400	0	0 0	
Width of migration corridor	km															
Proportion at rotor height	%															
Proportion of flights upwind	%	50.0%														
	Units	Value		Data sourc	es											
Windfarm data																
Name of windfarm site		SG - A														
Latitude	degrees	56.37														Murray Grant:
Number of turbines	dogrooo	60														To fit with 2017 advice
Width of windfarm	km	00														seasons:
	m															Breeding: 10.22
ndar onoor	Units	Value		Data sourc	95	-		-				-				Aut passage: 10.92
Furbine data	Cinto	14140		2444 00410												Spr passage:10.85
Turbine model		7MW												-		
No of blades			Jan	Feb	Mar	Apr	May	Jun		lul	Aug	Sep	Oct	Nov	Dec	
Rotation speed		3 10.85).2	10.3	10.1						
Rotor radius	rpm	10.85		10.8	, IU.	0 10	J.J 1	J.Z	10.3	10.1	10	, 10.7	1	1 11.	1 10.8	
Hub height	m	136.8		Feb	Mar	Apr	Mov	Jun		lul	A	San	Oct	Nov	Dec	
	m %	130.8	Jan 88%				May 3% 8	Jun 3%	J 88%	iui 88%	Aug 88%	Sep 88%				
Monthly proportion of time operational		F 400		88%	88%	0 88	5% 8	5%	88%	88%	88%	88%	88%	° 88%	° 88%	
Max blade width	m degrees	5.400 10														
Pitch																

<u>Herring gull</u>

COLLISION RISK ASSESSMENT			used in over	all collision ris	sk sheet						used in ava	ilable hours s	heet		
Sheet 1 - Input data			used in mig	rant collision	risk sheet						used in larg	e array correct	ction sheet		
·			used in sing	le transit colli	ision risk she	eet or extend	ed model				not used in	calculation b	ut stated for I	eference	
	Units	Value		Data source	es										
Bird data															
Species name		Herring gull													
Bird length	m														
Wingspan	m	1.44													
Flight speed	m/sec	12.8													
Nocturnal activity factor (1-5)		2													
Flight type, flapping or gliding		flapping													
				Data source	es										
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daytime bird density	birds/sq km		0.1019258	0.1031593	0.1586145	0.0350926	0.1062241	0.08596	6 0.036023	9	0 0.017870	1 0.0730842	0.0338732	0.1252648	
Proportion at rotor height	%	22.7%													
Proportion of flights upwind	%	50.0%													
				Data source	es										
Birds on migration data															
Migration passages	birds		0	0	0	0	0) I	0 0)	0 2000	0 4000	0	0	
Width of migration corridor	km														
Proportion at rotor height	%														
Proportion of flights upwind	%	50.0%													
	Units	Value		Data source	es										
Windfarm data															
Name of windfarm site		SG - A													
Latitude	degrees	56.37													
Number of turbines		60													
Width of windfarm	km														
Tidal offset	m														-1
	Units	Value		Data source	es										Murray Grant: 10.22 for breeding
Turbine data															season
Turbine model		7MW													10.94 for non-breedin
No of blades		3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	season
Rotation speed	rpm		-								10 10.7				
Rotor radius	'n														
Hub height	m			Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Monthly proportion of time operational	%		88%		88%						3% 88%				
Max blade width	m	5.400													
Pitch	degrees	10													

Seagreen Bravo – 2017 design

Gannet

Spacies name Game			upod in miar														
Interfact Note			useu in migr	ant collision	risk sheet						used in larg	e array corre	ction sheet				
Bird data Sampet Samp			used in singl	le transit coll	sion risk she	et or extend	ded model				not used in	calculation b	ut stated for	reference			
Bird data Spaces name Bird ength m 0.94 m <td></td>																	
Spacies name Spacies name<	Units	Value		Data source	s												
Bird length m 0.94 low low <thlow< th=""> <thlow< th=""></thlow<></thlow<>																	
Wingspan m 1.73 m 1.73 m 1.73 m 1.73 m		Gannet															
Fight speed m/sec 14 y 14 y <th< td=""><td>m</td><td>0.94</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	m	0.94															
Nocturnal activity factor (1-5) Image: 1 model in a point of the poin	m	1.73															
Flight ype, flapping or gliding Image: state	m/sec	14.9															
Data sources Data sources Image: Control of the contro		1															
Bird survey data Jan Feb Mar Apr May Jun Jud Aug Sep Oct Nov Dec Daytime bird density bird/sig km 0.3153314 0.7838746 1.7348523 1.096 3.0958486 3.8067404 2.7147059 3.9040197 1.859025 1.4086777 0.5946467 0.0908181 Proportion at rotor height % 5.1% <td></td> <td>flapping</td> <td></td>		flapping															
Daytime bird density birds/sq km 0.3153314 0.7838746 1.7348623 1.096 3.0965486 3.006704 2.7147059 3.040197 1.859025 1.4086777 0.5946467 0.0008181 Proportion at rotor height % 5.1% P				Data source	s												
Dayline bird density birds/sq km 0.3153314 0.7388746 1.7348623 1.096 3.0958486 3.000197 1.859025 1.4086777 0.5946467 0.0008181 Proportion of rights % 50.0% Image: constraint of the light symbol % 50.0% Image: constraint of the light symbol 1.096 3.0958486 3.8067404 2.7147059 3.9040197 1.859025 1.4086777 0.5946467 0.0908181 Proportion of rights upwind % 50.0% Image: constraint of the light symbol <			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Proportion of flights upwind % 50.0% Image: constraint of the co	birds/sq km		0.3153314	0.7838746	1.7348523	1.09	6 3.0958486	3.8067404	1 2.714705		1.859025	1.4086777	0.5946467	0.0808181	1		
Birds on migration data Migration passages Data sources Description Marray Grant: Rotation speed Rotar on speed Marray Grant: Rotation speed migration passages Marray Grant Marray Grant<	%	5.1%															
Birds on migration data birds 0<	%	50.0%															
Birds on migration data birds 0<				Data source	s												
Migration passages birds 0 0 0 0 0 2000 4000 0 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td></td><td></td><td></td></t<>							1							1			
With d migration consider Proportion at rotor height Proportion of flights upwind $\%$ Km <t< td=""><td>birds</td><td></td><td>0</td><td>0</td><td>0</td><td></td><td>0 (</td><td>) (</td><td>)</td><td>0</td><td>0 2000</td><td>4000</td><td>) (</td><td>) (</td><td>)</td><td></td><td></td></t<>	birds		0	0	0		0 () ()	0	0 2000	4000) () ()		
Proportion at rotor height $\%$ ∞ ∞ α <	km																
Units Value Data sources Image of windfarm data Image o	%																
Windfarm data SG - A M	%	50.0%															
Name of windfarm site SG - A Image of windfarm site Image of windfarm	Units	Value		Data source	s												
Latitude degrees 56.37 one one one																	
Number of turbines 60 Interview 60		SG - A											0.063	3			
With of windfarm km see of the second period second	degrees	56.37															
With drawing	Ĩ	60															
Tidal offset m Value Data source Image: constraint of the set	km																
UnitsValueData sourcesIce	m																oreach
Turbine data Image: state of the sta	Units	Value		Data source	s												
No of blades No of																	
rpm 10.37 11.2 10.9 10.8 10.5 10.2 10.3 10.1 10 10.7 11 11.1 10.9 As calculated in CRM sheet for sheet fo		7MW													Spring pass - 10.	.95	
rpm 10.37 11.2 10.9 10.8 10.5 10.2 10.3 10.1 10 10.7 11 11.1 10.9 As calculated in CRM sheet for sheet fo		3	Jan	Feb	Mar	Apr	May	Jun	Jul	Aua	Sep	Oct	Nov	Dec			
m 110 ¹ m state state<	rpm														As calculated in	CRM sheet fo	or SG A
Hub height m 136.8 ³ Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Image: Constraints Monthly proportion of time operational % 88%																	
Monthly proportion of time operational % 88%				Feb	Mar	Apr	May	Jun	Jul	Aua	Sep	Oct	Nov	Dec	-		
Max blade width m 5.400																	
		5,400															
		m m/sec birds/sq km % % % birds birds km % % Units degrees km n Units Units	Gannet m 0.94 m 1.73 m/sec 14.9 1 flapping birds/sq km 9 % 5.1% % 5.1% % 50.0% Units Value SG - A degrees degrees 56.37 % 60 km 760 km 10.37 m 11.0 m 136.8 % 5.400	Gannet m 0.94 m 1.73 m/sec 14.9 flapping 1 birds/sq km 0.3153314 % 5.1% % 50.0% birds/sq km 0.3153314 % 50.0% birds 0 birds 0 % 50.0% Units Value % 50.37 % 56.37 % 56.37 % 60 km	Gannet m 0.94 m Image: Constraint of the second se	Gannet m 0.94 m Image: Constraint of the system mode of the system of the system of the system mode of the system of the system of the system mode of the system of the system of the system of the system mode of the system of the sys	Gannet m 0.94 m Image: Constraint of the second of the se	Gannet m 0.94 m Image: model of the second	Gannet m 0.94 m <th< td=""><td>Gannet Gannet Gannet<</td><td>Gannet m 0.94 m <th< td=""><td>Gamet m 0.94 </td><td>Gannet m 0.94 m 17.3 m/sec 14.9 1 1.73 m/sec 1.4.9 1 1.73 m/sec 1.65 m/sec 1.03 m/sec 3.9040197 1.859025 1.408777 birds 0<</td><td>Gamet m 0.94 m 1.73 m/sec 1.04 m 1.05 m/sec 1.04 m 1.05 m/sec 1.04 m 1.05 m/sec 1.04 m 1.05 m 1.02 m 1.03 m 10.1 m 10.1 m 10.7 m 11.01 m 11.01 m 11.01 m 11.01 m 10.7 m 10.7 m</td></th<><td>Gannet m 0.94 m 1 <</td><td>Gennet m Openanet 0.94 m Openanet 1.73 Openanet 0.91 Openanet 0.</td><td>Gennet m Open 0.94 m Open 0.94 m <</td></td></th<>	Gannet Gannet<	Gannet m 0.94 m <th< td=""><td>Gamet m 0.94 </td><td>Gannet m 0.94 m 17.3 m/sec 14.9 1 1.73 m/sec 1.4.9 1 1.73 m/sec 1.65 m/sec 1.03 m/sec 3.9040197 1.859025 1.408777 birds 0<</td><td>Gamet m 0.94 m 1.73 m/sec 1.04 m 1.05 m/sec 1.04 m 1.05 m/sec 1.04 m 1.05 m/sec 1.04 m 1.05 m 1.02 m 1.03 m 10.1 m 10.1 m 10.7 m 11.01 m 11.01 m 11.01 m 11.01 m 10.7 m 10.7 m</td></th<> <td>Gannet m 0.94 m 1 <</td> <td>Gennet m Openanet 0.94 m Openanet 1.73 Openanet 0.91 Openanet 0.</td> <td>Gennet m Open 0.94 m Open 0.94 m <</td>	Gamet m 0.94	Gannet m 0.94 m 17.3 m/sec 14.9 1 1.73 m/sec 1.4.9 1 1.73 m/sec 1.65 m/sec 1.03 m/sec 3.9040197 1.859025 1.408777 birds 0<	Gamet m 0.94 m 1.73 m/sec 1.04 m 1.05 m/sec 1.04 m 1.05 m/sec 1.04 m 1.05 m/sec 1.04 m 1.05 m 1.02 m 1.03 m 10.1 m 10.1 m 10.7 m 11.01 m 11.01 m 11.01 m 11.01 m 10.7 m 10.7 m	Gannet m 0.94 m 1 <	Gennet m Openanet 0.94 m Openanet 1.73 Openanet 0.91 Openanet 0.	Gennet m Open 0.94 m Open 0.94 m <

<u>Kittiwake</u>

COLLISION RISK ASSESSMENT			used in over								used in avai	lable hours s	heet			
Sheet 1 - Input data			used in migr									e array correc				
			used in sing	le transit coll	ision risk sh	eet or extend	led model				not used in	calculation b	ut stated for	reference		
	Units	Value		Data source	es							_				
Bird data																
Species name		Kittiwake														
Bird length	m	0.39	1													
Wingspan	m	1.08														
Flight speed	m/sec	13.1														
Nocturnal activity factor (1-5)		2	2													
Flight type, flapping or gliding		flapping	1													
				Data source	es											
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Daytime bird density	birds/sq km		2.3364019	2.0476724	2.4573382	1.3560429	2.707487	3.159349	1.3376954	0.3514693	0.3860366	1.4617893	6.682772	0.686747	5	
Proportion at rotor height	%	10.3%														
Proportion of flights upwind	%	50.0%														
				Data source	es											
Birds on migration data	i i										1					
Vigration passages	birds		0	0	C) () () (() (2000	4000	(C	ð	
Width of migration corridor	km															
Proportion at rotor height	%															
Proportion of flights upwind	%	50.0%														
	Units	Value		Data source	es										-	
Windfarm data																
Name of windfarm site		SG - B														
_atitude	degrees	56.37														
Number of turbines	J	60													Murray Gran To fit with 20	
Width of windfarm	km														seasons:	17 duvice on
Tidal offset	m														Breeding seas	son =10.22
	Units	Value		Data source	es	-									Aut pass = 10	
Furbine data						_						-		-	Spr pass = 10).85
Turbine model		7MW	1													
No of blades				Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Rotation speed	rpm	10.85													a	
Rotor radius	m	110		10.9	10.0	10.	5 10.2		10.1		, 10.7	1		10.	4	
Hub height	m	136.8		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	-	
Monthly proportion of time operational	%	100.0	88%												6	
Max blade width	m	5.400		0078	0070	00/		, 00/0	0070		, 00%	0078	00/			
Pitch	degrees	10					-									
- ILGH	uegrees	10	-													

<u>Herring gull</u>

COLLISION RISK ASSESSMENT			used in ove	rall collision r	sk sheet									used in avail	able hours sl	heet					
Sheet 1 - Input data			used in migrant collision risk sheet											used in large	e array correc	ction she	et				
			used in sing	gle transit col	ision risk s	heet or e	extended	Jed model						not used in a	alculation but stated for refer			eference			
	Units	Value		Data sourc	es																
Bird data																					
Species name	H	Herring gull																			
Bird length	m	0.61																			
Wingspan	m	1.44																			
Flight speed	m/sec	12.8																			
Nocturnal activity factor (1-5)		2																			
Flight type, flapping or gliding		flapping																			
				Data sourc																	
Bird survey data			Jan	Feb	Mar	Apr	1	May	Jun	J	ul	Aug		Sep	Oct	Nov		Dec			
Daytime bird density	birds/sq km		0.0628627	0.0415933	0.102442	29	0	0.04095	0.14667	'96	0)	0	0.0226718	0.021952		0	0.2145828	3		
Proportion at rotor height	%	22.7%																			
Proportion of flights upwind	%	50.0%																			
				Data sourc	es				(
Birds on migration data																					
Migration passages	birds		(0 0		0	0	()	0	0)	0	2000	4000		0	()		
Width of migration corridor	km																				
Proportion at rotor height	%																				
Proportion of flights upwind	%	50.0%																			
	Units	Value		Data sourc	es																
Windfarm data			1							_							_				
Name of windfarm site		SG - B														0	.063				
Latitude	degrees	56.37																			
Number of turbines	J	60																			
Width of windfarm	km																_				
Tidal offset	m																				
	Units	Value		Data sourc	es					_							_				
Turbine data					1		_														
Turbine model		7MW																			
No of blades		3	Jan	Feb	Mar	Apr		Mav	Jun		ul	Aug		Sep	Oct	Nov		Dec		lurray Grant:	
Rotation speed	rpm	10.94				in the second	10.5	10.2		0.3	10.1		10	10.7			11.1	10.9	1	0.22 for breeding	
Rotor radius	m			- 10.3	10	.0	10.0	10.2		5.5	10.1		10	10.7				10.0	5	eason	
Hub height	m	136.8		Feb	Mar	Apr		May	Jun	J	ul	Aug		Sep	Oct	Nov		Dec		0.94 for non-breed	Jing
Monthly proportion of time operational	%	100.0	88%				88%	88%			88%		88%	88%			88%	88%		eason	_
Max blade width	m	5.400		5070	00	,	0073	00/1		. /0	0070		0070	0070	0070		2070	507			
Pitch	degrees	10																			
	acgrees	10																			
			-	-		-	_			_							-		4		