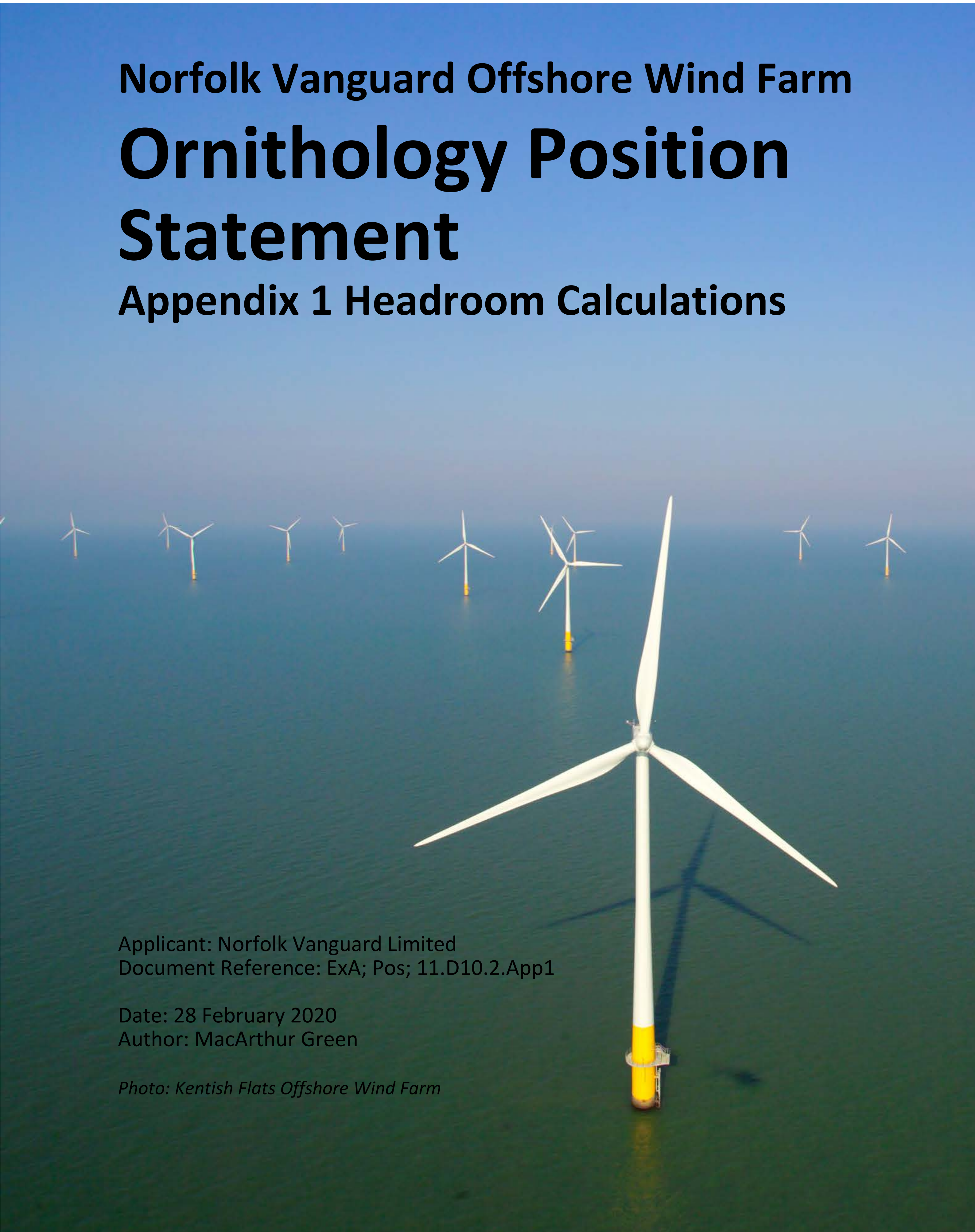
Norfolk Vanguard Offshore Wind Farm

Ornithology Position Statement

Appendix 1 Headroom Calculations



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Author: MacArthur Green

Photo: Kentish Flats Offshore Wind Farm

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
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28/02/2020	01F	Final	MT	RS	RS

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1 INTRODUCTION

1.1 Headroom worked examples

1. To illustrate the effect on collision estimates of using built vs. assessed or consented wind farm designs, the following comparison has been conducted for the Hornsea Project One wind farm using kittiwake as an example. Calculations for updating the Triton Knoll kittiwake collision risk estimates are also presented.

2. The original Hornsea Project One application (ES) was based on 332 3.6MW turbines, and consent was granted for up to 240 5MW turbines. It was stated by Smart Wind (2014)[1] that the consented design reduced collision risks for gannet and kittiwake by 13% compared with the original ES design, however as far as the Applicant has been able to determine, no updated collision modelling was submitted in to the Hornsea Project One examination. In 2016, a Non-material change (NMC) application[2] was submitted (and subsequently approved) which proposed maximum turbine numbers of either 203 (6MW), 174 (7MW) or 152 (8MW), depending on which turbine was selected. Each of these achieved the generating limit of 1200MW (amended to 1218MW, as set out in the NMC). The wind farm has now completed construction using 7MW turbines, and therefore 174 turbines have been installed.

3. Using the collision modelling update method developed by MacArthur Green for The Crown Estate[3] it is straightforward to update the original collision predictions using the 'common currency' excel spreadsheet. This tool recalculates collision mortality using three pieces of information: the assessed (or consented) wind farm parameters and associated collision mortalities and the revised (consented or built) turbine parameters. This process avoids the requirement to re-run the collision model and therefore removes the need to obtain the complete set of input data (seabird densities, etc.) from the wind farm applications.

4. Table 1 below presents a summary of the collision estimates which demonstrate that the Hornsea Project One kittiwake collisions to be used in cumulative and in-combination assessments should be reduced to correspond with the built wind farm (174 x 7MW turbines) rather than the current figures which corresponds to the

[1] Smart Wind (2014) Hornsea Offshore Wind Farm Project One The Applicant's Written Response to Deadline V Application Reference: EN010033 14 May 2014

[2] Hornsea Project One Name Plate Capacity And Limit Of Deviation Work Area Dco Amendments Supporting Statement. https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010033/EN010033-002874-DONG%20Energy%20HOW01%20DCO%20Amendments%20Supporting%20Statement

[3] Trinder, M 2017. Estimates of Ornithological Headroom in Offshore Wind Farm Collision Mortality. Unpublished report to The Crown Estate (submitted as Appendix 43 to Deadline I submission Hornsea Project Three: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010080/EN010080-001095-DI_HOW03_Appendix%2043.pdf)

assessed design (332 x 3.6MW). The reduction in annual kittiwake EIA collisions obtained for Hornsea Project One from the assessed to consented designs is 13%, as noted above, and from assessed to as built is 43%, a reduction in mortality of 52, from 123 to 71. The equivalent reduction for birds apportioned to the FFC SPA from Hornsea Project One is from 41 to 24.

5. Equivalent figures for the Triton Knoll wind farm are also summarised in Table 1. For this project the method developed for The Crown Estate was used (see Annex 1) with updated turbine parameters provided by the developer and made available on the Marine Data Exchange[4]. The reduction in total kittiwake collisions for this site is 64%, from 209 to 76 and for birds apportioned to the FFC SPA from Triton Knoll is from 35 to 13.

Table 1 Assessed versus built Hornsea Project One and Triton Knoll Wind Turbine Generators (WTGs) and impact on kittiwake

Impact scale	Assessed WTGs	Consented WTGs	Built WTGs	Assessed kittiwake CRM	Consented kittiwake CRM	Built kittiwake CRM	Headroom (reduction from assessed to built), number and percentage
EIA	332	240	174	123	107	71	52 (43%)
HRA				41	36	24	17 (41%)
EIA	333	288	90	209	Not available	75.9	133.1 (64%)
HRA				35.4	Not available	12.9	22.5 (63%)

6. Furthermore, similar declines can be obtained for other wind farms, and these can be calculated with readily available data on turbine designs and mortality estimates using the tool developed for this purpose (the validity of this method is demonstrated in Annex 1), rather than needing to extract the original input parameters which can be difficult to obtain for older wind farm projects (and sometimes were not included).

7. Thus, once legal certainty can be obtained regarding a wind farm's built design, following the submissions outlined above, collision estimates can be quickly and easily updated for use in cumulative and in-combination assessment.

[4] http://marinedataexchange.co.uk/search?q=#fq=fq%3DProject%253Amde1tceea3651

2 ANNEX1

Hornsea 1 CRM calculations – demonstration of revisions to collision estimates

8. To demonstrate the difference in collision mortality obtained for a wind farm's built design compared to its assessed one, data and calculations for the Hornsea Project One wind farm are presented below. This has focussed on EIA kittiwake, but similar results are obtained for all species. The source data from SmartWind (2013)[5] were obtained from application documents (copied below) and used as inputs to the Band collision model.

9. Seabird density data are presented in Table C.164, assessed wind farm data in Table C.133 and the associated collision predictions for the assessed wind farm in Table C.169.

[5] Hornsea Offshore Wind Farm Project One Environmental Statement Volume 5 – Offshore Annexes Chapter 5.5.1 Ornithology Technical Report PINS Document Reference: 7.5.5.1 APFP Regulation 5(2)(a) July 2013 https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010033/EN010033-000566-7.5.5.1%20Ornithology%20Technical%20Report.pdf

Results Years 1 and 2 sub-zone 1

Table C.164 Densities of flying birds at Hornsea sub-zone 1 development area between March 2010 and February 2012. Data gathered during ship-based surveys.

Species	Density (birds/km2) Jan	Density (birds/km2) Feb	Density (birds/km2) Mar	Density (birds/km2) Apr	Density (birds/km2) May	Density (birds/km2) Jun	Density (birds/km2) Jul	Density (birds/km2) Aug	Density (birds/km2) Sep	Density (birds/km2) Oct	Density (birds/km2) Nov	Density (birds/km2) Dec
Fulmar	0.19	0.07	0.29	0.04	0.24	0.41	0.23	0.11	0.10	0.04	0.04	0.00
Gannet	0.24	0.07	0.43	0.07	0.03	0.02	0.07	0.14	0.18	0.35	0.55	0.04
Kittiwake	0.34	0.36	0.49	0.19	0.07	0.71	1.27	0.69	0.77	0.34	0.88	0.24
Little Gull	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	2.62	0.25	0.00
Common Gull	0.02	0.03	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01
Great Black-backed Gull	0.22	0.11	0.13	0.05	0.04	0.01	0.05	0.05	0.22	0.03	0.13	0.15
Lesser Black-backed Gull	0.02	0.00	0.00	0.03	0.07	0.07	0.11	0.10	0.02	0.00	0.00	0.03
Herring Gull	0.01	0.02	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.09
Large gulls combined	0.25	0.13	0.17	0.09	0.12	0.07	0.16	0.15	0.24	0.03	0.16	0.27
Common Tern	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.33	0.06	0.00	0.00
Arctic Tern	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.06	0.00	0.01	0.00	0.00
Guillemot	0.57	0.23	0.38	0.03	0.07	0.04	0.10	0.00	0.07	0.07	0.13	0.33
Razorbill	0.27	0.03	0.22	0.09	0.01	0.05	0.08	0.00	0.02	0.16	0.08	0.03
Guillemot/Razorbill	0.84	0.26	0.60	0.12	0.08	0.09	0.18	0.00	0.09	0.22	0.21	0.36
Common/Arctic Terns combined	0.00	0.00	0.00	0.00	0.10	0.02	0.00	0.07	0.33	0.07	0.00	0.00
Arctic Skua	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Great Skua	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00

Table C.133 Parameters used in collision rate modelling, for two wind farm variants at Hornsea project 1.

Variant	Number of blades	Rotation speed (rpm)	Rotor radius (m)	Minimum rotor height	Maximum blade width (m)	Pitch (°)	Number of turbines	Latitude (DD)
332 x 3.6MW	3	13.0	60	22	4.2	15[1]	332	53.89
150 x 8MW	3	11.9	89	22	5.9	15[1]	150	53.89

[1] *Data based on nominal value.*

Table C.169 Results of collision rate monitoring for Hornsea sub-zone 1 development area between March 2010 and February 2012. Potential number of collisions assuming an avoidance rate of 99%.

332 x 3.6MW

Species	Collisions per month with avoidance rate 0.99 Jan	Collisions per month with avoidance rate 0.99 Feb	Collisions per month with avoidance rate 0.99 Mar	Collisions per month with avoidance rate 0.99 Apr	Collisions per month with avoidance rate 0.99 May	Collisions per month with avoidance rate 0.99 Jun	Collisions per month with avoidance rate 0.99 Jul	Collisions per month with avoidance rate 0.99 Aug	Collisions per month with avoidance rate 0.99 Sep	Collisions per month with avoidance rate 0.99 Oct	Collisions per month with avoidance rate 0.99 Nov	Collisions per month with avoidance rate 0.99 Dec	TOTAL COLLISIONS PER YEAR WITH AVOIDANCE RATE OF 0.99
Fulmar	0	0	0	0	0	0	0	0	0	0	0	0	0
Gannet	6	2	12	2	1	1	2	5	5	10	13	1	60
Kittiwake	5	5	9	3	1	14	25	13	13	6	14	4	112
Little Gull	0	0	0	0	0	0	0	0	0	4	0	0	5
Common Gull	1	1	0	1	0	0	0	0	0	0	0	0	3
Great Black-backed Gull	33	15	22	9	8	2	9	9	37	4	20	22	188
Lesser Black-backed Gull	2	0	0	3	7	7	11	10	2	0	0	3	45
Herring Gull	1	4	7	1	2	0	0	0	0	0	4	14	32
Large gulls combined	27	13	21	11	16	10	21	19	29	3	17	29	216
Common Tern	0	0	0	0	0	0	0	0	0	0	0	0	0
Arctic Tern	0	0	0	0	0	0	0	0	0	0	0	0	0
Guillemot	0	0	0	0	0	0	0	0	0	0	0	0	0
Razorbill	0	0	0	0	0	0	0	0	0	0	0	0	0
Guillemot/Razorbill	0	0	0	0	0	0	0	0	0	0	0	0	0
Common/Arctic Terns combin	0	0	0	0	0	0	0	0	0	0	0	0	0
Arctic Skua	0	0	0	0	0	0	0	0	0	0	0	0	0
Great Skua	0	0	0	0	0	0	0	0	0	0	0	0	0

150 x 8MW

TOTAL

10. It can be seen that the assessed annual collision prediction for kittiwake (Table C.169) at an avoidance rate of 99% was 112 (note that the current kittiwake avoidance rate of 98.9% was not presented, but multiplying 112 by ((1-0.0989)/(1-0.99)) updates this to an avoidance rate of 98.9% = 123).

11. Using the input data in Tables C.133 and C.164) the following values were entered into the Band excel collision model.

	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**		**Data sources**											
6	**Bird data**															
7	Species name		**Kittiwake**													
8	Bird length	m	0.39													
9	Wingspan	m	1.08													
10	Flight speed	m/sec	13.1													
11	Nocturnal activity factor (1-5)		3													
12	Flight type, flapping or gliding		flapping													
13					**Data sources**											
14	**Bird survey data**			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
15	Daytime bird density	birds/sq km		0.34	0.36	0.49	0.19	0.07	0.71	1.27	0.69	0.77	0.34	0.88	0.24	
16	Proportion at rotor height	%	3.7%													
17	Proportion of flights upwind	%	50.0%													
18					**Data sources**											
19	**Birds on migration data**															
20	Migration passages	birds		0	0	0	0	0	0	0	0	0	0	0	0	
21	Width of migration corridor	km	8													
22	Proportion at rotor height	%	75%													
23	Proportion of flights upwind	%	50.0%													
24		**Units**	**Value**		**Data sources**											
25	**Windfarm data**															
26	Name of windfarm site		**H1**													
27	Latitude	degrees	53.89													
28	Number of turbines		332													
29	Width of windfarm	km	38													
30	Tidal offset	m	0													
31		**Units**	**Value**		**Data sources**											
32	**Turbine data**															
33	Turbine model		**5MW turbine**													
34	No of blades		3													
35	Rotation speed	rpm	13													
36	Rotor radius	m	60													
37	Hub height	m	82	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
38	Monthly proportion of time operational	%		85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	
39	Max blade width	m	4.200													
40	Pitch	degrees	15													
41																
42																
43	**Avoidance rates used in presenting results**		95.00%													
44			98.90%													
45			99.00%													
46			99.50%													
47																
48																

12. Collision results were obtained as below.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	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		Kittiwake						from survey data							
6		Flight speed	m/sec	13.1						calculated field							
7		Nocturnal activity factor (1-5)		3													
8		Nocturnal activity (% of daytime)		50%													
9	Windfarm data:																
10		Latitude	degrees	53.9													
11		Number of turbines		332													
12		Rotor radius	m	60													
13		Minimum height of rotor	m	82													
14		Total rotor frontal area	sq m	3754832													
15					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**year average**
16		Proportion of time operational	%		85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85.0%
17																	
18	**Stage A - flight activity**																
19		Daytime areal bird density	birds/sq km		0.34	0.36	0.49	0.19	0.07	0.71	1.27	0.69	0.77	0.34	0.88	0.24	
20		Proportion at rotor height	%	3.7%													
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			249122	250861	401373	#####	63929	644562	1177903	613278	626636	269139	635672	172966	
24																	
25	**Option 1 -Basic model - Stages B, C and D**																**per annum**
26		Potential bird transits through rotors			9218	9282	14851	5911	2365	23849	43582	22691	23186	9958	23520	6400	**194813**
27		Collision risk for single rotor transit	(from sheet 3)	6.7%													
28		Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**525**	**529**	**846**	**337**	**135**	**1359**	**2484**	**1293**	**1321**	**568**	**1340**	**365**	**11103**
29																	
30	**Option 2-Basic model using proportion from flight distribution**				**1373**	**1383**	**2213**	**881**	**352**	**3554**	**6494**	**3381**	**3455**	**1484**	**3505**	**954**	**29028**
31																	
32	**Option 3-Extended model using flight height distribution**			Gannet													
33		Proportion at rotor height	(from sheet 4)	9.7%													
34		Potential bird transits through rotors	Flux integral	0.0516	12847	12937	20699	8239	3297	33240	60744	31627	32315	13879	32781	8920	**271525**
35		Collisions assuming no avoidance	Collision integral	0.00194	**411**	**414**	**662**	**264**	**106**	**1064**	**1944**	**1012**	**1034**	**444**	**1049**	**285**	**8689**
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%	525	529	846	337	135	1359	2484	1293	1321	568	1340	365	**11103**
40																	
41	Collisions assuming avoidance rate		birds per month or year	95.00%	26	26	42	17	7	68	124	65	66	28	67	18	**555**
42				98.90%	6	6	9	4	1	15	27	14	15	6	15	4	**122**
43				99.00%	5	5	8	3	1	14	25	13	13	6	13	4	**111**
44				99.50%	3	3	4	2	1	7	12	6	7	3	7	2	**56**
45																	
46	Collisions after applying large array correction			95.00%	26	26	42	17	7	68	124	65	66	28	67	18	**555**
47				98.90%	6	6	9	4	1	15	27	14	15	6	15	4	**122**
48				99.00%	5	5	8	3	1	14	25	13	13	6	13	4	**111**
49				99.50%	3	3	4	2	1	7	12	6	7	3	7	2	**56**
50																	
51																	

13. As can be seen above, the annual kittiwake collisions at an avoidance rate of 99% (cell R43 above) is 111, which compares with the assessed figure of 112 above (this difference is expected to be due to rounding variations, since the input data were only presented to two decimal places) and at 98.9% (cell R42) the mortality is 122.

14. To estimate the built wind farm collisions, the Band spreadsheet was then updated using the turbine parameters presented in the Hornsea Project One NMC which correspond to the built wind farm (174 x 7 MW); Table 1.3 below.

Table 1.2: The three defined turbine scenarios based upon the numbers allowed under the DCO and the parameters that would have been used at the time of the DCO (note, of these options only the 8MW turbine was actually presented for the purposes of the DCO)

Parameter	6 MW	7 MW	8 MW
No. of turbines	200	171	150
Rotation speed (m/s)	11	10.5	10.2
Rotor radius (m)	77	86	89
Hub height (m)	98.45 (HAT)	107.45 (HAT)	110.45 (HAT)
Monthly proportion of time operational (%) (all months)	85	85	85
Blade width (m)	5	5.4	5.4
Pitch (°)	10	3	3

Table 1.3: Updated turbine parameters for the three defined turbine scenarios (bold text indicates where parameters differ from those presented in Table 1.2)

Parameter	6 MW	7 MW	8 MW
No. of turbines with the increase in name plate capacity	**203**	**174**	**152**
Rotation speed (m/s)	11	10.5	10.2
Rotor radius (m)	77	**77**	89
Hub height (m)	**98.35 (HAT)**	**113.99 (HAT)**	**110.35 (HAT)**
Monthly proportion of time operational (%) (all months)	85	85	85
Blade width (m)	5	**5**	5.4
Pitch (°)	**3**	3	3

15. The updated Band spreadsheet calculation, using the 7MW turbine parameters from table 1.3 above are presented below.

	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**		**Data sources**											
6	**Bird data**															
7	Species name		**Kittiwake**													
8	Bird length	m	0.39													
9	Wingspan	m	1.08													
10	Flight speed	m/sec	13.1													
11	Nocturnal activity factor (1-5)		3													
12	Flight type, flapping or gliding		flapping													
13					**Data sources**											
14	**Bird survey data**			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
15	Daytime bird density	birds/sq km		0.34	0.36	0.49	0.19	0.07	0.71	1.27	0.69	0.77	0.34	0.88	0.24	
16	Proportion at rotor height	%	3.7%													
17	Proportion of flights upwind	%	50.0%													
18					**Data sources**											
19	**Birds on migration data**															
20	Migration passages	birds		0	0	0	0	0	0	0	0	0	0	0	0	
21	Width of migration corridor	km	8													
22	Proportion at rotor height	%	75%													
23	Proportion of flights upwind	%	50.0%													
24		**Units**	**Value**		**Data sources**											
25	**Windfarm data**															
26	Name of windfarm site		**H1**													
27	Latitude	degrees	53.89													
28	Number of turbines		174													
29	Width of windfarm	km	38													
30	Tidal offset	m	0													
31		**Units**	**Value**		**Data sources**											
32	**Turbine data**															
33	Turbine model		**7MW**													
34	No of blades		3													
35	Rotation speed	rpm	10.5													
36	Rotor radius	m	77													
37	Hub height	m	113.99	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
38	Monthly proportion of time operational	%		85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	
39	Max blade width	m	5.000													
40	Pitch	degrees	3													
41																
42																
43	**Avoidance rates used in presenting results**		95.00%													
44			98.90%													
45			99.00%													
46			99.50%													

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
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		Kittiwake						from survey data									
6		Flight speed	m/sec	13.1						calculated field									
7		Nocturnal activity factor (1-5)		3															
8		Nocturnal activity (% of daytime)		50%															
9	Windfarm data:																		
10		Latitude	degrees	53.9															
11		Number of turbines		174															
12		Rotor radius	m	77															
13		Minimum height of rotor	m	113.99															
14		Total rotor frontal area	sq m	3241011															
15					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		**year average**	
16		Proportion of time operational	%		85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%	85%		85.0%	
17																			
18	**Stage A - flight activity**																		
19		Daytime areal bird density	birds/sq km		0.34	0.36	0.49	0.19	0.07	0.71	1.27	0.69	0.77	0.34	0.88	0.24			
20		Proportion at rotor height	%	3.7%															
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			167557	168727	269959	#####	42998	433526	792246	412485	421469	181020	427547	116335			
24																			
25	**Option 1 -Basic model - Stages B, C and D**																	**per annum**	
26		Potential bird transits through rotors			6200	6243	9989	3976	1591	16040	29313	15262	15594	6698	15819	4304		**131029**	
27		Collision risk for single rotor transit	(from sheet 3)	5.8%															
28		Collisions for entire windfarm, allowing for non-op time, assuming no avoidance	birds per month or year		**306**	**308**	**493**	**196**	**79**	**792**	**1447**	**753**	**770**	**331**	**781**	**212**		**6466**	
29																			
30	**Option 2-Basic model using proportion from flight distribution**				**135**	**136**	**218**	**87**	**35**	**350**	**640**	**333**	**341**	**146**	**346**	**94**		**2863**	
31																			
32	**Option 3-Extended model using flight height distribution**			Gannet															
33		Proportion at rotor height	(from sheet 4)	1.6%															
34		Potential bird transits through rotors	Flux integral	0.0516	8641	8701	13922	5542	2217	22357	40856	21272	21735	9335	22048	5999		**182625**	
35		Collisions assuming no avoidance	Collision integral	0.00194	**277**	**278**	**446**	**177**	**71**	**715**	**1307**	**681**	**696**	**299**	**706**	**192**		**5844**	
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%	306	308	493	196	79	792	1447	753	770	331	781	212		**6466**	
40																			
41	Collisions assuming avoidance rate		birds per month or year	95.00%	15	15	25	10	4	40	72	38	38	17	39	11		**323**	
42				98.90%	3	3	5	2	1	9	16	8	8	4	9	2		**71**	
43				99.00%	3	3	5	2	1	8	14	8	8	3	8	2		**65**	
44				99.50%	2	2	2	1	0	4	7	4	4	2	4	1		**32**	
45																			
46	Collisions after applying large array correction			95.00%	15	15	25	10	4	40	72	38	38	17	39	11		**323**	
47				98.90%	3	3	5	2	1	9	16	8	8	4	9	2		**71**	
48				99.00%	3	3	5	2	1	8	14	8	8	3	8	2		**65**	
49				99.50%	2	2	2	1	0	4	7	4	4	2	4	1		**32**	
50																			

16. As can be seen above, the Band derived total kittiwake annual collisions at 99% for the built scenario (174 x 7MW) are reduced to 65 (cell R43). Adjusting this figure from the avoidance rate of 99% to the current advised kittiwake rate of 98.8% gives a value of 71 (obtained as follows: 65 x ((1-0.989)/(1-0.99))). This is the appropriate kittiwake annual collision estimate for the built Hornsea Project One wind farm which should be used in cumulative assessments in place of the 123, derived from the assessed design, which is currently used.

17. The process outlined above requires that all the necessary input parameters are provided in the project assessment which has not always been the case. An alternative method, which only requires the old and new turbine parameters and original collision estimates was developed for The Crown Estate by MacArthur Green. Snapshots from the excel file that undertakes these updates are presented below. The collision values used were those for an avoidance rate of 98.9%, 123.

18. The table below contains the input turbine parameters for the assessed turbine inputs (332 x 5MW) and the built ones, as presented in the NMC (174 x 7MW).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1							OLD					NEW						
2	Wind farm	Status	Date of consent	Consented no. turbines (max.)	Assessed no. turbines	Assessed turbine capacity (MW)	Rotor radius (m)	Hub height (m)	Average RPM	Max blade width (m)	Average blade pitch (deg.)	Actual no. turbines	Built turbine capacity (MW)	Rotor radius (m)	Hub height (m)	Average RPM	Max blade width (m)	Average blade pitch (deg.)
22	Hornsea 1	Consented	31/12/2014	240	332	3.6	60	82	13	4.2	15	174	7	77	113.99	10.5	5	3

19. The table below shows the parameters used and the calculated 'CRM adjustment' figure (0.5824, column L) which indicates the proportional adjustment to be made to the old collisions (123) to obtain the updated mortality of 71.6.

A	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
		OLD (application)				NEW (actual)					ANNUAL CRM				
wind farm	species	no. turbines	Radius	TRF	Pcollision	no. turbines	Radius	TRF	Pcollision	CRM adjustment	old CRM	model	AR	new CRM	headroom
Hornsea 1	Kittiwake	332	60	3754831.5	0.0671	174	77	3241011.5	0.0581	0.5824	123	1	98.9	71.6	51.4

20. As demonstrated here, this figure (71.6), was obtained with much fewer data requirements and is the same as that obtained through recalculation from the original dataset (using the Band spreadsheets), thereby demonstrating the validity of this method for the purpose of updating collision estimates.

Triton Knoll CRM calculations – demonstration of revisions to collision estimates

21. The collision estimate for the Triton Knoll wind farm have been updated using the method developed for The Crown Estate by MacArthur Green. Snapshots from the excel file that undertakes these updates are presented below.

22. The table below contains the input turbine parameters for the assessed turbine inputs (333 x 3.6MW) and the built ones, obtained from The Crown Estate Marine Data Exchange[6] (90 x 9.525MW).

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
						OLD					NEW						
Wind farm	Status	Date of consent	Consented no. turbines (max.)	Assessed no. turbines	Assessed turbine capacity (MW)	Rotor radius (m)	Hub height (m)	Average RPM	Max blade width (m)	Average blade pitch (deg.)	Actual no. turbines	Built turbine capacity (MW)	Rotor radius (m)	Hub height (m)	Average RPM	Max blade width (m)	Average blade pitch (deg.)
Triton Knoll	Consented	11/07/2013	288	333	3.6	62.5		9.47	4.2	6	90	9.525	82	110.2	10.8	5.4	15

23. The table below shows the parameters used and the calculated 'CRM adjustment' figure (0.3633, column L) which indicates the proportional adjustment to be made to the old collisions (209, column M) to obtain the updated mortality of 75.9 (column P) and a headroom of 133.1 (column Q).

A	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
		OLD (application)				NEW (actual)					ANNUAL CRM					
wind farm	species	no. turbines	Radius	TRF	Pcollision	no. turbines	Radius	TRF	Pcollision	CRM adjustment	old CRM	model	AR	new CRM	headroom	New CRM / MW
Triton Knoll	Kittiwake	333	62.5	4086524.8	0.0604	90	82	1901166.2	0.0618	0.3633	209	1	98.9	75.9	133.1	0.08

[6] http://marinedataexchange.co.uk/search?q=#fq=fq%3DProject%253Amde1tceea3651