

Norfolk Vanguard Offshore Wind Farm

Ornithology Position

Statement

Appendix 1 Headroom Calculations



Applicant: Norfolk Vanguard Limited
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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) application² 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 Estate³ 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.

- 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 Exchange⁴. 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%)

- 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).
- 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	Density	Density	Density	Density	Density	Density	Density	Density	Density	Density	Density
	(birds/km ²) Jan	(birds/km ²) Feb	(birds/km ²) Mar	(birds/km ²) Apr	(birds/km ²) May	(birds/km ²) Jun	(birds/km ²) Jul	(birds/km ²) Aug	(birds/km ²) Sep	(birds/km ²) Oct	(birds/km ²) Nov	(birds/km ²) 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												TOTAL COLLISIONS PER YEAR WITH AVOIDANCE RATE OF 0.99	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Fulmar	0	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	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

- 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	Q	R	S
1	COLLISION RISK ASSESSMENT																		
2	Sheet 2 – Overall collision risk																		
3				All data input on Sheet 1:						from Sheet 1 – input data									
4	Bird details:			no data entry needed on this sheet!						from Sheet 6 – available hours									
5	Species			Kittiwake															
6	Flight speed	m/sec		13.1															
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	sqm		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	#####	63329	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	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%													
47																

	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:																
3				no data entry needed on this sheet!																
4	Bird details:																			
5	Species			Kittiwake																
6	Flight speed	m/sec		13.1																
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	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	269353	#####	42998	433526	792246	412465	421463	181020	427547	116335				
24	Option 1 – Basic model – Stages B, C and D																			
26	Potential bird transits through rotors				6200	6243	9989	3976	1591	16040	29313	15262	15534	6698	15819	4304		per annum		
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	Option 2 – Basic model using proportion from flight distribution																			
30					135	136	218	87	35	350	640	333	341	146	346	94		2863		
31	Option 3 – Extended model using flight height distribution																			
32				Gannet																
33	Proportion at rotor height	(from sheet 4)			1.8%															
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	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: $65 \times ((1-0.989)/(1-0.99))$). 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	

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			
wind farm	species	OLD (application)	no. turbines	Radius	TRF	Pcollision	NEW (actual)	no. turbines	Radius	TRF	Pcollision	CRM adjustment	ANNUAL CRM	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 Exchange⁶ (90 x 9.525MW).

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).

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>