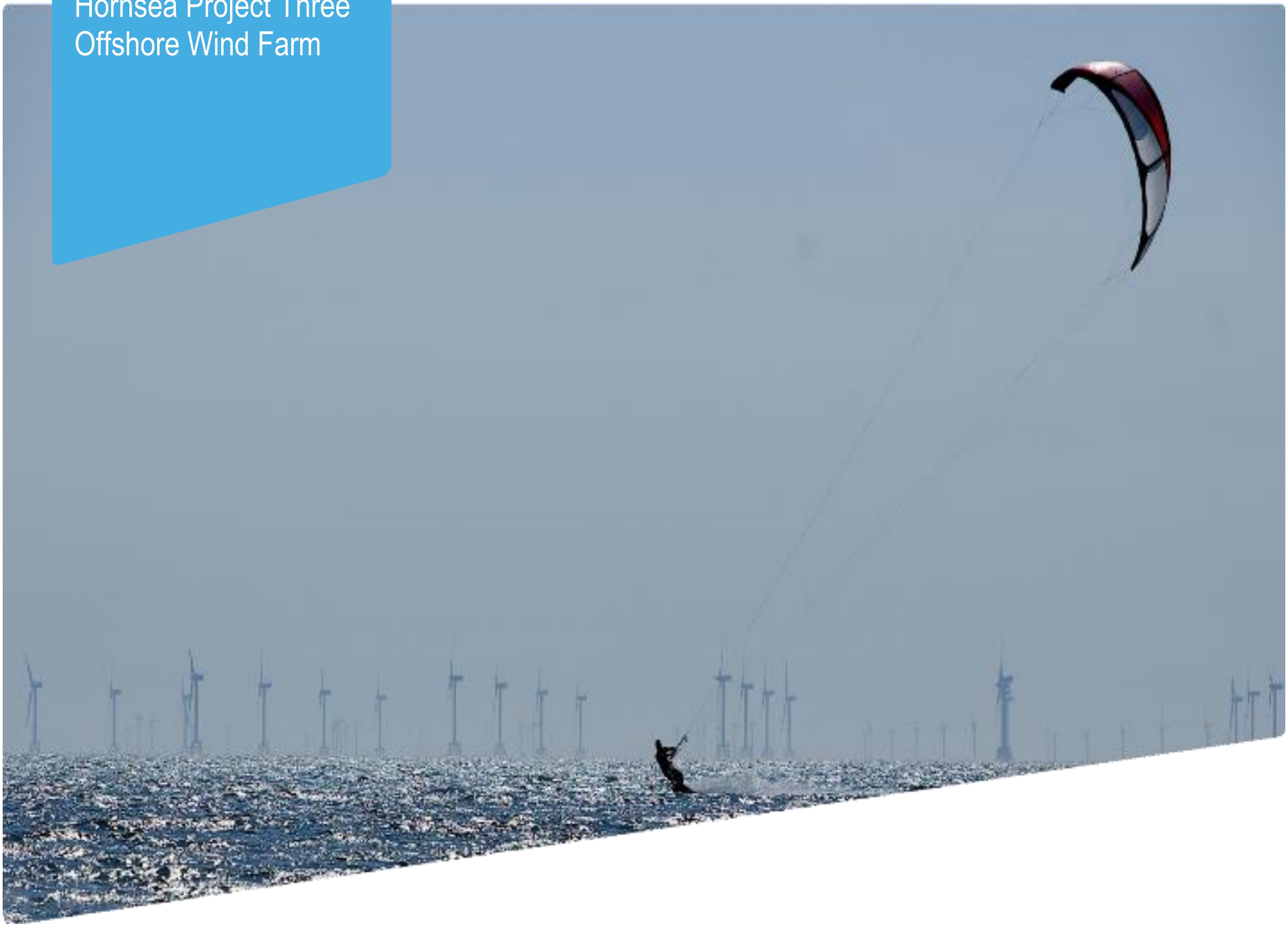
Hornsea Project Three
Offshore Wind Farm



Hornsea Project Three

Offshore Wind Farm

Appendix 10 to Deadline 10 submission - Applicant's response to Natural England's Deadline 9 submission (Ornithology)

Date: 1st April 2019

Hornsea 3
Offshore Wind Farm

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Front cover picture: Kite surfer near a UK offshore wind farm © Ørsted Hornsea Project Three (UK) Ltd., 2019.

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1. Introduction

1.1 The Applicant has reviewed Natural England's submissions at Deadline 9 and has identified two aspects that require a response. These responses are in relation to:

- REP9-069 and the comments in relation to the site-specific boat-based flight height data;
- REP9-070 and the perceived errors highlighted by Natural England.

1.2 These two responses are discussed in the following sections termed 'boat-based flight height data' and 'collision risk modelling'.

2. Boat-based flight height data (REP9-069)

Approach to calculating PCH values

2.1 The approach applied by the Applicant when calculating PCH values using the boat-based flight height data was fully described in paragraph 1.3.4.7 of APP-109. For clarity this text is repeated below:

> *"The boat-based surveys categorised flying birds into five metre height bands meaning that, for example, birds assigned to the 10 metre flight height band were flying between 7.5 and 12.5 m. The lower rotor tip height at Hornsea Three is 33.17 (MSL),* ***therefore the 35 metre flight height band (32.5 – 37.5 m) has been used to calculate the proportion of birds at PCH. Although likely to include a proportion of birds that are actually outside of the rotor swept area (i.e. those between 32.5 and 33.17 m), the use of a complete five metre band is considered precautionary****. In order to provide a measure of confidence to the flight height data to be used for Option 1 the next flight height band below 32.5 m (27.5 to 32.5 m) has also been included in the PCH value. The inclusion of these band as an 'upper confidence' measure aligns with the approach to analysis requested by Natural England during the examination at Hornsea Project Two (see SMart Wind, 2015b). The PCH values calculated for each species are presented in Table 1.6."*

2.2 Natural England have further queried whether all flight height data within the lower height band has been used to calculate a PCH value. The text highlighted in bold in the extract of paragraph 1.3.4.7 above is considered to address this point, clearly indicating that all data from the lower height band has been used with no post-processing of the data. This is the approach that has been applied when using these data to calculate PCH values throughout the application and the examination.

2.3 The Applicant would highlight that this approach was accepted by Natural England as part of the Hornsea Project Two application for which they utilised collision risk estimates from Option 1 to inform their conclusions (see REP2-023).

Boat-based flight height data

2.4 For Hornsea Project Two there was ongoing discussions between the Hornsea Project Two applicant and Natural England in relation to the flight height data obtained during boat-based surveys. In order to address Natural England's concerns the Hornsea Project Two applicant providing an upper confidence metric taking into account additional flight height bands to those that fell within the rotor swept area. This allowed Natural England to base their conclusions on collision risk estimates derived using Option 1 of the Band (2012) CRM (see REP2-023). The approach applied at Hornsea Project Two is identical to that applied by the Applicant in the collision risk modelling conducted or Hornsea Three. In addition to this response the Applicant has provided Appendix 9 to the Applicant's deadline 10 submission which provides full details in relation to the Hornsea Project Two applicant's position on the flight height data collected during boat-based surveys. That position aligns with the Applicant's position at Hornsea Three with a summary provided in this report.

2.5 Natural England's underlying concern in relation to the flight height data obtained from boat-based surveys was the difference between the PCH values obtained from these data and those reported by Johnston et al. (2014). There are good reasons for these differences including the height bands used to calculate PCH and the inshore location of all but one of the projects from which data were used to inform the calculation of generic flight height distributions in Johnston et al. (2014). The potential limitations of using generic flight height data are identified within the Band (2012) guidance:

> *"Caution is needed in deploying this generic data. It is entirely possible that the ecological circumstances of a particular site differ from those sites used to generate the generic data, and hence the bird behaviours and flight heights may not be well represented by the generic data".*

2.6 At Hornsea Project Two, the applicant presented PCH values presented at other offshore wind farms which showed that the PCH value obtained from the boat-based data at Hornsea Project Two was not as anomalous as suggested when comparing to the PCH values presented in Johnston *et al.* (2014) (see paragraphs 1.6.20 to 1.6.23, Table 1.5 and Figure 1.3 in Appendix 9 to the Applicant's submission at Deadline 10)

2.7 Natural England, at Hornsea Project Two suggested that the collection of flight height data in five metre bands was unusual and that bands representing below, within and above rotor heights would be standard. At Hornsea Project Two the applicant was able to identify the flight height bands used during surveys conducted at 26 projects (see Table 1.3 in Appendix 9 to the Applicant's submission at Deadline 10). Of these projects the flight height bands at only eight could be described as below, within and above rotor height. Many projects used more detailed flight height bands with eight using flight height bands representing five metres of less including the use of one metre bands. Discounting the accuracy of this methods, Natural England's assertion that the use of five metre bands is unusual is clearly incorrect. It was also highlighted by the Hornsea Project Two applicant that collision risk estimates for other projects considered in the cumulative and in-combination assessments were calculated using flight height information collected using more detailed flight height bands. These collision risk estimates have been used by Natural England when assessing cumulative and in-combination impacts.

2.8 The data collection at Hornsea Project Two was aligned with that proposed in the review of methods by Camphuysen et al. (2004) carried out for the Collaborative Offshore Wind Research Into the Environment (COWRIE) project and advocated by JNCC. Camphuysen et al. (2004) presents COWRIE's guidelines for boat-based surveys of marine birds for offshore wind farm assessments. These guidelines suggest the use of bands more detailed than suggested by Natural England with additional finer bands towards lower heights (0-2 m, 2-10 m, 10-25 m, 25-50 m, 50-100 m, 100-200 m, >200 m). A subsequent review of these methods commissioned by COWRIE (Maclean et al., 2009) did not recommend any changes to the proposed method for recording the flight height of birds. All other aspects of the methodology used at Hornsea Project Two were consistent with the guidelines in Camphuysen et al. (2004) (e.g. the use of snapshot counts) and also drew on guidance provided by JNCC (Webb and Durinck (1992) and JNCC (2014)).

2.9 Natural England have presented information that they consider undermines the accuracy of boat-based estimation of flight height data. This information was provided at Hornsea Project Two and in the intervening period the Applicant is not aware of this work having been published and therefore it has not been subject to external review. It is impossible to say whether these preliminary data are reliable as a full description of the methodology has not been provided. The Applicant would firstly highlight that, if these results are to be believed, they apply as equally to the boat-based data used to inform Option 1 as they do to the generic flight height data used for Option 2 with the generic flight height distributions derived from boat-based survey data as advocated by Natural England at Hornsea Three. Further to this, of the flight height records for gannet, kittiwake, lesser black-backed gull, herring gull and great black-backed gull, 96%, 98%, 77%, 81% and 81% were either within or below the 25 m flight height band. Even if the data presented by Natural England were to be accepted these birds would all still be below the lower rotor height at Hornsea Three. Because these flights are generally less than 25 m above the surface of the water, it seems unlikely that surveyors would wrongly attribute flights as being lower than rotor height, and therefore it is considered that there is high confidence in the survey data.

2.10 The use of the upper confidence metric (i.e. incorporating data from the next lowest flight height band into PCH calculations) was applied at Hornsea Project Two in order to allay the concerns of Natural England in relation to the flight height data. Natural England have not presented any further evidence that would invalidate this approach. The Applicant has applied an identical approach at Hornsea Three and therefore it is not clear why Natural England now reject the use of Option 1, collision risk estimates from which were the basis of their conclusions at Hornsea Project Two.

2.11 In summary the Hornsea Project Two applicant concluded that the site-specific flight height data was adequate to inform assessments for the following key reasons, all of which are also applicable to Hornsea Three:

- *"Data collected did not follow an unusual methodology;*
- *Site specific data in this case* [at Hornsea Project Two] *should be seen as the primary indicator of local conditions;*
- *Any observer error in assigning flight heights has a negligible effect on PCH calculation;*
- *PCH value for kittiwake at* [Hornsea] *Project Two is not an outlier when considering a range of datasets; and*
- *Generic data for kittiwake PCH is not directly comparable to* [Hornsea] *Project Two."*

2.12 These conclusions are also considered applicable to the other species considered for collision risk modelling at Hornsea Three. Although a review of PCH values for other species has not been conducted for gannet, lesser black-backed gull, herring gull and great black-backed gull and so it is not possible to apply the relevant conclusion from Hornsea Project Two to these species.

3. Collision risk modelling (REP9-070)

REP6-043

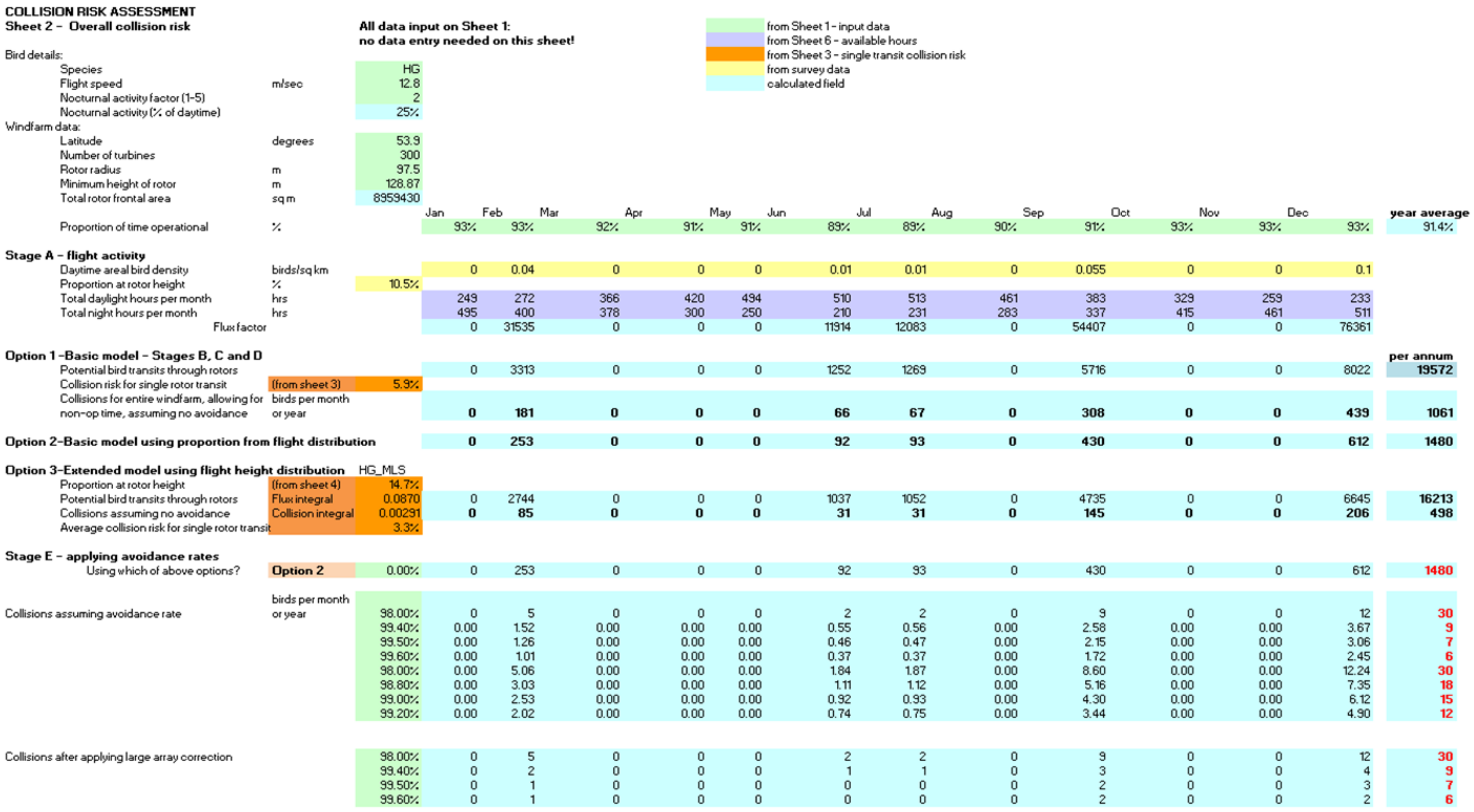
3.1 A small transcription error occurred when populating Table 3.15 in REP6-043. This table should read as presented in Table 3.1, with red text indicating where values have changed.

Table 3.1: Corrected version of "*Table 3.15: Monthly collision risk estimates for herring gull calculated using Option 2 of Band (2012) using confidence intervals associated with density with a nocturnal activity factor range of 2-3*" as presented in REP6-043.

Avoidance rate (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Density = Mean estimate												
99.4	0	1.52 - 1.92	0	0	0	0.55 - 0.6	0.56 - 0.62	0	2.58 - 3.05	0	0	3.67 - 4.97
99.5	0	1.26 - 1.6	0	0	0	0.46 - 0.5	0.47 - 0.51	0	2.15 - 2.54	0	0	3.06 - 4.15
99.6	0	1.01 - 1.28	0	0	0	0.37 - 0.4	0.37 - 0.41	0	1.72 - 2.03	0	0	2.45 - 3.32
Density = Upper confidence limit												
99.4	0	3.03 - 3.85	0	0	0	1.94 - 2.12	1.68 - 1.85	0	5.63 - 6.64	0	0	6.61 - 8.95
99.5	0	2.53 - 3.21	0	0	0	1.61 - 1.76	1.4 - 1.54	0	4.69 - 5.54	0	0	5.51 - 7.46
99.6	0	2.02 - 2.57	0	0	0	1.29 - 1.41	1.12 - 1.23	0	3.75 - 4.43	0	0	4.41 - 5.97
Density = Lower confidence limit												
99.4	0	0	0	0	0	0	0	0	0	0	0	1.1 - 1.49
99.5	0	0	0	0	0	0	0	0	0	0	0	0.92 - 1.24
99.6	0	0	0	0	0	0	0	0	0	0	0	0.73 - 0.99

REP7-032

3.2 Figure 1.13 and Figure 1.23 contained minor errors in relation to the total columns presenting collision risk estimates. This was caused by the underlying formulas not incorporating those collision risk estimates calculated for December. This error does not affect any of the collision risk estimates presented throughout any other submissions. An updated version of Figure 1.13 and Figure 1.23 is presented in Figure 3.1 and Figure 3.2, respectively with red text identifying where values have changed.



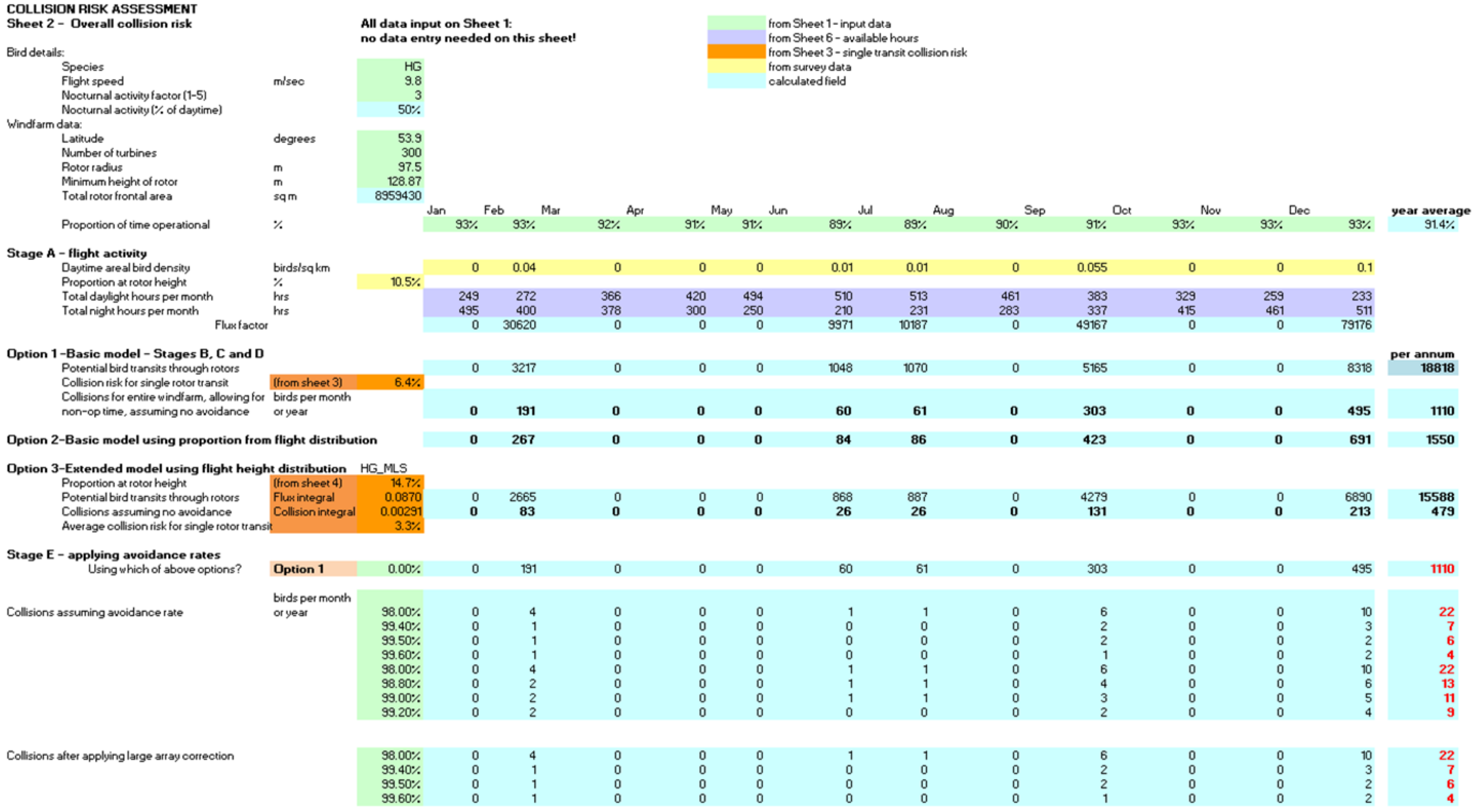
COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

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

🟩 from Sheet 1 - input data
▨ from Sheet 6 - available hours
🟧 from Sheet 3 - single transit collision risk
🟨 from survey data
▢ calculated field

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Bird details:															
Species		HG													
Flight speed	m/sec	12.8													
Nocturnal activity factor (1-5)		2													
Nocturnal activity (% of daytime)		25%													
Windfarm data:															
Latitude	degrees	53.9													
Number of turbines		300													
Rotor radius	m	97.5													
Minimum height of rotor	m	128.87													
Total rotor frontal area	sq m	8959430													**year average**
Proportion of time operational	%		93%	93%	92%	91%	91%	89%	89%	90%	91%	93%	93%	93%	91.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0	0.04	0	0	0	0.01	0.01	0	0.055	0	0	0.1	
Proportion at rotor height	%	10.5%													
Total daylight hours per month	hrs		249	272	366	420	494	510	513	461	383	329	259	233	
Total night hours per month	hrs		495	400	378	300	250	210	231	283	337	415	461	511	
Flux factor			0	31535	0	0	0	11914	12083	0	54407	0	0	76361	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			0	3313	0	0	0	1252	1269	0	5716	0	0	8022	**19572**
Collision risk for single rotor transit	(from sheet 3)	5.9%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**0**	**181**	**0**	**0**	**0**	**66**	**67**	**0**	**308**	**0**	**0**	**439**	**1061**
Option 2-Basic model using proportion from flight distribution			**0**	**253**	**0**	**0**	**0**	**92**	**93**	**0**	**430**	**0**	**0**	**612**	**1480**
Option 3-Extended model using flight height distribution		HG_MLS													
Proportion at rotor height	(from sheet 4)	14.7%													
Potential bird transits through rotors	Flux integral	0.0870	0	2744	0	0	0	1037	1052	0	4735	0	0	6645	**16213**
Collisions assuming no avoidance	Collision integral	0.00291	**0**	**85**	**0**	**0**	**0**	**31**	**31**	**0**	**145**	**0**	**0**	**206**	**498**
Average collision risk for single rotor transit		3.3%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 2**	0.00%	0	253	0	0	0	92	93	0	430	0	0	612	**1480**
Collisions assuming avoidance rate	birds per month or year	98.00%	0	5	0	0	0	2	2	0	9	0	0	12	**30**
		99.40%	0.00	1.52	0.00	0.00	0.00	0.55	0.56	0.00	2.58	0.00	0.00	3.67	**9**
		99.50%	0.00	1.26	0.00	0.00	0.00	0.46	0.47	0.00	2.15	0.00	0.00	3.06	**7**
		99.60%	0.00	1.01	0.00	0.00	0.00	0.37	0.37	0.00	1.72	0.00	0.00	2.45	**6**
		98.00%	0.00	5.06	0.00	0.00	0.00	1.84	1.87	0.00	8.60	0.00	0.00	12.24	**30**
		98.80%	0.00	3.03	0.00	0.00	0.00	1.11	1.12	0.00	5.16	0.00	0.00	7.35	**18**
		99.00%	0.00	2.53	0.00	0.00	0.00	0.92	0.93	0.00	4.30	0.00	0.00	6.12	**15**
		99.20%	0.00	2.02	0.00	0.00	0.00	0.74	0.75	0.00	3.44	0.00	0.00	4.90	**12**
Collisions after applying large array correction		98.00%	0	5	0	0	0	2	2	0	9	0	0	12	**30**
		99.40%	0	2	0	0	0	1	1	0	3	0	0	4	**9**
		99.50%	0	1	0	0	0	0	0	0	2	0	0	3	**7**
		99.60%	0	1	0	0	0	0	0	0	2	0	0	2	**6**

Figure 3.1: Corrected version of "*Figure 1.13: Overall collision risk spreadsheet from the Band (2012) CRM for herring gull using the Applicant's interpretation of Natural England's position (using mean estimates for density and flight height distribution and a nocturnal activity of 2)*" as presented in REP7-032



COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

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

🟩	from Sheet 1 - input data
🟪	from Sheet 6 - available hours
🟧	from Sheet 3 - single transit collision risk
🟨	from survey data
🟦	calculated field

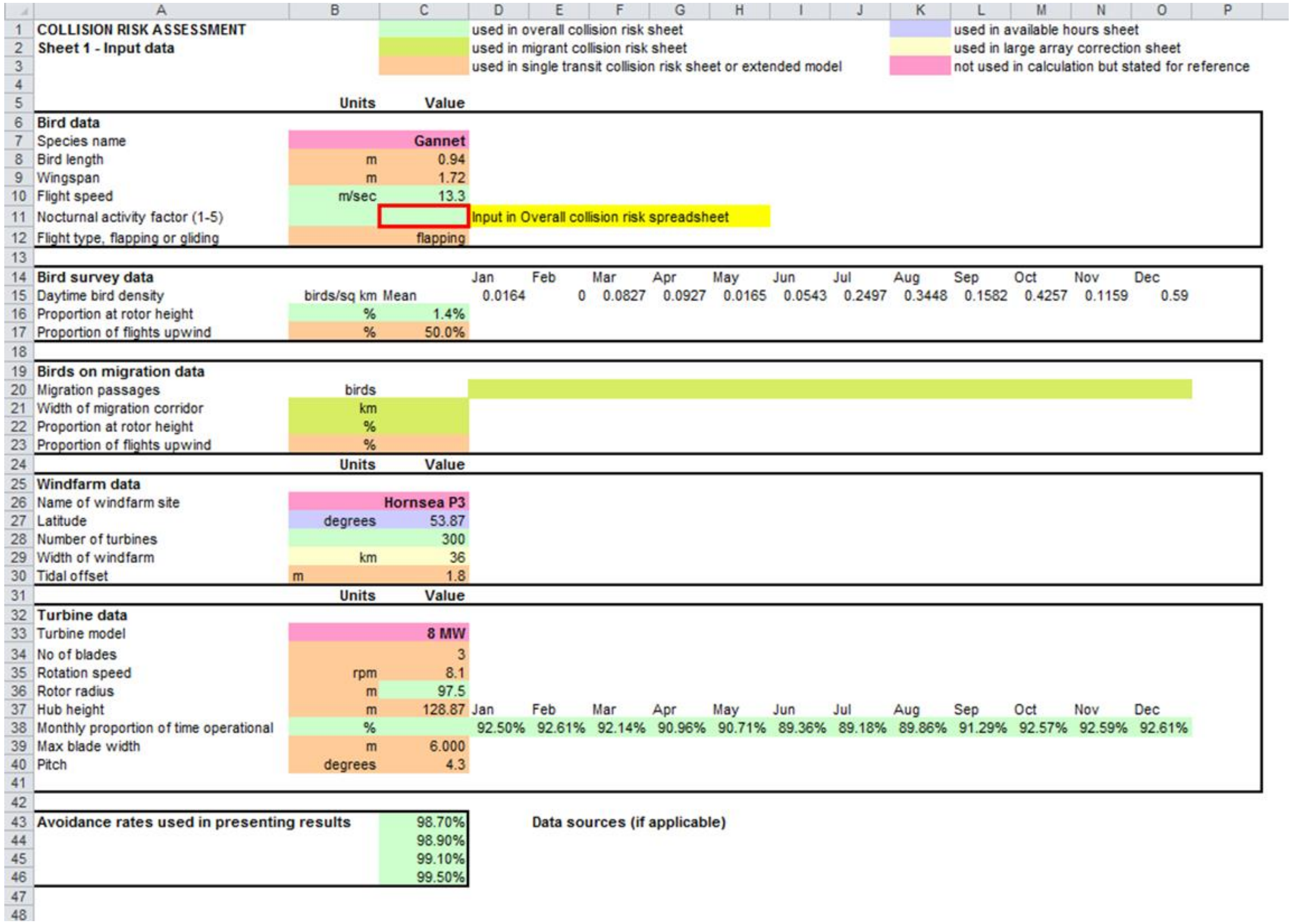
Bird details:																
Species			HG													
Flight speed	m/sec		9.8													
Nocturnal activity factor (1-5)			3													
Nocturnal activity (% of daytime)			50%													
Windfarm data:																
Latitude	degrees		53.9													
Number of turbines			300													
Rotor radius	m		97.5													
Minimum height of rotor	m		128.87													
Total rotor frontal area	sq m		8959430													
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**year average**
Proportion of time operational	%			93%	93%	92%	91%	91%	89%	89%	90%	91%	93%	93%	93%	91.4%
Stage A - flight activity																
Daytime areal bird density	birds/sq km			0	0.04	0	0	0	0.01	0.01	0	0.055	0	0	0.1	
Proportion at rotor height	%		10.5%													
Total daylight hours per month	hrs			249	272	366	420	494	510	513	461	383	329	259	233	
Total night hours per month	hrs			495	400	378	300	250	210	231	283	337	415	461	511	
Flux factor				0	30620	0	0	0	9971	10187	0	49167	0	0	79176	
Option 1 -Basic model - Stages B, C and D																**per annum**
Potential bird transits through rotors				0	3217	0	0	0	1048	1070	0	5165	0	0	8318	**18818**
Collision risk for single rotor transit		(from sheet 3)	6.4%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year			**0**	**191**	**0**	**0**	**0**	**60**	**61**	**0**	**303**	**0**	**0**	**495**	**1110**
Option 2-Basic model using proportion from flight distribution				**0**	**267**	**0**	**0**	**0**	**84**	**86**	**0**	**423**	**0**	**0**	**691**	**1550**
Option 3-Extended model using flight height distribution		HG_MLS														
Proportion at rotor height		(from sheet 4)	14.7%													
Potential bird transits through rotors		Flux integral	0.0870	0	2665	0	0	0	868	887	0	4279	0	0	6890	**15588**
Collisions assuming no avoidance		Collision integral	0.00291	**0**	**83**	**0**	**0**	**0**	**26**	**26**	**0**	**131**	**0**	**0**	**213**	**479**
Average collision risk for single rotor transit			3.3%													
Stage E - applying avoidance rates																
Using which of above options?		**Option 1**	0.00%	0	191	0	0	0	60	61	0	303	0	0	495	**1110**
Collisions assuming avoidance rate	birds per month or year		98.00%	0	4	0	0	0	1	1	0	6	0	0	10	**22**
			99.40%	0	1	0	0	0	0	0	0	2	0	0	3	**7**
			99.50%	0	1	0	0	0	0	0	0	2	0	0	2	**6**
			99.60%	0	1	0	0	0	0	0	0	1	0	0	2	**4**
			98.00%	0	4	0	0	0	1	1	0	6	0	0	10	**22**
			98.80%	0	2	0	0	0	1	1	0	4	0	0	6	**13**
			99.00%	0	2	0	0	0	1	1	0	3	0	0	5	**11**
			99.20%	0	2	0	0	0	0	0	0	2	0	0	4	**9**
Collisions after applying large array correction			98.00%	0	4	0	0	0	1	1	0	6	0	0	10	**22**
			99.40%	0	1	0	0	0	0	0	0	2	0	0	3	**7**
			99.50%	0	1	0	0	0	0	0	0	2	0	0	2	**6**
			99.60%	0	1	0	0	0	0	0	0	1	0	0	2	**4**

Figure 3.2: Corrected version of “*Figure 1.23: Overall collision risk spreadsheet from the Band (2012) CRM for herring gull using the Applicant’s position (using mean estimates for density and PCH)*” as presented in REP7-032.

3.3 Natural England have also suggested that errors exist in the collision risk spreadsheets presented in relation to the Applicant's position for gannet and kittiwake. The Applicant's position is that nocturnal activity factors from Furness *et al.* (2018) and MacArthur Green (2018) should be used to inform collision risk modelling. These nocturnal activity factors can be incorporated into the Band (2012) CRM in two ways. The first approach is to enter a value in cell C11 the Input Data spreadsheet (Figure 3.3) and the second is to enter the value in cell D7 of the Overall Collision Risk spreadsheet (Figure 3.4). These cells are highlighted in red in Figure 3.3 and Figure 3.4. The Applicant, in the spreadsheets presented in REP7-032 has used Method 2 and identified this using comments on Figures 1.16, 1.17, 1.18 and 1.19 in REP7-032 (highlighted in yellow in Figure 3.3). The Applicant has also highlighted that multiple nocturnal activity factors (representing the activity of birds in different seasons) are required to produce collision risk estimates with the relevant text highlighted in yellow in Figure 3.4. The Applicant rejects any notion that this may be misleading.

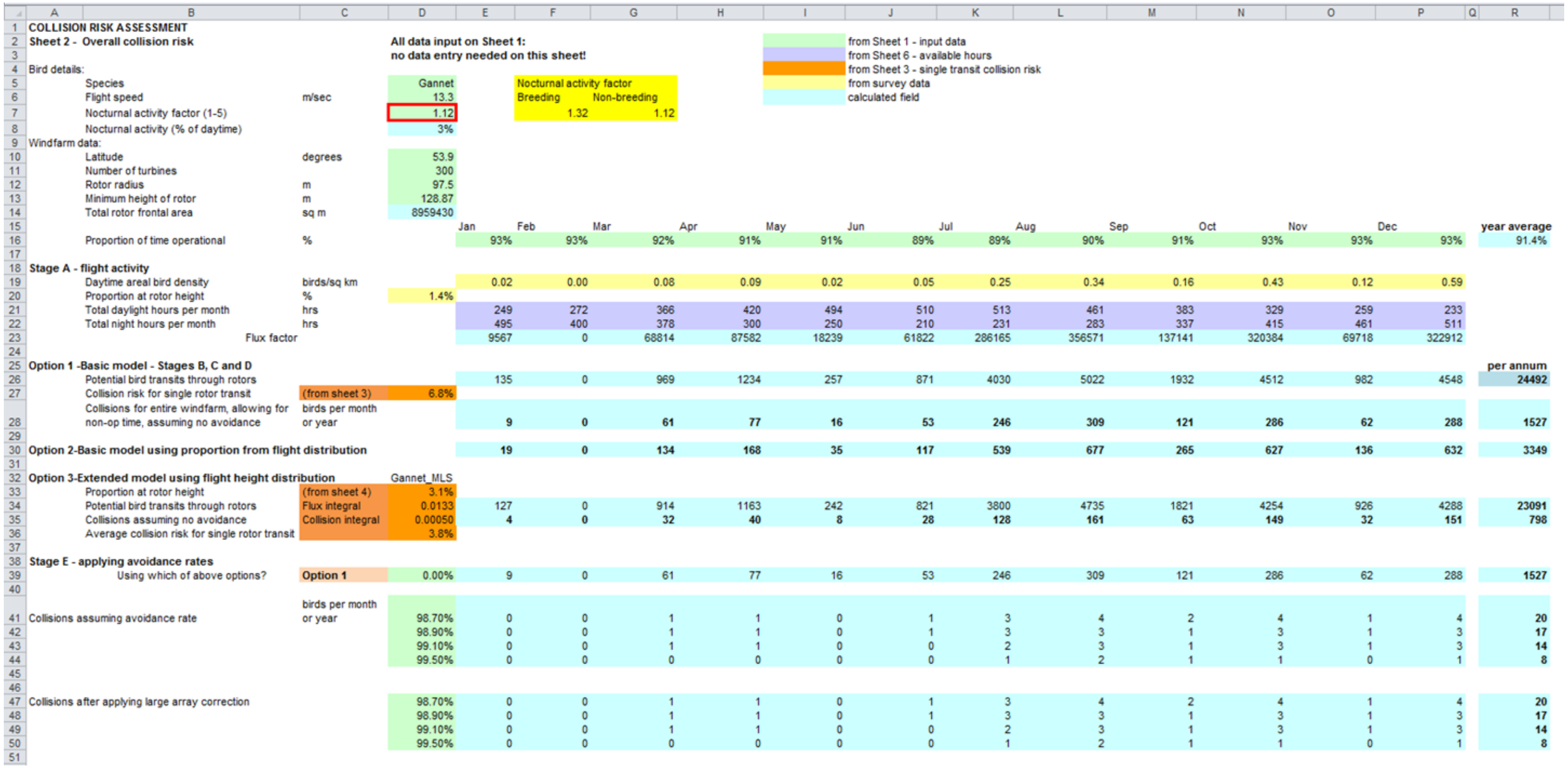
3.4 If a nocturnal activity factor is entered in the Input Data spreadsheet, cell D7 of the Overall Collision Risk spreadsheet contains a formula that reads that value (=*'Input data'!C11*). This is fundamentally no different to entering the value in cell C11 of the Overall Collision Risk spreadsheet. The Applicant explained the approach taken to incorporating seasonal nocturnal activity factors at Issue Specific Hearing 2 (5th December 2018).

3.5 Natural England have also suggested that the avoidance rates presented in Figure 1.18 and Figure 1.19, which present the collision risk modelling spreadsheets used to calculate the collision risk estimates for kittiwake, do not match. Figure 3.5 and Figure 3.6 clearly show that the avoidance rates are identical unless Natural England are referring to collision risk estimates calculated when applying a large array correction. However, the Applicant has consistently stated in Written Representations (e.g. APP-109) and at Issue Specific Hearings (see REP6-010) that the large array correction factor has not been applied. Natural England are therefore incorrect on this point.



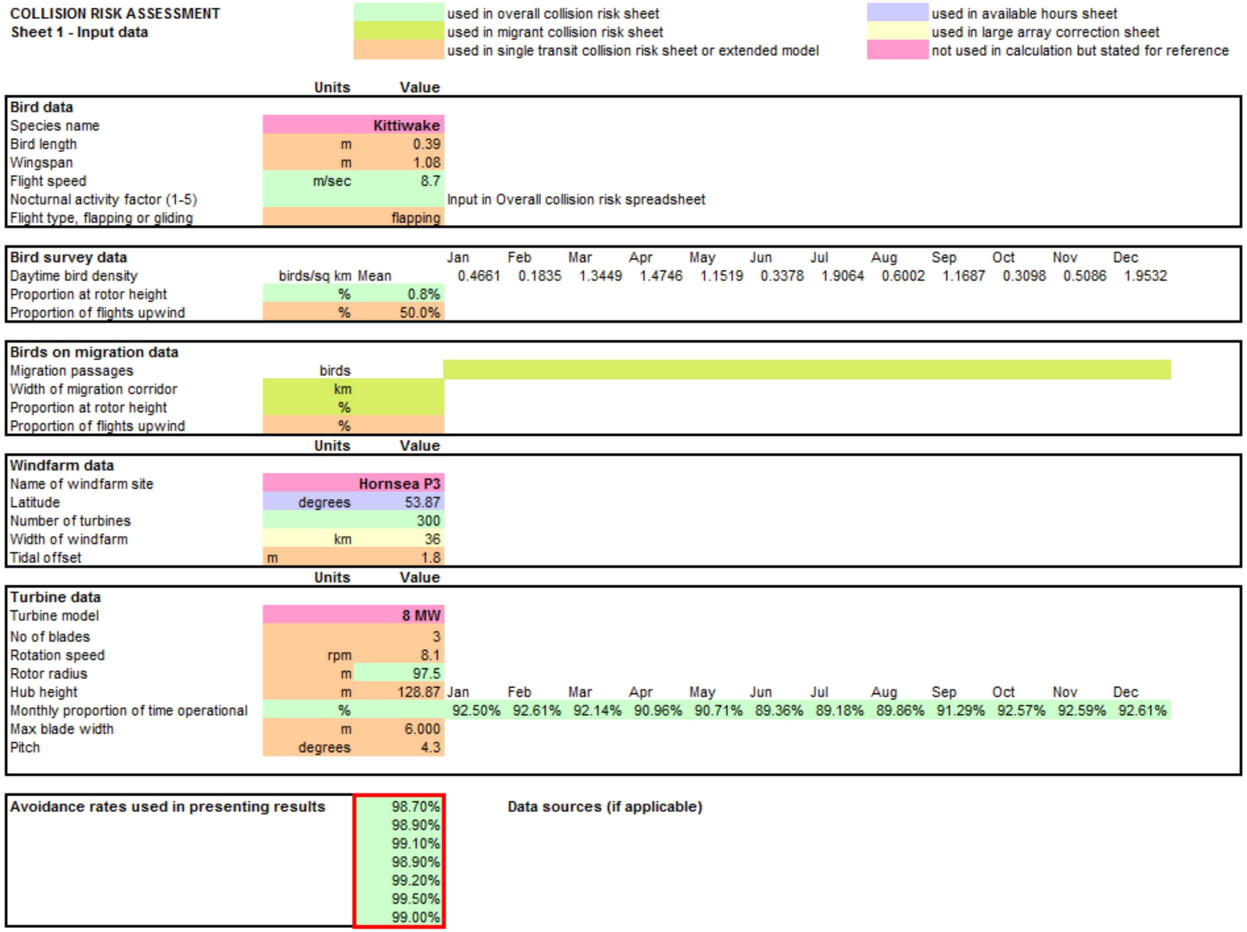
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**COLLISION RISK ASSESSMENT**		🟩	used in overall collision risk sheet							🟪	used in available hours sheet				
2	**Sheet 1 - Input data**		🟩	used in migrant collision risk sheet							🟨	used in large array correction sheet				
3			🟧	used in single transit collision risk sheet or extended model							🟥	not used in calculation but stated for reference				
4																
5		**Units**	**Value**													
6	**Bird data**															
7	Species name		**Gannet**													
8	Bird length	m	0.94													
9	Wingspan	m	1.72													
10	Flight speed	m/sec	13.3													
11	Nocturnal activity factor (1-5)			Input in Overall collision risk spreadsheet												
12	Flight type, flapping or gliding		flapping													
13																
14	**Bird survey data**			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
15	Daytime bird density	birds/sq km	Mean	0.0164	0	0.0827	0.0927	0.0165	0.0543	0.2497	0.3448	0.1582	0.4257	0.1159	0.59	
16	Proportion at rotor height	%	1.4%													
17	Proportion of flights upwind	%	50.0%													
18																
19	**Birds on migration data**															
20	Migration passages	birds														
21	Width of migration corridor	km														
22	Proportion at rotor height	%														
23	Proportion of flights upwind	%														
24		**Units**	**Value**													
25	**Windfarm data**															
26	Name of windfarm site		**Hornsea P3**													
27	Latitude	degrees	53.87													
28	Number of turbines		300													
29	Width of windfarm	km	36													
30	Tidal offset	m	1.8													
31		**Units**	**Value**													
32	**Turbine data**															
33	Turbine model		**8 MW**													
34	No of blades		3													
35	Rotation speed	rpm	8.1													
36	Rotor radius	m	97.5													
37	Hub height	m	128.87	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
38	Monthly proportion of time operational	%		92.50%	92.61%	92.14%	90.96%	90.71%	89.36%	89.18%	89.86%	91.29%	92.57%	92.59%	92.61%	
39	Max blade width	m	6.000													
40	Pitch	degrees	4.3													
41																
42																
43	**Avoidance rates used in presenting results**		98.70%		**Data sources (if applicable)**											
44			98.90%													
45			99.10%													
46			99.50%													
47																
48																

Figure 3.3: Nocturnal activity factor entry in the Band (2012) CRM, Input Data spreadsheet (Method 1)



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	**COLLISION RISK ASSESSMENT**																	
2	**Sheet 2 - Overall collision risk**			**All data input on Sheet 1:**					🟩	from Sheet 1 - input data								
3				**no data entry needed on this sheet!**					🟪	from Sheet 6 - available hours								
4	Bird details:								🟧	from Sheet 3 - single transit collision risk								
5		Species		Gannet		Nocturnal activity factor			🟨	from survey data								
6		Flight speed	m/sec	13.3		Breeding	Non-breeding		🟦	calculated field								
7		Nocturnal activity factor (1-5)		1.12		1.32	1.12											
8		Nocturnal activity (% of daytime)		3%														
9	Windfarm data:																	
10		Latitude	degrees	53.9														
11		Number of turbines		300														
12		Rotor radius	m	97.5														
13		Minimum height of rotor	m	128.87														
14		Total rotor frontal area	sq m	8959430														
15					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		**year average**
16		Proportion of time operational	%		93%	93%	92%	91%	91%	89%	89%	90%	91%	93%	93%	93%		91.4%
17																		
18	**Stage A - flight activity**																	
19		Daytime areal bird density	birds/sq km		0.02	0.00	0.08	0.09	0.02	0.05	0.25	0.34	0.16	0.43	0.12	0.59		
20		Proportion at rotor height	%	1.4%														
21		Total daylight hours per month	hrs		249	272	366	420	494	510	513	461	383	329	259	233		
22		Total night hours per month	hrs		495	400	378	300	250	210	231	283	337	415	461	511		
23		Flux factor			9567	0	68814	87582	18239	61822	286165	356571	137141	320384	69718	322912		
24																		
25	**Option 1 -Basic model - Stages B, C and D**																	**per annum**
26		Potential bird transits through rotors			135	0	969	1234	257	871	4030	5022	1932	4512	982	4548		**24492**
27		Collision risk for single rotor transit	(from sheet 3)	6.8%														
28		Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**9**	**0**	**61**	**77**	**16**	**53**	**246**	**309**	**121**	**286**	**62**	**288**		**1527**
29																		
30	**Option 2-Basic model using proportion from flight distribution**				**19**	**0**	**134**	**168**	**35**	**117**	**539**	**677**	**265**	**627**	**136**	**632**		**3349**
31																		
32	**Option 3-Extended model using flight height distribution**			Gannet_MLS														
33		Proportion at rotor height	(from sheet 4)	3.1%														
34		Potential bird transits through rotors	Flux integral	0.0133	127	0	914	1163	242	821	3800	4735	1821	4254	926	4288		**23091**
35		Collisions assuming no avoidance	Collision integral	0.00050	**4**	**0**	**32**	**40**	**8**	**28**	**128**	**161**	**63**	**149**	**32**	**151**		798
36		Average collision risk for single rotor transit		3.8%														
37																		
38	**Stage E - applying avoidance rates**																	
39		Using which of above options?	**Option 1**	0.00%	9	0	61	77	16	53	246	309	121	286	62	288		**1527**
40																		
41	Collisions assuming avoidance rate		birds per month or year	98.70%	0	0	1	1	0	1	3	4	2	4	1	4		**20**
42				98.90%	0	0	1	1	0	1	3	3	1	3	1	3		**17**
43				99.10%	0	0	1	1	0	0	2	3	1	3	1	3		**14**
44				99.50%	0	0	0	0	0	0	1	2	1	1	0	1		**8**
45																		
46																		
47	Collisions after applying large array correction			98.70%	0	0	1	1	0	1	3	4	2	4	1	4		**20**
48				98.90%	0	0	1	1	0	1	3	3	1	3	1	3		**17**
49				99.10%	0	0	1	1	0	0	2	3	1	3	1	3		**14**
50				99.50%	0	0	0	0	0	0	1	2	1	1	0	1		**8**
51																		

Figure 3.4: Nocturnal activity factor entry in the Band (2012) CRM, Overall Collision Risk spreadsheet (Method 2)



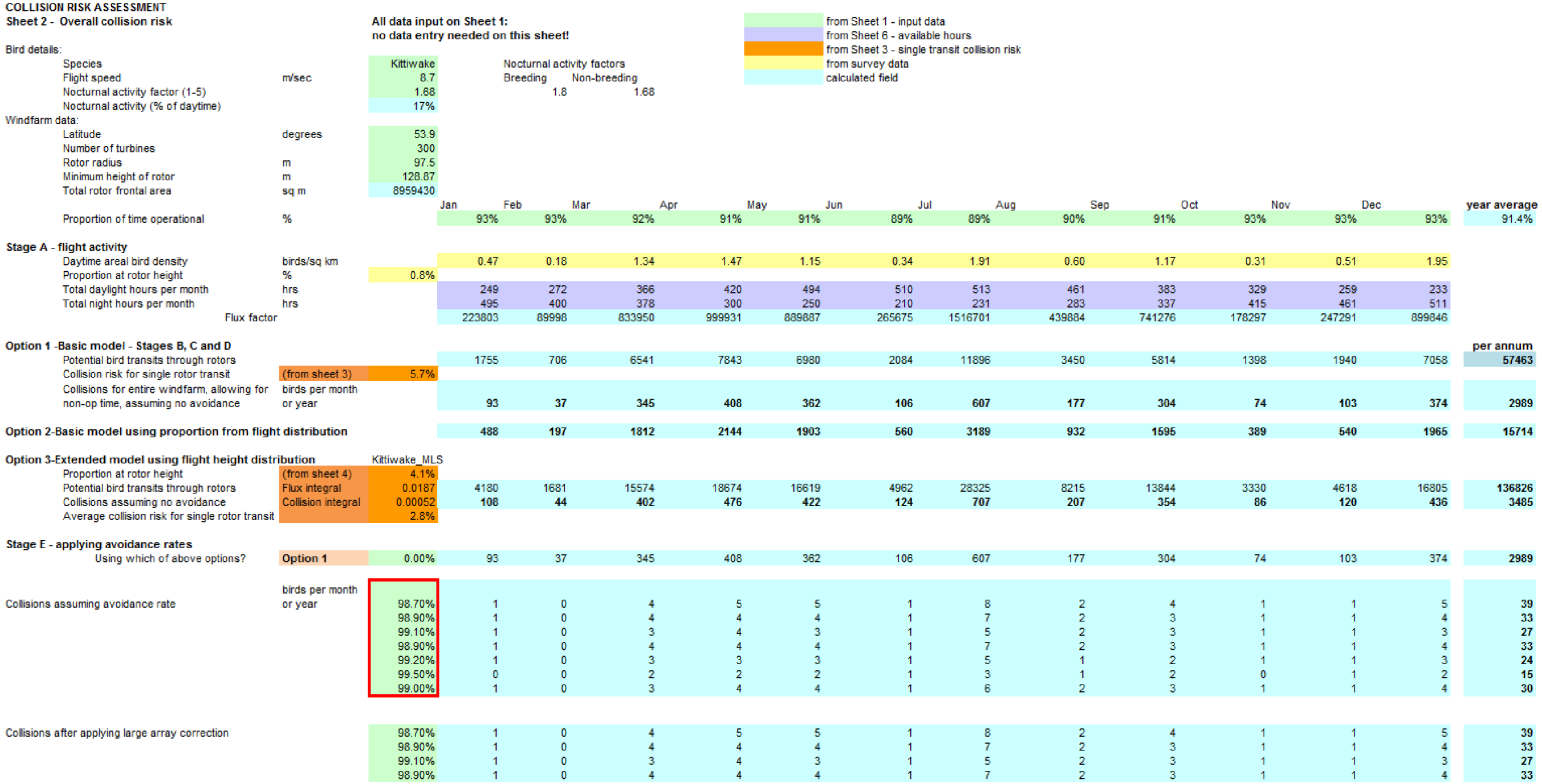
COLLISION RISK ASSESSMENT
Sheet 1 - Input data

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

	Units	**Value**												
Bird data														
Species name		**Kittiwake**												
Bird length	m	0.39												
Wingspan	m	1.08												
Flight speed	m/sec	8.7												
Nocturnal activity factor (1-5)			Input in Overall collision risk spreadsheet											
Flight type, flapping or gliding		flapping												
Bird survey data			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daytime bird density	birds/sq km	Mean	0.4661	0.1835	1.3449	1.4746	1.1519	0.3378	1.9064	0.6002	1.1687	0.3098	0.5086	1.9532
Proportion at rotor height	%	0.8%												
Proportion of flights upwind	%	50.0%												
Birds on migration data														
Migration passages	birds													
Width of migration corridor	km													
Proportion at rotor height	%													
Proportion of flights upwind	%													
	Units	**Value**												
Windfarm data														
Name of windfarm site		**Hornsea P3**												
Latitude	degrees	53.87												
Number of turbines		300												
Width of windfarm	km	36												
Tidal offset	m	1.8												
	Units	**Value**												
Turbine data														
Turbine model		**8 MW**												
No of blades		3												
Rotation speed	rpm	8.1												
Rotor radius	m	97.5												
Hub height	m	128.87	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly proportion of time operational	%		92.50%	92.61%	92.14%	90.96%	90.71%	89.36%	89.18%	89.86%	91.29%	92.57%	92.59%	92.61%
Max blade width	m	6.000												
Pitch	degrees	4.3												

Avoidance rates used in presenting results	98.70%	**Data sources (if applicable)**
	98.90%	
	99.10%	
	98.90%	
	99.20%	
	99.50%	
	99.00%	

Figure 3.5: Figure 1.18 as included in REP7-032 showing the input values for avoidance rate



COLLISION RISK ASSESSMENT
Sheet 2 - Overall collision risk

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

🟩	from Sheet 1 - input data
🟪	from Sheet 6 - available hours
🟧	from Sheet 3 - single transit collision risk
🟨	from survey data
🟦	calculated field

Nocturnal activity factors

Breeding	Non-breeding
1.8	1.68

Bird details:		
Species		Kittiwake
Flight speed	m/sec	8.7
Nocturnal activity factor (1-5)		1.68
Nocturnal activity (% of daytime)		17%
Windfarm data:		
Latitude	degrees	53.9
Number of turbines		300
Rotor radius	m	97.5
Minimum height of rotor	m	128.87
Total rotor frontal area	sq m	8959430

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year average
Proportion of time operational	%		93%	93%	92%	91%	91%	89%	89%	90%	91%	93%	93%	93%	91.4%
Stage A - flight activity															
Daytime areal bird density	birds/sq km		0.47	0.18	1.34	1.47	1.15	0.34	1.91	0.60	1.17	0.31	0.51	1.95	
Proportion at rotor height	%	0.8%													
Total daylight hours per month	hrs		249	272	366	420	494	510	513	461	383	329	259	233	
Total night hours per month	hrs		495	400	378	300	250	210	231	283	337	415	461	511	
Flux factor			223803	89998	833950	999931	889887	265675	1516701	439884	741276	178297	247291	899846	
Option 1 -Basic model - Stages B, C and D															**per annum**
Potential bird transits through rotors			1755	706	6541	7843	6980	2084	11896	3450	5814	1398	1940	7058	**57463**
Collision risk for single rotor transit	(from sheet 3)	5.7%													
Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**93**	**37**	**345**	**408**	**362**	**106**	**607**	**177**	**304**	**74**	**103**	**374**	**2989**
Option 2-Basic model using proportion from flight distribution			**488**	**197**	**1812**	**2144**	**1903**	**560**	**3189**	**932**	**1595**	**389**	**540**	**1965**	**15714**
Option 3-Extended model using flight height distribution		Kittiwake_MLS													
Proportion at rotor height	(from sheet 4)	4.1%													
Potential bird transits through rotors	Flux integral	0.0187	4180	1681	15574	18674	16619	4962	28325	8215	13844	3330	4618	16805	**136826**
Collisions assuming no avoidance	Collision integral	0.00052	**108**	**44**	**402**	**476**	**422**	**124**	**707**	**207**	**354**	**86**	**120**	**436**	**3485**
Average collision risk for single rotor transit		2.8%													
Stage E - applying avoidance rates															
Using which of above options?	**Option 1**	0.00%	93	37	345	408	362	106	607	177	304	74	103	374	**2989**
Collisions assuming avoidance rate	birds per month or year	98.70%	1	0	4	5	5	1	8	2	4	1	1	5	**39**
		98.90%	1	0	4	4	4	1	7	2	3	1	1	4	**33**
		99.10%	1	0	3	4	3	1	5	2	3	1	1	3	**27**
		98.90%	1	0	4	4	4	1	7	2	3	1	1	4	**33**
		99.20%	1	0	3	3	3	1	5	1	2	1	1	3	**24**
		99.50%	0	0	2	2	2	1	3	1	2	0	1	2	**15**
		99.00%	1	0	3	4	4	1	6	2	3	1	1	4	**30**
Collisions after applying large array correction		98.70%	1	0	4	5	5	1	8	2	4	1	1	5	**39**
		98.90%	1	0	4	4	4	1	7	2	3	1	1	4	**33**
		99.10%	1	0	3	4	3	1	5	2	3	1	1	3	**27**
		98.90%	1	0	4	4	4	1	7	2	3	1	1	4	**33**

Figure 3.6: Figure 1.19 as included in REP7-032 showing the avoidance rates used for collision risk modelling

4. References

Band, B. (2012). Using a collision risk model to assess bird collision risks for offshore wind farms – with extended method. [Online]. Available at: http://www.bto.org/science/wetlandand- marine/soss/projects (Accessed 2 November 2012).

Camphuysen, C.J., Fox, T., Leopold, M.F. and Petersen, I.K. (2004). Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the UK. A report for COWRIE.

JNCC (2014). Boat survey training material [online]. Available at: http://jncc.defra.gov.uk/page-4568. [Accessed April 2014].

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

Webb, A. and Durinck, J. (1992). Counting birds from ships. In: Manual for aeroplane and ship surveys of waterfowl and seabirds, eds. J. Komdeur, J. Bertelsen and G. Cracknell, 24-37. Slimbridge, I.W.R.B. Special Publication No.19.