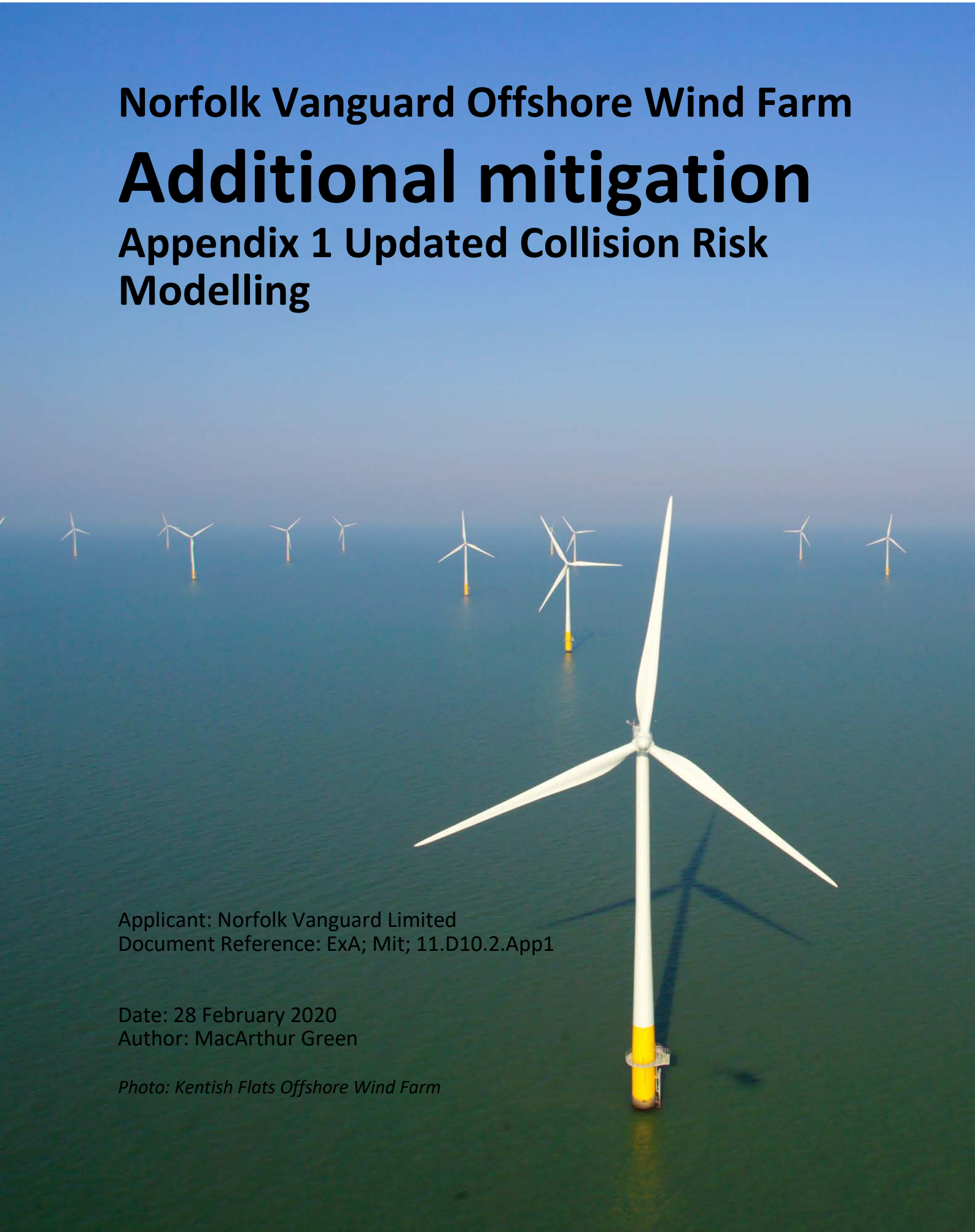
VATTENFALL

Norfolk Vanguard Offshore Wind Farm

Additional mitigation

Appendix 1 Updated Collision Risk Modelling



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Glossary

CRM	Collision Risk Model
EIA	Environmental Impact Assessment
HAT	Highest Astronomical Tide
MHWS	Mean High Water Springs
MSL	Mean Sea Level
MW	Megawatt
SPA	Special Protection Area

1 INTRODUCTION

1.1 Project Background and Update

1. This note provides an update of the collision risk modelling (CRM) for the Norfolk Vanguard Offshore Wind Farm (the Project), reflecting the following project design updates of relevance to the collision risk modelling (CRM) assessment:

    - Removal of the smallest turbine options from the design envelope, specifically the 10MW and 11MW turbines, with the smallest turbine now included in the design having a capacity of 11.55MW. For the purposes of CRM, a larger capacity turbine (14.7MW) has also been assessed; and

    - An increase in draught height (the minimum distance between the lower rotor tip height and the sea surface) to 30m above Mean High Water Springs (MHWS[1]) for turbines with a capacity of 14.7MW and above, and 35m for turbines with a capacity up to and including 14.6MW.

2. This mitigation has been adopted following a request for information from the Department for Business, Energy and Industrial Strategy (BEIS), (6 December 2019) for Norfolk Vanguard Limited (the Applicant) to consider further mitigation not discussed during the examination to lessen or reduce impacts on the qualifying kittiwake feature of the Flamborough and Filey Coast Special Protection Area (SPA) and the qualifying lesser black-backed gull feature of the Alde-Ore Estuary SPA.

3. The CRM outputs for the 11.55MW and 14.7MW turbines replace that for the previous Project design as presented during the Examination (AS-049) which related to the 10MW turbine with a minimum draught height of 27m from MHWS.

4. The CRM has been undertaken using the deterministic Band (2012) model. The turbine parameters for the 11.55MW and 14.7MW turbines have been provided in Table 1 together with the equivalent parameters for the 10MW turbine (as used in AS-049) for comparison. All the remaining CRM parameters (e.g. seabird densities and dimensions) remain the same as those presented in APP-217 and are provided in Appendix 1.

[1] It should be noted that in documents reporting on collision risk modelling submitted for Norfolk Vanguard prior to Deadline 8 (AS-049) rotor draught heights were given in relation to Highest Astronomical Tide (HAT) while subsequent ones were given in relation to Mean High Water Springs (MHWS). As was noted in AS-049, this was an error in labelling only, with HAT mistakenly used in place of MHWS. The tidal offset used in the collision risk modelling to adjust to Mean Sea Level (MSL) was the same throughout and should have been stated as relating to MHWS from the outset.

Table 1. Wind farm and turbine input parameters

Parameter	Turbine model		
	10MW	11.55MW	14.7MW
Number	180	158	124
Rotor radius (m)	95	100	115
Hub height (m from MHWS)	122	135	145
RPM	8.3	7.5	6
Max. blade width (m)	7.5	5.8	7.5
Blade pitch (°)	15		
Tidal offset (m; difference between MSL and MHWS)	0.8		
Operational period (%)	90		
Latitude (km; East / West)	52.2 / 52.9		
Wind Farm width (km; East / West)	22.3 / 17.7		

5. On the basis of the collision predictions for the 10MW turbine with a 27m draught height, Natural England agreed with the Applicant that Norfolk Vanguard alone will not result in any significant impacts at the Environmental Impact Assessment (EIA) level, nor will it result in any Adverse Effects on Integrity of any Special Protection Area (SPA) populations (REP8-104). Consequently, since the collision predictions have decreased following the mitigations discussed in this note, the Applicant considers that the same conclusions will apply and therefore the impact assessment has not been updated.

6. Tables providing updated cumulative and in-combination estimates have been included in Appendix 2. The figures used in these tables were taken from the Norfolk Boreas Deadline 2 submission with updates for:

   - Norfolk Vanguard (as set out in this report);
   - Norfolk Boreas (for the same project design revisions as applied to Norfolk Vanguard, submitted at Norfolk Boreas Deadline 5); and,

7. Amended figures for the Dogger Bank Creyke Beck A and B projects (for gannet and kittiwake) and East Anglia ONE North and East Anglia TWO for little gull, as requested by Natural England (Norfolk Boreas Examination submission REP4-040

2 COLLISION RISK PREDICTIONS

2.1 Norfolk Vanguard total collisions (EIA)

8. The total annual worst case collision predictions for the six species of concern for collision risk at Norfolk Vanguard (gannet, kittiwake, lesser black-backed gull, herring gull, great black-backed gull and little gull) for the previous worst case 10MW turbine at 27m from MHWS, (provided for comparison purposes only) are presented alongside those for the 11.55MW (at 35m from MHWS) and the 14.7MW (at 30m from MHWS) turbines in Table 2.

Table 2. Comparison of total annual mortality estimates for the 10MW (now removed from the Project design and in italics) with those for the 11.55MW and 14.7MW turbines. Draught heights are provided in relation to MHWS.

Species	*10MW @ 27m (now removed from the Project design)*	11.55MW @ 35m	14.7MW @ 30m	Percentage reduction for worst case (10MW @27m compared to 14.7MW @ 30m)
Gannet	*66.5 (12.1-160.8)*	21.2 (3.9-51.3)	32.1 (5.9-77.6)	51.8
Kittiwake	*115.5 (12.2-300.7)*	38.1 (4.0-99.2)	57.5 (6.1-149.7)	50.2
Lesser black-backed gull	*22.1 (0.8-67.4)*	9.6 (0.4-29.1)	12 (0.5-36.5)	50.6
Herring gull	*13.6 (0-52.8)*	6.2 (0-24.0)	7.5 (0-29.1)	45.8
Great black-backed gull	*46.8 (0.7-155.1)*	21.8 (0.3-72.2)	26 (0.4-86.1)	45.0
Little gull	*5.1 (0-17.4)*	1.6 (0-5.6)	2.5 (0-8.6)	44.5

9. The collision estimates for the 14.7MW turbine are slightly higher than those for the 11.55MW, and therefore these represent the revised worst case estimates for the Project.

10. The turbine and draught height revisions result in substantial reductions in collision risk of between 45% (great black-backed gull) and 52% (gannet) compared with those at the end of the Project examination (which themselves were considerably reduced compared with those in the original DCO application). The overall reduction for gannet between the original application estimate and the current one is 85% and for great black-backed gull is 62%, with the reductions for other species falling in between this range (REP3-051).

11. Monthly collision estimates for each species, calculated for the previous worst case (10MW at 27m from MHWS) are provided in Table 2.3 for comparison and for the updated turbine models (11.55MW at 35m from MHWS and 14.7MW at 30m from MHWS) are provided in Table 2.4 and Table 2.5. Note that these estimates include the species specific worst case division of turbines between the Norfolk Vanguard (NV) East and West sites (either 50% of the turbines in each or 67% in NV West and 33% in NV East). The worst case scenario for each species is indicated in the tables below (e.g. '50:50' or '67:33').

Table 2.3 Previous worst case collisions for the 10MW turbine with a 27m draught height (from MHWS). The 10MW turbine has been removed from the Project design envelope and these figures are provided for comparison purposes only.

Species (NV East: NV West)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Gannet (50:50)	0.5 (0-2.6)	0.9 (0-3.1)	1 (0-3.9)	0.5 (0-1.8)	1.1 (0-4.8)	4.6 (0-12.8)	1.7 (0-5.9)	4.1 (0-10.8)	4 (0-10.3)	7.2 (0.3-18.4)	31.4 (11.8-67.8)	9.6 (0-18.5)	66.5 (12.1-160.8)
Kittiwake (50:50)	26.9 (4.8-70.9)	11.8 (2.6-24.3)	17.2 (0.5-50.7)	8.2 (0-27.7)	7.8 (0.6-19.9)	6 (1.1-14.6)	2.5 (0-9)	2 (0-5.9)	1.4 (0-5.4)	3.1 (0-9.7)	18.8 (0.8-39.1)	9.6 (1.9-23.5)	115.5 (12.2-300.7)
Lesser black-backed gull (67:33)	0.8 (0-3.1)	0.2 (0-1.3)	0.6 (0-3.8)	0.6 (0-3.6)	0 (0-0)	3.1 (0-7.8)	4.2 (0-12)	7.6 (0.8-17.9)	1.6 (0-6.2)	2.8 (0-8.5)	0.3 (0-1.4)	0.3 (0-1.7)	22.1 (0.8-67.4)
Herring gull (50:50)	10.5 (0-36.1)	0.3 (0-1.8)	0.3 (0-2.7)	0.5 (0-2.1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1.4 (0-6.1)	0.7 (0-4.1)	13.6 (0-52.8)
Great black-backed gull (50:50)	25 (0.7-80)	2.7 (0-8)	0.6 (0-4.7)	0.6 (0-3.4)	0.4 (0-2.6)	0 (0-0)	0.9 (0-3.5)	5.5 (0-18.8)	3.4 (0-8)	0.7 (0-3)	3.7 (0-14.4)	3.2 (0-8.8)	46.8 (0.7-155.1)
Little gull (50:50)	0 (0-0)	0.1 (0-0.5)	0 (0-0)	0 (0-0)	1.9 (0-6.5)	0 (0-0)	0 (0-0)	2 (0-5.8)	0.3 (0-1.4)	0 (0-0)	0.8 (0-3.3)	0 (0-0)	5.1 (0-17.4)

Table 2.4 Collision estimates for the 11.55MW turbine with a 35m draught height (from MHWS).

Species (NV East: NV West)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Gannet (50:50)	0.2 (0-0.8)	0.3 (0-1)	0.3 (0-1.2)	0.1 (0-0.6)	0.3 (0-1.5)	1.5 (0-4.1)	0.6 (0-1.9)	1.3 (0-3.5)	1.3 (0-3.3)	2.3 (0.1-5.9)	10 (3.8-21.6)	3.1 (0-5.9)	21.2 (3.9-51.3)
Kittiwake (50:50)	8.9 (1.6-23.4)	3.9 (0.8-8)	5.7 (0.2-16.7)	2.7 (0-9.1)	2.6 (0.2-6.6)	2 (0.4-4.8)	0.8 (0-3)	0.7 (0-2)	0.5 (0-1.8)	1 (0-3.2)	6.2 (0.3-12.9)	3.2 (0.6-7.8)	38.1 (4-99.2)
Lesser black-backed gull (67:33)	0.4 (0-1.3)	0.1 (0-0.6)	0.2 (0-1.7)	0.3 (0-1.6)	0 (0-0)	1.3 (0-3.4)	1.8 (0-5.2)	3.3 (0.4-7.7)	0.7 (0-2.7)	1.2 (0-3.7)	0.1 (0-0.6)	0.1 (0-0.8)	9.6 (0.4-29.1)
Herring gull (50:50)	4.8 (0-16.4)	0.1 (0-0.8)	0.1 (0-1.2)	0.2 (0-1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0.6 (0-2.8)	0.3 (0-1.9)	6.2 (0-24)
Great black-backed gull (50:50)	11.6 (0.3-37.2)	1.3 (0-3.7)	0.3 (0-2.2)	0.3 (0-1.6)	0.2 (0-1.2)	0 (0-0)	0.4 (0-1.6)	2.6 (0-8.8)	1.6 (0-3.7)	0.3 (0-1.4)	1.7 (0-6.7)	1.5 (0-4.1)	21.8 (0.3-72.2)
Little gull (50:50)	0 (0-0)	0 (0-0.1)	0 (0-0)	0 (0-0)	0.6 (0-2.1)	0 (0-0)	0 (0-0)	0.6 (0-1.8)	0.1 (0-0.5)	0 (0-0)	0.2 (0-1.1)	0 (0-0)	1.6 (0-5.6)

Table 2.5 Collision estimates for the 14.7MW turbine with a 30m draught height (from MHWS).

Species (NV East: NV West)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Gannet (50:50)	0.3 (0-1.3)	0.4 (0-1.5)	0.5 (0-1.9)	0.2 (0-0.9)	0.5 (0-2.3)	2.2 (0-6.2)	0.8 (0-2.9)	2 (0-5.2)	1.9 (0-4.9)	3.5 (0.1-8.9)	15.1 (5.7-32.7)	4.6 (0-8.9)	32.1 (5.9-77.6)
Kittiwake (50:50)	13.4 (2.4-35.3)	5.9 (1.3-12.1)	8.6 (0.2-25.2)	4.1 (0-13.8)	3.9 (0.3-9.9)	3 (0.5-7.3)	1.3 (0-4.5)	1 (0-3)	0.7 (0-2.7)	1.5 (0-4.9)	9.3 (0.4-19.4)	4.8 (0.9-11.7)	57.5 (6.1-149.7)
Lesser black-backed gull (67:33)	0.4 (0-1.7)	0.1 (0-0.7)	0.3 (0-2.1)	0.3 (0-2)	0 (0-0)	1.7 (0-4.2)	2.3 (0-6.5)	4.1 (0.5-9.7)	0.8 (0-3.4)	1.5 (0-4.6)	0.2 (0-0.7)	0.2 (0-0.9)	12 (0.5-36.5)
Herring gull (50:50)	5.8 (0-19.8)	0.2 (0-1)	0.2 (0-1.5)	0.3 (0-1.2)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0.8 (0-3.4)	0.4 (0-2.3)	7.5 (0-29.1)
Great black-backed gull (50:50)	13.8 (0.4-44.4)	1.5 (0-4.4)	0.4 (0-2.6)	0.3 (0-1.9)	0.2 (0-1.4)	0 (0-0)	0.5 (0-1.9)	3.1 (0-10.4)	1.9 (0-4.4)	0.4 (0-1.7)	2.1 (0-8)	1.8 (0-4.9)	26 (0.4-86.1)
Little gull (50:50)	0 (0-0)	0 (0-0.2)	0 (0-0)	0 (0-0)	1 (0-3.2)	0 (0-0)	0 (0-0)	1 (0-2.8)	0.2 (0-0.7)	0 (0-0)	0.4 (0-1.6)	0 (0-0)	2.5 (0-8.6)

2.2 Collisions apportioned to relevant Special Protection Area (SPA) populations

12. Collisions for those species with predicted connectivity to SPA populations are provided in Table 2.6 (gannet), Table 2.7 (kittiwake) and Table 2.8 (lesser black-backed gull). It should be noted that figures for the 10MW turbine are presented for comparison purposes only.

13. For kittiwake and lesser black-backed gull the predictions are provided using the Applicant's preferred breeding season apportioning rates and those advised by Natural England, while for gannet the Applicant and Natural England use the same breeding season apportioning rate.

Table 2.6 Comparison of gannet mortality apportioned to the Flamborough and Filey Coast SPA populations for the 10MW and 27m draught height (now removed from the design), 11.55MW (35m draught height) and 14.7MW (30m draught height) turbines. The worst case figures for the 14.7MW turbine are shaded.

Turbine	Spring	Breeding	Autumn	Annual
10	*0.5 (0-1.2)*	*17 (0-50.3)*	*2.4 (0.8-5.3)*	*19.9 (0.8-56.8)*
11.55	0.2 (0-0.4)	5.4 (0-16.1)	0.8 (0.2-1.7)	6.3 (0.2-18.1)
14.7	0.3 (0-0.6)	8.2 (0-24.3)	1.2 (0.4-2.6)	9.6 (0.4-27.4)

Table 2.7 Comparison of kittiwake mortality apportioned to the Flamborough and Filey Coast SPA populations for the 10MW and 27m draught height (now removed from the design), 11.55MW (35m draught height) and 14.7MW (30m draught height) turbines. The worst case figures for the 14.7MW turbine are shaded.

Turbine	Method	Spring	Breeding	Autumn	Annual
10	*Applicant*	*2.8 (0.5-6.9)*	*4.8 (0.5-12)*	*1.8 (0.2-4.2)*	*9.3 (1.2-23)*
	Natural England	*2.8 (0.5-6.9)*	*37.7 (1.8-109.9)*	*1.8 (0.2-4.2)*	*42.2 (2.5-121)*
11.55	Applicant	0.9 (0.2-2.3)	1.6 (0.2-4)	0.6 (0.1-1.4)	3.1 (0.4-7.6)
	Natural England	0.9 (0.2-2.3)	12.4 (0.6-36.2)	0.6 (0.1-1.4)	13.9 (0.8-39.9)
14.7	Applicant	1.4 (0.3-3.4)	2.4 (0.3-6)	0.9 (0.1-2.1)	4.6 (0.6-11.5)
	Natural England	1.4 (0.3-3.4)	18.7 (0.9-54.7)	0.9 (0.1-2.1)	21 (1.2-60.2)

Table 2.8 Comparison of lesser black-backed gull apportioned to the Alde-Ore Estuary SPA populations for the 10MW and 27m draught height (now removed from the design), 11.55MW (35m draught height) and 14.7MW (30m draught height) turbines. The worst case figures for the 14.7MW turbine are shaded.

Turbine	Method	Spring	Breeding	Autumn	Midwinter	Annual
10	*Applicant*	*0 (0-0.1)*	*2.7 (0.1-7)*	*0.1 (0-0.5)*	*0 (0-0.2)*	*2.8 (0.1-7.8)*
	Natural England	*0 (0-0.1)*	*4.7 (0.3-12.4)*	*0.1 (0-0.5)*	*0 (0-0.2)*	*4.9 (0.3-13.2)*
11.55	Applicant	0 (0-0.1)	1.1 (0.1-3)	0.1 (0-0.2)	0 (0-0.1)	1.2 (0.1-3.4)
	Natural England	0 (0-0.1)	2 (0.1-5.4)	0.1 (0-0.2)	0 (0-0.1)	2.1 (0.1-5.7)
14.7	Applicant	0 (0-0.1)	1.4 (0.1-3.8)	0.1 (0-0.3)	0 (0-0.1)	1.6 (0.1-4.2)
	Natural England	0 (0-0.1)	2.5 (0.1-6.7)	0.1 (0-0.3)	0 (0-0.1)	2.6 (0.1-7.1)

14. The estimated annual gannet mortality apportioned to the Flamborough and Filey Coast SPA for the 14.7MW turbine (30m draught height) is 9.6, reduced from the previous estimate of 19.9 for the 10MW turbine (27m draught height), a decline of 52%.

15. The estimated annual kittiwake mortality apportioned to the Flamborough and Filey Coast SPA for the 14.7MW turbine (30m draught height) is 21.0 using Natural England's preferred methods, and 4.6 using the Applicant's preferred methods. These compare with the previous estimates of 42.2 and 9.3 respectively, for the 10MW turbine (27m draught height), a decline of 50%.

16. The estimated annual lesser black-backed gull mortality apportioned to the Alde-Ore Estuary SPA for the 14.7MW turbine (30m draught height) is 2.6 using Natural England's preferred methods, and 1.6 using the Applicant's preferred methods. These compare with the previous estimates of 4.9 and 2.8 respectively, for the 10MW turbine (27m draught height), a decline of 47%.

3 CONCLUSIONS

17. As an environmentally responsible developer, and in response to a request from the Secretary of State, the Applicant has undertaken a comprehensive review of the Project design in order to explore options for further mitigating the potential risks to seabirds. This has resulted in a commitment to remove the smaller turbine models (10MW and 11MW) from the design envelope, resulting in a decrease of the maximum number of turbines from 180 to 158, and to increase draught heights up to 35m for turbines with a capacity up to and including 14.6MW and 30m for turbines with a capacity of 14.7MW and above (from MHWS).

18. The combination of these Project revisions has reduced overall collision estimates by up to 52% compared with the previous worst case scenario as presented in the ornithology update at Deadline 8 of the examination (AS-049).

19. In order to secure the additional draught height mitigation, it is proposed to revise Requirement 2(1)(e) of the draft DCO (and the corresponding DML conditions) as follows:

2(1) Subject to paragraph (2), any wind turbine generator forming part of the authorised project must not-

(a)….

(e) have a draught height which is less than the minimum draught height specified for the relevant wind turbine generator capacity in the table below:

Wind Turbine Generator Capacity	***Minimum draught height***
up to and including 14.6MW	*35m from MHWS*
14.7 MW and above	*30m from MHWS*

20. This secures the worst case assessed of 14.7MW (and above) at a draught height of 30m from MHWS, and also secures the higher draught height of 35m from MHWS modelled for turbines up to and including 14.6MW, as presented above.

21. The draft DCO has also been amended to refer to the reduced maximum number of turbines (158) as follows:

    a. Schedule 1, Part 1, Paragraph 1(a)

    b. Schedule 1, Part 3, Requirement 3(1)

c. Schedule 9 -10 Part 3, Paragraph 2(1)(a)

d. Schedule 9 -10 Part 4, Condition 8(1)(b)

22. Other corresponding amendments have been made to relevant parameters resulting from the reduction in turbine numbers, including disposal figures, spacing of turbines, lengths of cable protection and amounts of scour protection. A record of the further changes made to the draft DCO can be found in the DCO Schedule of Changes (ExA;DCOSchedule;10.D2.6 (Version 7)).

Appendix 1 – CRM input parameters

23. To assist verification of the collision risk estimates for Norfolk Vanguard presented in this note, the seabird biometric values (Table 3.1) and seabird density estimates (Table 3.2 and Table 3.3) are provided below. In conjunction with the turbine parameter information (Table 1) these provide all the input values required to run the Band collision risk model.

Table 3.1. Species specific input parameters. Note for all species flapping flight was assumed and an equal percentage of flights are assumed to be upwind and downwind (i.e. 50% each).

Species	Biometrics			Nocturnal activity factor (%; gannet evidence based rates from Furness et al. 2018)				Proportion at collision height in surveys (above MSL)		Avoidance rate (%; SD if applicable)
	Body length (m)	Wingspan (m)	Flight speed (ms^{-1})	Baseline	NE lower rate	Evidence based - breeding	Evidence based - nonbreeding	NV east	NV west	
Gannet	0.94	1.72	14.9	25	0	8	4	0.17	0.12	98.9 (0.2)
Kittiwake	0.39	1.08	13.1	50	25	NA	NA	0.23	0.36	98.9 (0.2)
Little gull	0.26	0.78	12.2	25	NA	NA	NA	0.04	0.20	99.2 (0.1)
Lesser black-backed gull	0.58	1.42	13.1	50	25	NA	NA	0.19	0.46	99.5 (0.1)
Herring gull	0.6	1.44	12.8	50	25	NA	NA	0.24	0.67	99.5 (0.1)
Great black-backed gull	0.71	1.58	13.7	50	25	NA	NA	0.08	0.32	99.5 (0.1)

Table 3.2. Norfolk Vanguard East seabird densities (birds/km^2). Values are the mean (calculated across 2 or 3 months: Norfolk Vanguard East was surveyed for 32 months) and upper and lower 95% confidence intervals obtained from nonparametric bootstrapping of survey data (see ES technical Appendix 13.1 for details).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gannet	0.03 (0-0.14)	0.05 (0-0.19)	0.02 (0-0.09)	0.03 (0-0.12)	0.05 (0-0.2)	0.25 (0-0.68)	0.01 (0-0.07)	0.14 (0-0.32)	0.23 (0-0.55)	0.16 (0.02-0.46)	2.14 (0.68-5.05)	0.87 (0-1.69)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kittiwake	1.82 (0.34-4.82)	0.81 (0.19-1.65)	0.93 (0-2.83)	0.45 (0-1.49)	0.37 (0.03-0.97)	0.07 (0-0.26)	0.04 (0-0.14)	0.02 (0-0.14)	0.03 (0-0.11)	0.08 (0-0.34)	0.95 (0-1.94)	0.68 (0.14-1.61)
Little gull	0 (0-0)	0.01 (0-0.07)	0 (0-0)	0 (0-0)	0.19 (0-0.65)	0 (0-0)	0 (0-0)	0.21 (0-0.6)	0.01 (0-0.08)	0 (0-0)	0.06 (0-0.33)	0 (0-0)
Lesser black-backed gull	0.07 (0-0.27)	0.02 (0-0.13)	0.01 (0-0.12)	0.02 (0-0.1)	0 (0-0)	0 (0-0)	0.02 (0-0.12)	0.15 (0-0.41)	0 (0-0)	0.01 (0-0.07)	0.03 (0-0.12)	0.03 (0-0.16)
Herring gull	0.52 (0-1.79)	0 (0-0)	0.01 (0-0.12)	0.02 (0-0.09)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0.04 (0-0.22)	0.03 (0-0.21)
Great black-backed gull	1.05 (0.03-3.38)	0.02 (0-0.13)	0.01 (0-0.09)	0.02 (0-0.13)	0 (0-0)	0 (0-0)	0 (0-0)	0.16 (0-0.51)	0 (0-0)	0 (0-0)	0.09 (0-0.43)	0.14 (0-0.39)

Table 3.3. Norfolk Vanguard West seabird densities (birds/km^2). Values are the mean (calculated across 2 months) and upper and lower 95% confidence intervals obtained from nonparametric bootstrapping of survey data (see ES technical Appendix 13.1 for details).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gannet	0.01 (0-0.09)	0.03 (0-0.09)	0.05 (0-0.19)	0 (0-0)	0.02 (0-0.09)	0.03 (0-0.09)	0.09 (0-0.28)	0.12 (0-0.37)	0.06 (0-0.19)	0.39 (0-0.96)	0.64 (0.37-0.95)	0 (0-0)
Kittiwake	0.11 (0-0.25)	0.08 (0-0.19)	0.19 (0.03-0.43)	0.06 (0-0.25)	0.08 (0-0.19)	0.28 (0.06-0.59)	0.11 (0-0.37)	0.1 (0-0.22)	0.07 (0-0.24)	0.12 (0-0.31)	0.42 (0.06-0.9)	0.02 (0-0.09)
Little gull	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0.03 (0-0.09)	0 (0-0)	0.06 (0-0.15)	0 (0-0)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lesser black-backed gull	0 (0-0)	0 (0-0)	0.02 (0-0.09)	0.01 (0-0.09)	0 (0-0)	0.11 (0-0.28)	0.14 (0-0.36)	0.2 (0.03-0.45)	0.06 (0-0.25)	0.11 (0-0.31)	0 (0-0)	0 (0-0)
Herring gull	0 (0-0)	0.02 (0-0.09)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0.03 (0-0.09)	0 (0-0)
Great black-backed gull	0.05 (0-0.15)	0.11 (0-0.25)	0.02 (0-0.09)	0 (0-0)	0.02 (0-0.09)	0 (0-0)	0.03 (0-0.12)	0.05 (0-0.19)	0.14 (0-0.32)	0.03 (0-0.12)	0.07 (0-0.22)	0 (0-0)

Appendix 2 – Cumulative and In-combination collision tables

24. This appendix provides updated cumulative and in-combination collision risk tables for gannet, kittiwake, lesser black-backed gull, herring gull, great black-backed gull and little gull. Following Natural England advice, the totals are presented with and without Hornsea Project Three and Hornsea Project Four (for the latter only preliminary estimates are available).

Table 3.4 Gannet cumulative and in-combination collision risk.

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
1	Beatrice Demonstrator	0.6	0	0.9	0.04	0.7	0.05	2.2	0.1
1	Greater Gabbard	14	0	8.8	0.42	4.8	0.3	27.5	0.7
1	Gunfleet Sands	-	-	-	-	-	-	-	-
1	Kentish Flats	1.4	0	0.8	0.04	1.1	0.07	3.3	0.1
1	Kentish Flats Extension	-	-	-	-	-	-	-	-
1	Lincs	2.1	2.1	1.3	0.06	1.7	0.1	5	2.3
1	London Array	2.3	0	1.4	0.07	1.8	0.11	5.5	0.2
1	Lynn and Inner Dowsing	0.2	0.2	0.1	0.01	0.2	0.01	0.5	0.2
1	Scroby Sands	-	-	-	-	-	-	-	-
1	Sheringham Shoal	14.1	14.1	3.5	0.17	0	0	17.6	14.3
1	Teesside	4.9	2.4	1.7	0.08	0	0	6.7	2.5
1	Thanet	1.1	0	0	0	0	0	1.1	0
1	Humber Gateway	1.9	1.9	1.1	0.05	1.5	0.09	4.5	2
1	Westermost Rough	0.2	0.2	0.1	0.01	0.2	0.01	0.5	0.2
1	Hywind	5.6	0	0.8	0.04	0.8	0.05	7.2	0.1
2	Kincardine	3	0	0	0	0	0	3	0
2	Beatrice	37.4	0	48.8	2.34	9.5	0.59	95.7	2.9
2	Dudgeon	22.3	22.3	38.9	1.87	19.1	1.18	80.3	25.3
2	Galloper	18.1	0	30.9	1.48	12.6	0.78	61.6	2.3
2	Race Bank	33.7	33.7	11.7	0.56	4.1	0.25	49.5	34.5
2	Rampion	36.2	0	63.5	3.05	2.1	0.13	101.8	3.2
2	Hornsea Project One	11.5	11.5	32	1.54	22.5	1.4	66	14.4
3	Blyth Demonstration Project	3.5	0	2.1	0.1	2.8	0.17	8.4	0.3
3	Dogger Bank Creyke Beck Projects A and B	81.1	40.6	83.5	4.0	54.4	3.4	219.0	47.9
3	East Anglia ONE	3.4	3.4	131	6.29	6.3	0.39	140.7	10.1
3	European Offshore Wind Deployment Centre	4.2	0	5.1	0.25	0.1	0	9.3	0.3

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
3	Firth of Forth Alpha and Bravo	800.8	0	49.3	2.37	65.8	4.08	915.9	6.4
3	Inch Cape	336.9	0	29.2	1.4	5.2	0.32	371.3	1.7
3	Methil	6	0	0	0	0	0	6	0
3	Moray Firth (EDA)	80.6	0	35.4	1.7	8.9	0.55	124.9	2.3
3	Neart na Gaoithe	143	0	47	2.26	23	1.43	213	3.7
3	Dogger Bank Teesside Projects A and B	14.8	7.4	10.1	0.49	10.8	0.67	35.7	8.5
3	Triton Knoll	26.8	26.8	64.1	3.08	30.1	1.87	121	31.7
3	Hornsea Project Two	7	7	14	0.67	6	0.37	27	8
4	East Anglia THREE	6.1	6.1	33.3	1.6	9.6	0.6	49	8.3
5	Hornsea Project Three	26	26	12	0.58	11	0.68	49	27.3
5	Thanet Extension	0	0	11.1	0.53	22.9	1.42	34	2
5	Norfolk Vanguard	8.2	8.2	18.6	1.2	5.3	0.3	32.1	9.6
6	Moray West	10	0	2	0.1	1	0.06	13	0.2
6	Norfolk Boreas	14.1	14.2	12.7	0.8	3.9	0.2	30.7	15.1
6	East Anglia TWO	12.7	12.7	28.7	1.38	5.6	0.35	47	14.4
6	East Anglia ONE North	11	11	12.8	0.61	3.4	0.21	27.2	11.8
6	*Hornsea 4 (PEIR)*	43.3	43.3	9.9	0.48	8.1	0.5	61.3	44.3
	Total (all projects)	**1850.1**	**295.1**	**858.2**	**41.7**	**366.9**	**22.7**	**3075.0**	**359.2**
	Total (minus Hornsea Project Three)	**1824.1**	**269.1**	**846.2**	**41.2**	**355.9**	**22.0**	**3026.0**	**331.9**
	Total (minus Hornsea Project Four)	**1806.8**	**251.8**	**848.3**	**41.3**	**358.8**	**22.2**	**3013.7**	**314.9**
	Total (minus Hornsea Project Three and Hornsea Project Four)	**1780.8**	**225.8**	**836.3**	**40.7**	**347.8**	**21.5**	**2964.7**	**287.6**

Table 3.5 Kittiwake cumulative and in-combination collision risk.

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
1	Beatrice Demonstrator	0	0	2.1	0.11	1.7	0.12	3.8	0.23
1	Greater Gabbard	1.1	0	15	0.81	11.4	0.82	27.5	1.63
1	Gunfleet Sands	-	-	-	-	-	-	-	
1	Kentish Flats	0	0	0.9	0.05	0.7	0.05	1.6	0.1
1	Kentish Flats Extension	0	0	0	0	2.7	0.19	2.7	0.19
1	Lincs	0.7	0.7	1.2	0.06	0.7	0.05	2.6	0.81
1	London Array	1.4	0	2.3	0.12	1.8	0.13	5.5	0.25
1	Lynn and Inner Dowsing	-	-	-	-	-	-	-	
1	Scroby Sands	-	-	-	-	-	-	-	
1	Sheringham Shoal	-	-	-	-	-	-	-	
1	Teesside	38.4	0	24	1.3	2.5	0.18	64.9	1.48
1	Thanet	0.2	0	0.5	0.03	0.4	0.03	1.1	0.06
1	Humber Gateway	1.9	1.9	3.2	0.17	1.9	0.14	7	2.21
1	Westermost Rough	0.1	0.1	0.2	0.01	0.1	0.01	0.5	0.12
1	Hywind	16.6	0	0.9	0.05	0.9	0.06	18.3	0.11
2	Kincardine	22	0	9	0.49	1	0.07	32	0.56
2	Beatrice	94.7	0	10.7	0.58	39.8	2.87	145.2	3.45
2	Dudgeon	-	-	-	-	-	-	-	
2	Galloper	6.3	0	27.8	1.5	31.8	2.29	65.9	3.79
2	Race Bank	1.9	1.9	23.9	1.29	5.6	0.4	31.4	3.59
2	Rampion	54.4	0	37.4	2.02	29.7	2.14	121.5	4.16
2	Hornsea Project One	44	36.5	55.9	3.02	20.9	1.5	120.8	41.02
3	Blyth Demonstration Project	1.7	0	2.3	0.12	1.4	0.1	5.4	0.22
3	Dogger Bank Creyke Beck Projects A and B	288.6	55.8	135.0	7.3	295.4	21.3	719.0	84.3
3	East Anglia ONE	1.8	0	160.4	8.66	46.8	3.37	209	12.03
3	European Offshore Wind Deployment Centre	11.8	0	5.8	0.31	1.1	0.08	18.7	0.39
3	Firth of Forth Alpha and Bravo	153.1	0	313.1	16.91	247.6	17.83	713.8	34.74

Tier	Wind farm	Breeding season		Autumn migration		Spring migration		Annual	
		Total	FFC SPA	Total	FFC SPA	Total	FFC SPA	Total	FFC SPA
3	Inch Cape	13.1	0	224.8	12.14	63.5	4.57	301.4	16.71
3	Methil	0.4	0	0	0	0	0	0.4	0
3	Moray Firth (EDA)	43.6	0	2	0.11	19.3	1.39	64.9	1.5
3	Neart na Gaoithe	32.9	0	56.1	3.03	4.4	0.32	93.4	3.35
3	Dogger Bank Teesside Projects A and B	136.9	26.4	90.7	4.9	216.9	15.62	444.5	46.92
3	Triton Knoll	24.6	24.6	139	7.51	45.4	3.27	209	35.38
3	Hornsea Project Two	16	13.3	9	0.49	3	0.22	28	14.01
4	East Anglia THREE	6.1	0	69	3.73	37.6	2.71	112.7	6.44
5	Hornsea Project Three	187.5	176.3	94.6	5.11	15	1.08	297.1	182.49
5	Thanet Extension	2.3	0	5.3	0.29	15.3	1.1	22.9	1.39
5	Norfolk Vanguard	21.8	18.7	16.4	0.9	19.3	1.4	57.5	21.0
6	Moray West	79	0	24	1.3	7	0.5	110	1.8
6	Norfolk Boreas	13.3	11.4	32.2	1.7	11.9	0.9	57.5	14.0
6	East Anglia TWO	19.8	0	9.3	0.5	20.9	1.5	50.0	2.0
6	East Anglia ONE North	18.6	0	12.1	0.65	27.3	1.9	58.0	2.6
6	*Hornsea 4 (PEIR)*	*153.3*	*153.3*	*34.7*	*1.87*	*9.9*	*0.71*	*197.9*	155.9
	Total (all projects)	**1509.9**	**520.9**	**1650.8**	**89.1**	**1262.6**	**90.9**	**4423.4**	**700.9**
	Total (minus Hornsea Project Three)	**1246.9**	**273.6**	**1518.1**	**82.0**	**1241.5**	**89.4**	**4006.6**	**444.9**
	Total (minus Hornsea Project Four)	**1356.6**	**367.6**	**1616.1**	**87.3**	**1252.7**	**90.2**	**4225.5**	**545.0**
	Total (minus Hornsea Project Three and Hornsea Project Four)	**1169.1**	**191.3**	**1521.5**	**82.2**	**1237.7**	**89.1**	**3928.4**	**362.5**

Table 3.6 Lesser black-backed gull cumulative and in-combination collision risk. Breeding season apportioning rates use the values in Norfolk Boreas REP2-035, Table 7.3.

Tier	Wind farm	Breeding season		Nonbreeding season		Annual	
		Total	AOE SPA	Total	AOE SPA	Total	AOE SPA (nonbreeding season apportioned plus breeding season for wind farms <141km)
1	Beatrice Demonstrator	-	-	-	-	-	-
1	Greater Gabbard	12.4	8	49.6	2	62	10
1	Gunfleet Sands	1	0.3	0	0	1	0.3
1	Kentish Flats	-	-	-	-	-	-
1	Kentish Flats Extension	0.3	0.1	1.3	0.1	1.6	0.2
1	Lincs	1.7		6.8	0.3	8.5	0.3
1	London Array	-	-	-	-	-	-
1	Lynn and Inner Dowsing	-	-	-	-	-	-
1	Scroby Sands	-	-	-	-	-	-
1	Sheringham Shoal	1.7	0.3	6.6	0.3	8.3	0.6
1	Teesside	0		0	0	0	0
1	Thanet	3.2	1.4	12.8	0.5	16	1.9
1	Humber Gateway	0.3		1.1	0	1.4	0
1	Westermost Rough	0.1		0.3	0	0.4	0
1	Hywind	0		0	0	0	0
2	Kincardine	0		0	0	0	0
2	Beatrice	0		0	0	0	0
2	Dudgeon	7.7	1.1	30.6	1.2	38.3	2.3
2	Galloper	27.8	18	111	4.4	138.8	22.4
2	Race Bank	43.2		10.8	0.4	54	0.4
2	Rampion	1.6		6.3	0.3	7.9	0.3
2	Hornsea Project One	4.4		17.4	0.7	21.8	0.7
3	Blyth Demonstration Project	0		0	0	0	0

Tier	Wind farm	Breeding season		Nonbreeding season		Annual	
		Total	AOE SPA	Total	AOE SPA	Total	AOE SPA (nonbreeding season apportioned plus breeding season for wind farms <141km)
3	Dogger Bank Creyke Beck Projects A and B	2.6		10.4	0.4	13	0.4
3	East Anglia ONE	5.9	2.2	33.8	1.4	39.7	3.6
3	European Offshore Wind Deployment Centre	0		0	0	0	0
3	Firth of Forth Alpha and Bravo	2.1		8.4	0.3	10.5	0.3
3	Inch Cape	0		0	0	0	0
3	Methil	0.5		0	0	0.5	0
3	Moray Firth (EDA)	0		0	0	0	0
3	Neart na Gaoithe	0.3		1.2	0	1.5	0
3	Dogger Bank Teesside Projects A and B	2.4		9.6	0.4	12	0.4
3	Triton Knoll	7.4		29.6	1.2	37	1.2
3	Hornsea Project Two	2		2	0.1	4	0.1
4	East Anglia THREE	1.8	0.4	8.2	0.3	10	0.7
5	Hornsea Project Three	17.3		0	0	17.3	0
5	Thanet Extension	3	1.3	2	0.1	5	1.4
5	Norfolk Vanguard	8.4	2.5	3.6	0.1	12	2.6
6	Moray West	0		0	0	0	0
6	Norfolk Boreas	6.2	1.9	8.1	0.2	14.3	2.1
6	East Anglia TWO	4.7	1.8	0.5	0	5.2	1.8
6	East Anglia ONE North	1	0.2	0.6	0	1.6	0.2
6	*Hornsea 4 (PEIR)*	1.9		0	0	1.9	0
	Total (all projects)	**172.9**	**39.5**	**372.6**	**14.7**	**545.5**	**54.2**
	Total (minus Hornsea Project Three)	**155.6**	**39.5**	**372.6**	**14.7**	**528.2**	**54.2**
	Total (minus Hornsea Project Four)	**171**	**39.5**	**372.6**	**14.7**	**543.6**	**54.2**
	Total (minus Hornsea Project Three and Hornsea Project Four)	**153.7**	**39.5**	**372.6**	**14.7**	**526.3**	**54.2**

Table 3.7 Herring gull cumulative collision risk.

Tier	Wind farm	Breeding season	Nonbreeding season	Annual
1	Beatrice Demonstrator	0		0
1	Greater Gabbard	0		0
1	Gunfleet Sands	-	-	-
1	Kentish Flats	0	0	0
1	Kentish Flats Extension	0.5	1.7	2.2
1	Lincs	0		0
1	London Array	-	-	-
1	Lynn and Inner Dowsing	0		0
1	Scroby Sands	-	-	-
1	Sheringham Shoal	0		0
1	Teesside	8.7	34.5	43.2
1	Thanet	4.9	19.6	24.5
1	Humber Gateway	0.4	1.1	1.5
1	Westermost Rough	0.1	0	0.1
1	Hywind	0.6	7.8	8.4
2	Kincardine	1	0	1
2	Beatrice	49.4	197.4	246.8
2	Dudgeon	-	-	-
2	Galloper	27.2		27.2
2	Race Bank	0		0
2	Rampion	155		155
2	Hornsea Project One	2.9	11.6	14.5
3	Blyth Demonstration Project	0.5	2.2	2.7
3	Dogger Bank Creyke Beck Projects A and B	0		0
3	East Anglia ONE	0	28	28
3	European Offshore Wind Deployment Centre	4.8		4.8
3	Firth of Forth Alpha and Bravo	10	21	31
3	Inch Cape	0	13.5	13.5

Tier	Wind farm	Breeding season	Nonbreeding season	Annual
3	Methil	5.8	3.7	9.5
3	Moray Firth (EDA)	52		52
3	Neart na Gaoithe	5	12.5	17.5
3	Dogger Bank Teesside Projects A and B	0		0
3	Triton Knoll	0		0
3	Hornsea Project Two	23.8		23.8
4	East Anglia THREE	0	23	23
5	Hornsea Project Three	1	8.3	9.3
5	Thanet Extension	15	10	25
5	Norfolk Vanguard	0.4	7.1	7.5
6	Moray West	12	1	13
6	Norfolk Boreas	1.5	5.4	6.9
6	East Anglia TWO	0	0.5	0.5
6	East Anglia ONE North	0	0	0
6	*Hornsea 4 (PEIR)*	1.8	0.8	2.6
	Total (all projects)	**384.3**	**410.7**	**795.0**
	Total (minus Hornsea Project Three)	**383.3**	**402.4**	**785.7**
	Total (minus Hornsea Project Four)	**382.5**	**409.9**	**792.4**
	Total (minus Hornsea Project Three and Hornsea Project Four)	**381.5**	**401.6**	**783.1**

Table 3.8 Great black-backed gull cumulative collision risk.

Tier	Wind farm	Breeding season	Nonbreeding season	Annual
1	Beatrice Demonstrator	0	0	0
1	Greater Gabbard	15	60	75
1	Gunfleet Sands	-	-	-
1	Kentish Flats	-	-	-
1	Kentish Flats Extension	0.1	0.2	0.3
1	Lincs	0	0	0
1	London Array	-	-	-
1	Lynn and Inner Dowsing	0	0	0
1	Scroby Sands	-	-	-
1	Sheringham Shoal	0	0	0
1	Teesside	8.7	34.8	43.6
1	Thanet	0.1	0.4	0.5
1	Humber Gateway	1.3	5.1	6.3
1	Westermost Rough	0	0	0.1
1	Hywind	0.3	4.5	4.8
2	Kincardine	0	0	0
2	Beatrice	30.2	120.8	151
2	Dudgeon	0	0	0
2	Galloper	4.5	18	22.5
2	Race Bank	0	0	0
2	Rampion	5.2	20.8	26
2	Hornsea Project One	17.2	68.6	85.8
3	Blyth Demonstration Project	1.3	5.1	6.3
3	Dogger Bank Creyke Beck Projects A and B	5.8	23.3	29.1
3	East Anglia ONE	0	46	46
3	European Offshore Wind Deployment Centre	0.6	2.4	3
3	Firth of Forth Alpha and Bravo	13.4	53.4	66.8

Tier	Wind farm	Breeding season	Nonbreeding season	Annual
3	Inch Cape	0	36.8	36.8
3	Methil	0.8	0.8	1.6
3	Moray Firth (EDA)	9.5	25.5	35
3	Neart na Gaoithe	0.9	3.6	4.5
3	Dogger Bank Teesside Projects A and B	6.4	25.5	31.9
3	Triton Knoll	24.4	97.6	122
3	Hornsea Project Two	3	20	23
4	East Anglia THREE	4.6	34.4	39
5	Hornsea Project Three	19.4	46.6	66
5	Thanet Extension	6.5	35.5	42
5	Norfolk Vanguard	4.5	21.5	26
6	Moray West	4	5	9
6	Norfolk Boreas	6.9	28.7	35.6
6	East Anglia TWO	3.8	3.7	7.5
6	East Anglia ONE North	3.9	1.3	5.2
6	*Hornsea 4 (PEIR)*	3	13.6	13.6
	Total (all projects)	**205.3**	**863.5**	**1065.8**
	Total (minus Hornsea Project Three)	**185.9**	**816.9**	**999.8**
	Total (minus Hornsea Project Four)	**202.3**	**849.9**	**1052.2**
	Total (minus Hornsea Project Three and Hornsea Project Four)	**182.9**	**803.3**	**986.2**

Table 3.9 Assessed collision rates for little gull at offshore wind farm sites with potential connectivity to the Greater Wash SPA.

Wind farm	Annual collisions	Avoidance rate (%)	Assessed wind farm size	Collisions updated for 99.2% avoidance rate	Built or proposed wind farm size	Collisions updated for built or proposed wind farm
Triton Knoll	65	98	288 x 3.6MW	26	90 x 9.5MW	c. 15
Race Bank	52	98	206 x 3MW	21	91 x 6MW	12
Sheringham Shoal	8	98	108 x 3MW	3	88 x 3.6MW	3
Hornsea Project One	10	98	332 x 3.6MW	4	174 x 7MW	2
Hornsea Project Two	1.3	98	360 x 5MW	0.5	N/A	0.5
Hornsea Project Three	0.5	99.2	300 x 6MW	0.5	N/A	0.5
Norfolk Vanguard	2.5	99.2	124 x 14.7MW	2.5	N/A	2.5
Norfolk Boreas	1.1	99.2	124 x 14.7MW	1.1	N/A	1.1
East Anglia ONE North	1.1	99.2	53 x 15MW	1.1	N/A	1.1
East Anglia TWO	1.7	99.2	60 x 15MW	1.7	N/A	1.7
Total	**143.2**			**61.4**		**39.4**