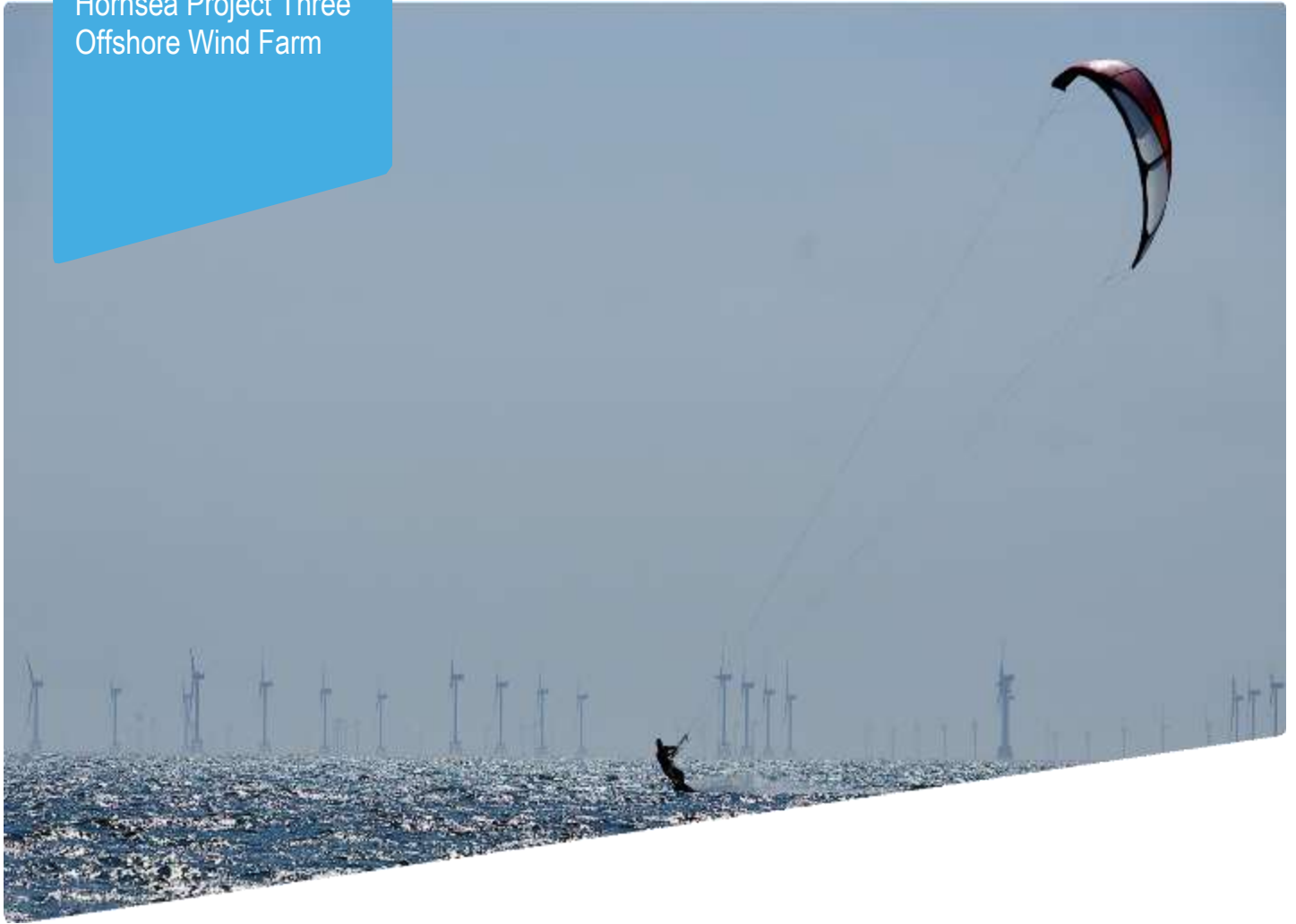


Hornsea Project Three  
Offshore Wind Farm



## Hornsea Project Three Offshore Wind Farm

Appendix 4 to Deadline I submission –  
Analysis of precaution in cumulative and in-combination  
assessments – as-built scenarios – Clarification Note

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## 1. Analysis of precaution in cumulative and in-combination assessments – as-built scenarios

### Introduction

- 1.1 Due to the extensive timescales across which offshore wind farm consenting and pre-planning activities occur, it is often the case that as-built turbine scenarios are different to those that were assessed. Often, due to advances in technology, as-built scenarios are composed fewer, higher capacity turbines which is likely to result in associated collision risk. Differences between assessed and as-built scenarios creates uncertainty associated with cumulative and in-combination assessments although attempts at capturing this (e.g. by tiering projects) have been applied in assessments for offshore wind farms.
- 1.2 The use of collision risk estimates calculated based on the assumptions applied by projects at the point of application or, at the latest, point of decision, that are subsequently used as part of cumulative or in-combination assessments for Hornsea Three has the potential to significantly over-estimate the total collision impact in terms of both EIA and RIAA assessments. This was considered as part Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) using previously calculated correction factors in MacArthur Green (2017). This report builds on the approach in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) considering the implications for collision risk estimates if the as-built scenarios for all projects were incorporated into the cumulative and in-combination assessments for Hornsea Three, calculating correction factors for additional projects where relevant information exists to facilitate this process.
- 1.3 This report does not take account of other sources of uncertainty and over-estimation inherent in collision risk estimates presented for projects considered cumulatively/in-combination. This includes, avoidance rate, nocturnal activity and flight speed with recent evidence (e.g. Skov *et al.* 2018 and Furness *et al.* 2018) suggesting that these parameters are, in some cases, considerable over-estimates. Consideration of the over-estimation inherent in these aspects of collision risk modelling is considered in the clarification note: “Refinement of collision risk estimates”. It is considered that judgment on assessed collision risk should therefore be conducted taking into account these areas of over-estimation which affect all projects considered cumulatively/in-combination with Hornsea Three.

### Background

- 1.4 The over-estimation of collision risk on cumulative and in-combination scales has previously been detailed in work commissioned by the Crown Estate (MacArthur Green, 2017). Cumulative totals calculated from collision risk estimates calculated using assessed turbine scenarios were compared to corrected collision risk estimates calculated using as-built turbine scenarios. Correction factors to facilitate the calculation of as-built cumulative totals were derived using ratios of consented and as-built turbine parameters.
- 1.5 MacArthur Green (2017) identified considerable reductions in the North Sea for the four species considered at Hornsea Three in relation to collision risk:

- Gannet = 14%;
- Kittiwake = 15%;
- Lesser black-backed gull = 40%; and
- Great black-backed gull = 34%.

1.6 The differences between assessed and as-built turbine scenarios were considered in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) (see Table 5.44 and paragraphs 5.13.3.92 to 5.13.3.95 in Document 6.2.5 and Table 7.32 and paragraphs 7.6.3.9 to 7.6.3.11 in Document 5.2). The assessed, consented and as-built turbine scenarios were identified for all projects considered as part of cumulative/in-combination assessments with different approaches then applied based on the information obtained for each project.

1.7 Where differences arose between assessed turbine scenarios and as-built/planned turbine scenarios (i.e. those projects for which consideration in the assessment is qualitative) the correction factors calculated by MacArthur Green (2017), were used to calculate the likely change in collision risk estimates for a project with this then discussed qualitatively in the respective species sections. This approach was used for Dudgeon, Galloper, Humber Gateway, Kentish Flats Extension, Lincs, Race Bank, Sheringham Shoal, Teesside and Westermost Rough and was only applied when the turbine parameters used in MacArthur Green (2017) matched those used to calculate collision risk estimates at each project. This approach is maintained in this report (see paragraphs 1.26 to 1.27). The potential reductions to collision risk for relevant species in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) when applying the correction factors from MacArthur Green (2017) are presented in Table 1.1 and Table 1.2 respectively.

Table 1.1: Reductions in cumulative collision risk totals as a result of applying the correction factors presented in MacArthur Green (2017) to relevant projects

Species	Season			
	Breeding	Post-breeding	Non-breeding	Pre-breeding
Tier 1 projects only				
Gannet	35.3	7.2		5.5
Kittiwake	2.6	11.2		11.0
Lesser black-backed gull	29.3	26.7	22.2	28.1
Great black-backed gull	3.8		7.1	
Tier 1 and 2 projects				
Gannet	9.4	3.6		2.8
Kittiwake	1.1	3.9		3.3

Species	Season			
	Breeding	Post-breeding	Pre-breeding	Annual
Lesser black-backed gull	26.5	21.9	20.7	23.1
Great black-backed gull	3.1		4.8	

Table 1.2: Potential reductions to in-combination collision risk estimates attributable to FFC pSPA when applying the correction factors presented in MacArthur Green (2017) for relevant projects.

Species	Season			
	Breeding	Post-breeding	Pre-breeding	Annual
Tier 1 projects only				
Gannet	37.5	7.2	5.5	50.3
Kittiwake	4.5	11.3	10.9	7.1
Tier 1 and 2 projects				
Gannet	13.0	3.6	2.8	19.3
Kittiwake	3.2	3.9	3.3	3.4

1.8 Where a difference between the assessed number of turbines and the consented number of turbines (i.e. those projects for which consideration in the assessment is quantitative) was identified a simple correction factor representing the change in the number of turbines was applied to the collision risk estimates for that project. This approach was applied to collision risk estimates for the following projects with the as-built number of turbines representing a consent limitation:

- Beatrice (gannet = 142 to 125 turbines; other species = 277 to 125 turbines. These turbine scenarios represent the worst case scenario for each species);
- Dudgeon (168 to 77 turbines);
- East Anglia One (325 to 240 turbines) (note the correction factor used in for assessments was for a HVDC transmission option whereas the wind farm has opted to use a HVAC option (750 MW using 150 turbines));
- Moray East (339 to 186 turbines); and
- Neart na Gaoithe (128 to 75 turbines).

1.9 The reductions in turbine number identified for these projects are all legally secured (i.e. through Section 36 consent variations). Revised collision risk estimates were obtained using a correction factor derived by calculating the difference between assessed and as-built/planned turbine scenarios for each project. Although this is an approximation, this was considered an acceptable method for assessment purposes and has been used by other applicants and Natural England as part of assessments undertaken for other offshore wind farms (e.g. see SmartWind, 2015 and Natural England, 2015). These reductions have been revisited as part of this report to provide further information on the legal process for each project and, by using refined turbine parameters, to calculate more accurate collision risk estimates (see paragraphs 1.28 to 1.30).

### **Turbine scenarios**

1.10 Table 1.1 identifies the turbine scenarios used by each project to calculate the collision risk estimates incorporated into the cumulative and in-combination assessments for relevant species in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) (i.e. the assessed turbine scenario). Also presented are the turbine scenarios that are either operational or planned for each project.



Table 1.3: Assessed and as-built/planned turbine scenarios for projects incorporated into the cumulative and in-combination assessments for Hornsea Three

Project	Project status	Assessed turbine scenario	Consented scenario	As-built/planned turbine scenario	Difference between number of turbines	Difference between turbine capacity
Aberdeen (European Offshore Wind Development Centre)	Partially operational	11 x 7 MW	Total capacity = 100 MW No. of turbines = 11	11 x 8.4 MW	No difference	Higher capacity
Beatrice	Under construction	142 x 7 MW	Total capacity = 750 MW No. of turbines = 125	84 x 7 MW	Decrease	No change
Blyth Offshore-Demonstration Extension	Operational	15 x 8 MW	Unavailable	5 x 8 MW	Decrease	No change
Dogger Bank Creyke Beck A & B	Consented without CfD	400 x 6 MW	Total capacity = 2400 MW No. of turbines = 400	400 x 6 MW / 176 turbines / 140 turbines	Potential decrease	Potential increase
Dogger Bank Teesside A and Sofia	Consented without CfD	400 x 6 MW	Total capacity = 2400 MW No. of turbines = 400	200 x 6 MW (Teesside A) 66 – 200 turbines of varying capacity (Sofia)	Potential decrease	Potential increase
Dudgeon	Operational	168 x 3 MW	Total capacity = 560 MW No. of turbines = 77	67 x 6 MW	Decrease	Higher capacity

Project	Project status	Assessed turbine scenario	Consented scenario	As-built/planned turbine scenario	Difference between number of turbines	Difference between turbine capacity
East Anglia One	Under construction	325 x 3.6 MW	Total capacity = 750 MW No. of turbines = 150	102 x 7 MW	Decrease	Higher capacity
East Anglia Three	Consented	172 x 7 MW	Total capacity = 1200 MW No. of turbines = 172	Unknown	-	-
Seagreen Alpha	Consented	75 x 7 MW	Total capacity = 525 MW No. of turbines = unavailable	120 turbines	Decrease	Unknown
Seagreen Bravo	Consented	75 x 7 MW	Total capacity = 525 MW No. of turbines = unavailable			
Galloper Wind Farm	Operational	140 x 3.6 MW	Total capacity = 504 MW No. of turbines = 140	56 x 6.3 MW	Decrease	Higher capacity
Greater Gabbard Wind Farm	Operational	140 x 3.6 MW	Unavailable	140 x 3.6 MW	No difference	No change
Hornsea 1	Under construction	240 x 5 MW	Total capacity = 1200 MW No. of turbines = 120	174 x 7 MW	Decrease	Higher capacity

Project	Project status	Assessed turbine scenario	Consented scenario	As-built/planned turbine scenario	Difference between number of turbines	Difference between turbine capacity
Hornsea 2	Consented	300 x 5 MW	Total capacity = 1800 MW No. of turbines = 300	92-231 turbines	Decrease	Unknown
Humber Gateway	Operational	83 x 3.6 MW	Total capacity = 300 MW No. of turbines = 83	73 x 3 MW	Decrease	Lower capacity
Hywind	Operational	5 x 6 MW	Total capacity = 30 MW No. of turbines = unavailable	5 x 6 MW	No difference	No change
Inch Cape	Consented	213 turbines	Unavailable	72 turbines	Decrease	Unknown
Kentish Flats Extension	Operational	17 x 3 MW	Total capacity = 51 MW No. of turbines = unavailable	15 x 3.3 MW	Decrease	Higher capacity
Kincardine	Under construction	8 x 6 MW	Total capacity = 50 MW No. of turbines = unavailable	7 turbines	Decrease	Unknown
Lincs	Operational	83 x 3 MW	Total capacity = 250 MW No. of turbines = 83	75 x 3.6 MW	Decrease	Higher capacity

Project	Project status	Assessed turbine scenario	Consented scenario	As-built/planned turbine scenario	Difference between number of turbines	Difference between turbine capacity
London Array	Operational	271 x 3 MW	Total capacity = 1000 MW No. of turbines = 341	175 x 3.6 MW	Decrease	Higher capacity
Methil	Consented	1 turbine	Unavailable	2 turbines	Increase	Unknown
Moray East	Consented	339 (139 x 3.6, 100 x 5 and 100 x 5 MW)	Total capacity = 1116 MW No. of turbines = 186	100 x 9.5 MW	Decrease	Higher capacity
Neart na Gaoithe	Consented	128 x 3.6 MW	Total capacity = 450 MW No. of turbines = 75	56 x 8 MW	Decrease	Higher capacity
Race Bank	Operational	206 x 3 MW	Total capacity = 580 MW No. of turbines = unavailable	91 x 6.3 MW	Decrease	Higher capacity
Sheringham Shoal	Operational	108 x 3 MW	Total capacity = 316.8 MW No. of turbines = 108	88 x 3.6 MW	Decrease	Higher capacity
Teesside Offshore Wind Farm	Operational	30 turbines	Total capacity = 100 MW No. of turbines = 30	27 x 2.3 MW	Decrease	Unknown

Project	Project status	Assessed turbine scenario	Consented scenario	As-built/planned turbine scenario	Difference between number of turbines	Difference between turbine capacity
Thanet	Operational	60 x 5 MW	Total capacity = 300 MW No. of turbines = unavailable	100 x 3 MW	Increase	Lower capacity
Triton Knoll	Consented	288 x 3.6 MW	Total capacity = 900 MW No. of turbines = 90	90 x 9.5 MW	Decrease	Higher capacity
Westermost Rough	Operational	50 x 3.6 MW	Total capacity = 245 MW No. of turbines = 80	35 x 6 MW	Decrease	Higher capacity

- 1.11 For the majority of projects included in the cumulative/in-combination assessments, the as-built turbine scenario is composed, or is proposed to be composed, of fewer, higher capacity turbines. This is therefore likely to represent a significant decrease in the collision risk for relevant species and ultimately for cumulative and in-combination assessments predominantly due to reductions in the number of turbines but also due to changes to turbine parameters associated with higher capacity turbines (although note that these changes may actually increase collision risk although to a lesser extent than the reduction associated with a reduced number of turbines).
- 1.12 Based on the information presented in Table 1.3, a number of approaches can be taken in order to derive collision risk estimates that better reflect the turbine scenario operating/planned at each project considered cumulatively/in-combination. These are:
1. Use collision risk estimates from project-specific documents (e.g. updated applications, non-material amendments, etc.);
  2. If the assessed and as-built turbine scenarios presented in Table 1.3 match those used to derive a correction factor in MacArthur Green (2017) then the correction factor presented in MacArthur Green (2017) is directly applied;
  3. If the assessed and as-built turbine parameters presented in Table 1.3 do not match those used to derive a correction factor in MacArthur Green (2017) then the approach used in MacArthur Green (2017) to calculate correction factors is used alongside updated turbine parameters; or
  4. No change applied.
- 1.13 For some projects no change is necessary (i.e. because turbine parameters have not changed) whereas for others updated turbine parameters are not available. These projects are therefore considered qualitatively and assigned to approach 4 in Table 1.4.
- 1.14 The approach to be applied to the collision risk estimates for each project considered in-combination is outlined in Table 1.4.

Table 1.4: Approach used for each project considered cumulatively/in-combination with Hornsea Three

Project	Approach used	Justification
Aberdeen (European Offshore Wind Development Centre)	3	The project is now operational and uses higher capacity turbines than those assessed. The turbine parameters presented in MacArthur Green (2017) are different to those actually assessed and therefore a revised correction factor has been calculated
Beatrice	1	Collision risk estimates for the as-built turbine scenario are presented in the Scoping Opinion Addendum produced for the alternative design application for Moray East and in the application for Moray West.
Blyth Offshore- Demonstration Extension	4	No information available
Dogger Bank Creyke Beck A & B	1	The project has recently submitted a non-material amendment which would alter the design envelope and potentially lead to a project with fewer, higher capacity turbines. This amendment does not remove the original turbine scenario and has not yet been authorised and therefore no quantitative change is considered in this report.
Dogger Bank Teesside A and Sofia	1	The Sofia project has recently submitted a non-material amendment which would alter the design envelope and potentially lead to a project with fewer, higher capacity turbines. This amendment does not remove the original turbine scenario and has not yet been authorised and therefore no quantitative change is considered in this report. No updated information is available for the Dogger Bank Teesside A project.
Dudgeon	2	The project is now operational and uses fewer, higher capacity turbines than those assessed. The turbine parameters for these scenarios match those used in MacArthur Green (2017) to calculate a correction factor.
East Anglia One	3	The project is currently under construction and is deploying fewer, higher capacity turbines than those assessed. The turbine parameters presented in MacArthur Green (2017) are different to those actually assessed and therefore a revised correction factor has been calculated
East Anglia Three	4	Project recently consented, no further information, no change made.

Project	Approach used	Justification
Seagreen Alpha	1	Project submitted a revised application in 2018 proposing the use of fewer, higher capacity turbines. Revised collision risk estimates are presented for gannet and kittiwake
Seagreen Bravo	1	Project submitted a revised application in 2018 proposing the use of fewer, higher capacity turbines. Revised collision risk estimates are presented for gannet and kittiwake
Galloper Wind Farm	2	The project is now operational and uses fewer, higher capacity turbines than those assessed. The turbine parameters for these scenarios match those used in MacArthur Green (2017) to calculate a correction factor.
Greater Gabbard Wind Farm	3	The project is now operational, with the as-built turbine scenario having different turbine parameters to those originally assessed. The turbine parameters presented in MacArthur Green (2017) are different to those actually assessed and therefore a revised correction factor has been calculated
Hornsea Project One	4	No change necessary. Collision risk estimates used in the Hornsea Three assessments were calculated using the planned turbine scenario
Hornsea Project Two	4	No change. Although the project is expected to construct fewer, higher capacity turbines, no information is available in relation to updated collision risk estimates or potential turbine parameters for the planned turbine scenario
Humber Gateway	2	The project is now operational and uses fewer, lower capacity turbines than those assessed. The turbine parameters for these scenarios match those used in MacArthur Green (2017) to calculate a correction factor.
Hywind	4	No difference between assessed and as-built turbine scenarios
Inch Cape	1	A Section 36 consent variation was authorised in 2015 with the project committing to reduce the number of turbines from 213 to 110 whilst also reducing the total generating capacity of the wind farm. In addition, the project submitted a revised application in 2018 proposing the use of fewer, higher capacity turbines. Revised collision risk estimates are presented for gannet and kittiwake



Project	Approach used	Justification
Kentish Flats Extension	2	The project is now operational and uses fewer, higher capacity turbines than those assessed. The turbine parameters for these scenarios match those used in MacArthur Green (2017) to calculate a correction factor.
Kincardine	4	Although the proposed number of turbines has reduced, the turbine parameters for the as-built turbine scenario are unknown. No change is therefore made.
Lincs	2	The project is now operational and uses fewer, higher capacity turbines than those assessed. The turbine parameters for these scenarios match those used in MacArthur Green (2017) to calculate a correction factor.
London Array	3	The project is operational and has deployed fewer, higher capacity turbines than those assessed. The turbine parameters presented in MacArthur Green (2017) are different to those actually assessed and therefore a revised correction factor has been calculated
Methil	4	No difference between assessed and as-built turbine scenarios identified
Moray East	1	Project submitted an application for a revised project design incorporating fewer, higher capacity turbines. This was supported by collision risk modelling incorporating four turbine scenarios. The collision risk estimates associated with the worst case scenario have been used in this report.
Neart na Gaoithe	1/3	The project submitted a revised application in 2018. The collision risk estimates are presented for gannet and kittiwake and these have therefore been used in this report (Approach 1). Collision risk estimates are not presented for lesser black-backed gull or great black-backed gull, however, the turbine parameters for the associated turbine scenario are known and therefore a correction factor has been derived (Approach 3).
Race Bank	2	The project is now operational and uses fewer, higher capacity turbines than those assessed. The turbine parameters for these scenarios match those used in MacArthur Green (2017) to calculate a correction factor.

Project	Approach used	Justification
Sheringham Shoal	2	The project is now operational and uses fewer, higher capacity turbines than those assessed. The turbine parameters for these scenarios match those used in MacArthur Green (2017) to calculate a correction factor.
Teesside Offshore Wind Farm	2	The project is now operational and uses fewer turbines than those assessed. The turbine parameters for these scenarios match those used in MacArthur Green (2017) to calculate a correction factor.
Thanet	1	Collision risk estimates for the as-built turbine scenario are available in project-specific documentation. These were used in the original assessments for Hornsea Three and are also used in this report.
Triton Knoll	3	The project is consented and has committed to constructing fewer, higher capacity turbines than those originally assessed. The turbine parameters presented in MacArthur Green (2017) are different to those actually assessed and therefore a revised correction factor has been calculated
Westermost Rough	2	The project is now operational and uses fewer, higher capacity turbines than those assessed. The turbine parameters for these scenarios match those used in MacArthur Green (2017) to calculate a correction factor.

### Approach 1 – Updated project-specific collision risk estimates

1.15 For a number of projects listed in Table 1.4, revised collision risk estimates calculated using updated turbine parameters are included in project-specific documentation. This includes:

- Beatrice;
- Dogger Bank Creyke Beck A&B;
- Dogger Bank Teesside A&B (now Dogger Bank Teesside A and Sofia);
- Seagreen Alpha;
- Seagreen Bravo;
- Inch Cape;
- Moray East
- Neart na Gaoithe; and
- Thanet.

1.16 Each of these projects is considered as part of the Discussion section below in relation to the revised collision risk estimates and the associated confidence that can be placed in updated collision risk modelling.

#### *Beatrice*

1.17 The Beatrice offshore wind farm is currently under construction and is deploying 84 x 7 MW turbines. This represents a turbine scenario with fewer, higher capacity turbines when compared to the scenario for which collision risk modelling was conducted in the original application (142 x 7 MW (gannet) or 277 x 3.6 MW turbines (all other species)). Collision risk modelling incorporating this turbine scenario has been presented as part of the alternative design application for the Moray East offshore wind farm and was also incorporated into the application for the Moray West offshore wind farm. This report therefore uses the collision risk estimates calculated for Beatrice as part of these applications as these estimates provide a more accurate appraisal of collision risk for Beatrice.

#### *Dogger Bank projects*

1.18 Collision risk modelling for the Dogger Bank projects (Dogger Bank Creyke Beck A&B, Dogger Bank Teesside A and Sofia) used a 200 x 6 MW turbine scenario for each project. In June 2018, the Dogger Bank Creyke Beck A&B and Sofia projects issued non-material amendment applications to the Secretary of State (BEIS) outlining a number of proposed changes. Of relevance to collision risk modelling, it was proposed that the Development Consent Order (DCO) for each project be amended to allow for the construction of turbines with larger rotor diameters. Changes to other turbine parameters (e.g. rotor swept area) were not proposed and therefore the use of turbines with a larger rotor diameter would reduce the number of turbines that could be constructed. However, crucially these non-material amendments do not exclude the previously consented turbine scenario from the project design envelopes.

1.19 Collision risk modelling incorporating the updated turbine parameters was conducted and showed that, if the revised turbine parameters (i.e. those using the largest rotor diameter) were to be constructed, collision risk estimates would reduce. The likely reduction is discussed in the sections below however, it is not incorporated into the quantitative appraisal for each species as the originally assessed turbine scenario has not been removed from the design envelope for each project.

*Firth of Forth projects (Seagreen Alpha and Bravo, Inch Cape and Neart na Gaoithe)*

1.20 The Seagreen Alpha, Seagreen Bravo, Inch Cape and Neart na Gaoithe projects all received planning consent in 2014, with Neart na Gaoithe being awarded a CfD in 2015.

1.21 The assessment presented for Neart na Gaoithe in 2012 from which collision risk estimates were sourced for the assessments presented in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), was conducted on the basis of a 128 x 3.6 MW turbine scenario. However, the consent issued in 2014 was for a 75 x 6 MW turbine scenario for which collision risk estimates were not presented. In 2015, a Section 36 variation was submitted for the Neart na Gaoithe offshore wind farm which committed the project to a reduced number of higher capacity turbines (up to 75 turbines and a rated turbine capacity of up to 7 MW). The documentation supporting this variation contains collision risk estimates calculated for the consented turbine scenario (75 x 6 MW turbines). The assessments presented in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) for gannet and kittiwake at Hornsea Three have therefore been updated using the collision risk estimates associated with the varied consent. Updated collision risk estimates are not available for lesser black-backed gull and great black-backed gull, however as the turbine parameters are known, Approach 3 has been applied for these species (see paragraphs 1.28 to 1.30).

1.22 A similar Section 36 variation had previously been submitted for the Inch Cape offshore wind farm (in October 2014) with commitments to reduce the number of turbines from 213 to 110 and to reduce the total generating capacity of the project from 1050 MW to 784 MW. However, updated collision risk estimates do not appear to be available and therefore likely changes are discussed qualitatively in the Discussion section.

1.23 Revised applications for all of these projects were submitted in 2018 incorporating different project designs to those consented in 2014. Although collision risk estimates reflecting the revised turbine scenarios are available for each project, it is possible that each project could choose to construct the previously consented turbine scenario. As such, the changes to collision risk that may occur if the revised designs are awarded consent is only considered qualitatively in the Discussion section.

*Moray East*

- 1.24 Moray East received planning consent in 2014 and was awarded a CfD in 2017. In 2018, the project submitted a consent variation seeking to increase the maximum installed capacity at one of the component projects and to increase the maximum rated turbine capacity from 8 MW to 10MW (to allow the installation of the proposed 9.5 MW turbine). The most recent collision risk modelling for Moray East, which was used to support an application for an alternative design, considered both an 8.1 MW and a 10 MW turbine. This report therefore uses the collision risk estimates that represent the worst case scenario for relevant species with these representing the collision risk estimates incorporated into the recent application for the Moray West offshore wind farm.

*Thanet*

- 1.25 Collision risk modelling undertaken for the Thanet offshore wind farm incorporated two turbine scenarios (60 x 5 MW and 100 x 3 MW). The assessments undertaken for the application were based on the worst case scenario (60 x 5 MW) however, the as-built scenario is 100 x 3 MW turbines. Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) utilised the collision risk estimates calculated using the 100 x 3 MW turbine scenario and these collision risk estimates are therefore used in the following sections.

**Approach 2 – Corrected collision risk estimates using correction factors in MacArthur Green (2017)**

- 1.26 There are a number of projects considered cumulatively/in-combination for which the turbine parameters used in MacArthur Green (2017) correspond with those used to calculate collision risk estimates used in the cumulative and in-combination assessments for Hornsea Three. This includes:
- Dudgeon;
  - Galloper;
  - Humber Gateway;
  - Kentish Flats Extension;
  - Lincs;
  - Race Bank;
  - Sheringham Shoal;
  - Teesside; and
  - Westernmost Rough.
- 1.27 For these projects, the correction factors presented in MacArthur Green (2017) have been applied to the collision risk estimates obtained for each project (Table 1.5). This approach was conducted in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Table 1.5: Correction factors from MacArthur Green (2017) applied in Approach 2

Project	Correction factor			
	Gannet	Kittiwake	Lesser black-backed gull	Great black-backed gull
Dudgeon	0.46	0.51	0.49	0.50
Galloper	0.43	0.42	0.43	0.41
Humber Gateway	0.50	0.39	0.42	0.45
Kentish Flats Extension	0.80	0.72	0.80	0.80
Lincs	1.01	1.04	1.03	1.02
Race Bank	0.53	0.59	0.57	0.57
Sheringham Shoal	0.97	0.98	0.98	0.97
Teesside Offshore Wind Farm	0.68	0.67	0.67	0.68
Westermost Rough	0.83	0.82	0.82	0.83

**Approach 3 – Corrected collision risk estimates using corrected factors derived using the MacArthur Green (2017) with updated turbine parameters**

1.28 There are a number of projects considered cumulatively/in-combination for which the assessed turbine parameters used to calculate collision risk estimates do not match those used in MacArthur Green (2017) to derive a correction factor. This includes:

- Aberdeen (European Offshore Wind Development Centre);
- East Anglia One;
- Greater Gabbard;
- London Array;
- Neart na Gaoithe (lesser black-backed gull and great black-backed gull); and
- Triton Knoll.

The approach used to derive these correction factors has therefore been updated with the turbine parameters used to calculate the collision risk estimates used in the cumulative and in-combination assessments for Hornsea Three. The resulting correction factors (

1.29 Table 1.6) are then applied to the collision risk estimates used in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

1.30 The turbine parameters and relevant sources used to derive correction factors are presented in Appendix A. Where a range of values was presented for a parameter, the worst case value was applied to derive a correction factor.

Table 1.6: Correction factors derived for projects for which Approach 3 was applied

Project	Correction factor			
	Gannet	Kittiwake	Lesser black-backed gull	Great black-backed gull
Aberdeen	1.20	1.11	1.15	1.15
East Anglia One	0.42	0.40	0.41	0.42
Greater Gabbard	0.96	1.06	1.00	0.98
London Array	0.50	0.49	0.49	0.49
Near na Gaoithe	N/A	N/A	0.59	0.59
Triton Knoll	0.34	0.35	0.35	0.34

**Approach 4 – no change/information unavailable**

- 1.31 The as-built/planned turbine scenario deployed for some projects considered cumulatively/in-combination has not changed since assessments were conducted (Hywind, Methil). For other projects, changes to project design, which have been authorised by the Secretary of State as part of non-material amendments to Development Consent Orders, have been made resulting in lower collision risk estimates with those already incorporated into the assessments conducted for Hornsea Three (e.g. Hornsea Project One).
- 1.32 Some projects have only recently been consented and therefore no changes have been made to the assessed turbine scenario, although as changes have been made to the as-built/planned turbine scenario for the majority of projects in Table 1.4, it is considered likely that this may also occur at more recently consented projects (e.g. East Anglia Three).
- 1.33 For remaining projects, information is not available to allow the calculation of a correction factor to account for differences between assessed and as-built/planned turbine scenarios (Blyth, Hornsea Project Two and Kincardine).
- 1.34 A turbine correction (representing the difference between the number of assessed and consented number of turbines) was used as part of the Hornsea Three assessments and this is therefore retained in the analyses presented in this report.

## **Updated collision risk estimates**

### **Methodology**

- 1.35 The original collision risk estimates presented in Table 1.7, Table 1.10, Table 1.13 and Table 1.16 are consistent with those presented in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) for each of the four respective species. The collision risk estimates presented in Table 1.8, Table 1.11, Table 1.14 and Table 1.17 are calculated using the Basic Band model and use the avoidance rates as recommended by JNCC *et al.* (2014). The apportioning applied to these estimates is consistent with that used for each relevant project in the original Hornsea Three assessments.

### **Gannet**

- 1.36 Table 1.7 presents the updated cumulative and in-combination collision risk estimates for gannet using the Extended model where available. Table 1.8 presents the same analysis but for collision risk estimates calculated using the Basic Band model. The cumulative and in-combination collision risk totals have reduced on seasonal and annual bases when totalling the risk at Tier 1 projects and all Tiers combined.



Table 1.7: Comparison of assessed and as-built predicted cumulative and in-combination collision risk for gannet using the Extended Band model where available

Approach	Project	Collision risk estimates as used in Hornsea Three assessments						Updated collision risk estimates					
		Breeding		Post-breeding		Pre-breeding		Breeding		Post-breeding		Pre-breeding	
		EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA
N/A	Hornsea Three	7	3	5	0	3	0	7	3	5	0	3	0
Tier 1													
1	Beatrice			19	1	4	0			6	0	0	0
	Moray East			5	0	1	0			9	0	2	0
	Near na Gaoithe			57	3	64	4			28	1	13	1
	Thanet			0	0	0	0			0	0	0	0
2	Dudgeon	10	10	18	1	9	1	10	10	18	1	9	1
	Galloper			28	1	11	1			12	1	5	0
	Humber Gateway	2	2	1	0	1	0	1	1	0	0	1	0
	Kentish Flats Extension			0	0	0	0			0	0	0	0
	Lincs	2	2	1	0	2	0	2	2	1	0	2	0
	Race Bank	34	34	12	1	4	0	18	18	6	0	2	0
	Sheringham Shoal	14	14	3	0	0	0	14	14	3	0	0	0
	Teesside	5	5	2	0	0	0	3	3	1	0	0	0

Approach	Project	Collision risk estimates as used in Hornsea Three assessments						Updated collision risk estimates					
	Westermost Rough	0	0	0	0	0	0	0	0	0	0	0	0
3	Aberdeen			5	0	0	0			6	0	0	0
	East Anglia One			63	3	3	0			36	2	2	0
	Greater Gabbard			8	0	9	1			8	0	9	1
	London Array			2	0	0	0			1	0	0	0
	Triton Knoll	17	17	65	3	40	2	5	5	21	1	13	1
4	Blyth	4	4	2	0	3	0	4	4	2	0	3	0
	Hornsea Project One	1	0	2	0	1	0	1	0	2	0	1	0
	Hornsea Project Two	5	4	9	0	4	0	5	4	9	0	4	0
	Hywind			2	0	2	0			2	0	2	0
<b>Tier 1 total</b>		<b>100</b>	<b>94</b>	<b>309</b>	<b>15</b>	<b>163</b>	<b>10</b>	<b>70</b>	<b>64</b>	<b>175</b>	<b>8</b>	<b>71</b>	<b>4</b>
Tier 2													
1	Dogger Bank Creyke Beck A&B	41	20	48	2	32	2	41	20	48	2	32	2
	Dogger Bank Teesside A and Sofia	56	28	39	2	41	3	56	28	39	2	41	3
	Seagreen Alpha			91	4	33	2			91	4	33	2
	Seagreen Bravo			64	3	37	2			64	3	37	2

Approach	Project	Collision risk estimates as used in Hornsea Three assessments						Updated collision risk estimates					
	Inch Cape			29	1	5	0			29	1	5	0
4	East Anglia Three			33	2	10	1			33	2	10	1
	Kincardine			13	1	0	0			13	1	0	0
	Methil			0	0	0	0			0	0	0	0
<b>Tier 2 total</b>		<b>97</b>	<b>48</b>	<b>317</b>	<b>15</b>	<b>158</b>	<b>10</b>	<b>97</b>	<b>48</b>	<b>317</b>	<b>15</b>	<b>158</b>	<b>10</b>
<b>Total</b>		<b>197</b>	<b>142</b>	<b>627</b>	<b>30</b>	<b>321</b>	<b>20</b>	<b>167</b>	<b>113</b>	<b>492</b>	<b>24</b>	<b>230</b>	<b>14</b>

Table 1.8: Comparison of assessed and as-built predicted cumulative and in-combination collision risk for gannet using the Basic Band model

Approach	Project	Original collision risk estimates						Updated collision risk estimates					
		Breeding		Post-breeding		Pre-breeding		Breeding		Post-breeding		Pre-breeding	
		EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA
N/A	Hornsea Three	18	7	12	1	8	0	18	7	12	1	8	0
Tier 1													
1	Beatrice			44	2	10	1			22	1	5	0
	Moray East			19	1	5	0			24	1	11	1
	Near na Gaoithe			57	3	64	4			48	2	24	1
	Thanet			0	0	0	0			0	0	0	0
2	Dudgeon	10	10	18	1	9	1	10	10	18	1	9	1
	Galloper			28	1	11	1			12	1	5	0
	Humber Gateway	2	2	1	0	1	0	1	1	0	0	1	0
	Kentish Flats Extension			0	0	0	0			0	0	0	0
	Lincs	2	2	1	0	2	0	2	2	1	0	2	0
	Race Bank	34	34	12	1	4	0	18	18	6	0	2	0
	Sheringham Shoal	14	14	3	0	0	0	14	14	3	0	0	0
	Teesside	5	5	2	0	0	0	3	3	1	0	0	0
	Westermost Rough	0	0	0	0	0	0	0	0	0	0	0	0

Approach	Project	Original collision risk estimates						Updated collision risk estimates					
3	Aberdeen			5	0	0	0			6	0	0	0
	East Anglia One			123	7	6	0			71	3	4	0
	Greater Gabbard			8	0	9	1			8	0	9	1
	London Array			2	0	0	0			1	0	0	0
	Triton Knoll	17	17	65	3	40	2	5	5	21	1	13	1
4	Blyth	4	4	2	0	3	0	4	4	2	0	3	0
	Hornsea Project One	1	1	3	0	2	0	1	1	3	0	2	0
	Hornsea Project Two	7	5	14	1	6	0	7	5	14	1	6	0
	Hywind			2	0	2	0			2	0	2	0
<b>Tier 1 total</b>		<b>113</b>	<b>100</b>	<b>420</b>	<b>20</b>	<b>183</b>	<b>11</b>	<b>84</b>	<b>71</b>	<b>276</b>	<b>13</b>	<b>105</b>	<b>7</b>
Tier 2													
1	Dogger Bank Creyke Beck A&B	6	3	7	0	4	0	6	3	7	0	4	0
	Dogger Bank Teesside A and Sofia	15	7	10	0	11	1	15	7	10	0	11	1
	Seagreen Alpha			101	5	37	2			101	5	37	2
	Seagreen Bravo			71	3	40	2			71	3	40	2
	Inch Cape			29	1	5	0			29	1	5	0
4	East Anglia Three			38	2	11	1			38	2	11	1

Approach	Project	Original collision risk estimates						Updated collision risk estimates					
	Kincardine			8	0	1	0			8	0	1	0
	Methil			0	0	0	0			0	0	0	0
<b>Tier 2 total</b>		<b>20</b>	<b>10</b>	<b>264</b>	<b>13</b>	<b>109</b>	<b>7</b>	<b>20</b>	<b>10</b>	<b>264</b>	<b>13</b>	<b>109</b>	<b>7</b>
<b>Total</b>		<b>134</b>	<b>110</b>	<b>684</b>	<b>33</b>	<b>292</b>	<b>18</b>	<b>104</b>	<b>81</b>	<b>540</b>	<b>26</b>	<b>213</b>	<b>13</b>

1.37 There are considerable differences between the collision risk estimates for gannet calculated using assessed turbine scenarios and those corrected to reflect the as-built turbine scenarios for relevant projects. Table 1.9 presents the approximate percentage reductions that occur between the assessed and as-built totals for the two Band model Options and for Tier 1 projects and all (Tier 1 and 2) projects.

Table 1.9: Percentage reductions in cumulative and in-combination collision risk calculated for gannet

Season	Tiers	Extended model (% reduction)		Basic model (% reduction)	
		EIA	pSPA	EIA	pSPA
Breeding	1	30	32	26	29
	All	15	20	22	26
Post-breeding	1	43	47	34	35
	All	22	20	21	21
Pre-breeding	1	56	60	43	36
	All	56	60	43	36
Annual	1	45	36	35	31
	All	22	21	23	25

### Kittiwake

1.38 Table 1.10 presents the updated cumulative and in-combination collision risk estimates for kittiwake using the Extended model where available. Table 1.11 presents the same analysis but for collision risk estimates calculated using the Basic Band model. The cumulative and in-combination collision risk totals have reduced on seasonal and annual bases when totalling the risk at Tier 1 projects and all Tiers combined.

Table 1.10: Comparison of assessed and as-built predicted cumulative and in-combination collision risk for kittiwake using the Extended Band model where available

Approach	Project	Collision risk estimates as used in Hornsea Three assessments						Updated collision risk estimates					
		Breeding		Post-breeding		Pre-breeding		Breeding		Post-breeding		Pre-breeding	
		EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA
N/A	Hornsea Three	42	18	26	1	14	1	42	18	26	1	14	1
Tier 1													
1	Beatrice			2	0	2	0			1	0	1	0
	Moray East			2	0	7	1			4	0	12	1
	Neart na Gaoithe			18	1	11	1			8	0	1	0
	Thanet			0	0	0	0			0	0	0	0
2	Galloper			20	1	20	1			8	0	8	1
	Humber Gateway	2	2	2	0	1	0	1	1	1	0	1	0
	Kentish Flats Extension			1	0	0	0			1	0	0	0
	Lincs	1	1	1	0	1	0	1	1	1	0	1	0
	Race Bank	1	1	17	1	4	0	1	1	10	1	2	0
	Teesside			18	1	2	0			12	1	1	0
	Westermost Rough	0	0	0	0	0	0	0	0	0	0	0	0
3	Aberdeen			4	0	0	0			5	0	0	0



Approach	Project	Collision risk estimates as used in Hornsea Three assessments						Updated collision risk estimates					
	East Anglia One			17	1	6	0			9	0	3	0
	Greater Gabbard			5	0	13	1			6	0	13	1
	London Array			1	0	2	0			1	0	1	0
	Triton Knoll	12	12	91	5	49	4	4	4	29	2	16	1
4	Blyth			2	0	1	0			2	0	1	0
	Hornsea Project One	1	1	1	0	0	0	1	1	1	0	0	0
	Hornsea Project Two	2	2	1	0	0	0	2	2	1	0	0	0
	Hywind			2	0	0	0			2	0	0	0
<b>Tier 1 total</b>		<b>60</b>	<b>35</b>	<b>232</b>	<b>13</b>	<b>134</b>	<b>10</b>	<b>51</b>	<b>26</b>	<b>127</b>	<b>7</b>	<b>77</b>	<b>6</b>
Tier 2													
1	Dogger Bank Creyke Beck A&B	87	15	41	2	90	6	87	15	41	2	90	6
	Dogger Bank Teesside A and Sofia			28	2	66	5			28	2	66	5
	Seagreen Alpha			79	4	52	4			79	4	52	4
	Seagreen Bravo			50	3	30	2			50	3	30	2
	Inch Cape			163	9	45	3			163	9	45	3
4	East Anglia Three			54	3	25	2			54	3	25	2

Approach	Project	Collision risk estimates as used in Hornsea Three assessments						Updated collision risk estimates					
	Kincardine			25	1	3	0			25	1	3	0
	Methil			0	0	0	0			0	0	0	0
<b>Tier 2 total</b>		<b>87</b>	<b>15</b>	<b>441</b>	<b>24</b>	<b>312</b>	<b>22</b>	<b>87</b>	<b>15</b>	<b>441</b>	<b>24</b>	<b>312</b>	<b>22</b>
<b>Total</b>		<b>148</b>	<b>50</b>	<b>673</b>	<b>37</b>	<b>446</b>	<b>32</b>	<b>138</b>	<b>41</b>	<b>568</b>	<b>31</b>	<b>388</b>	<b>28</b>

Table 1.11: Comparison of assessed and as-built predicted cumulative and in-combination collision risk for kittiwake using the Basic Band model

Approach	Project	Original collision risk estimates						Updated collision risk estimates					
		Breeding		Post-breeding		Pre-breeding		Breeding		Post-breeding		Pre-breeding	
		EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA	EIA	pSPA
N/A	Hornsea Three	23	10	14	1	8	1	23	10	14	1	8	1
Tier 1													
1	Beatrice			6	0	6	0			5	0	5	0
	Moray East			2	0	6	0			4	0	11	1
	Near na Gaoithe			24	1	15	1			27	1	2	0
	Thanet			0	0	0	0			0	0	0	0
2	Galloper			28	2	27	2			12	1	11	1
	Humber Gateway	2	2	3	0	2	0	1	1	1	0	1	0
	Kentish Flats Extension			1	0	1	0			1	0	0	0
	Lincs	1	1	1	0	1	0	1	1	1	0	1	0
	Race Bank	2	2	24	1	6	0	1	1	14	1	3	0
	Teesside			25	1	3	0			17	1	2	0
	Westermost Rough	0	0	0	0	0	0	0	0	0	0	0	0
3	Aberdeen			6	0	0	0			7	0	1	0
	East Anglia One			295	16	105	8			159	9	56	4

Approach	Project	Original collision risk estimates						Updated collision risk estimates					
	Greater Gabbard			7	0	17	1			8	0	18	1
	London Array			2	0	3	0			1	0	1	0
	Triton Knoll	16	16	126	7	67	5	5	5	40	2	22	2
4	Blyth			2	0	1	0			2	0	1	0
	Hornsea Project One	3	2	3	0	1	0	3	2	3	0	1	0
	Hornsea Project Two	16	14	9	0	3	0	16	14	9	0	3	0
	Hywind			2	0	0	0			2	0	0	0
<b>Tier 1 total</b>		<b>64</b>	<b>47</b>	<b>581</b>	<b>32</b>	<b>272</b>	<b>20</b>	<b>51</b>	<b>33</b>	<b>327</b>	<b>18</b>	<b>147</b>	<b>11</b>
Tier 2													
1	Dogger Bank Creyke Beck A&B	288	48	135	7	295	21	288	48	135	7	295	21
	Dogger Bank Teesside A and Sofia			91	5	217	16			91	5	217	16
	Seagreen Alpha			171	9	112	8			171	9	112	8
	Seagreen Bravo			142	8	85	6			142	8	85	6
	Inch Cape			225	12	63	4			225	12	63	4
4	East Anglia Three			64	3	31	2			64	3	31	2
	Kincardine			8	0	1	0			8	0	1	0
	Methil			0	0	0	0			0	0	0	0

Approach	Project	Original collision risk estimates						Updated collision risk estimates					
Tier 2 total		288	48	837	46	804	58	288	48	837	46	804	58
Total		352	95	1418	77	1076	77	338	81	1164	63	951	68

1.39 There are considerable differences between the collision risk estimates for kittiwake calculated using assessed turbine scenarios and those corrected to reflect the as-built turbine scenarios for relevant projects. Table 1.12 presents the approximate percentage reductions that occur between the assessed and as-built totals for the two Band model Options and for Tier 1 projects and all (Tier 1 and 2) projects.

Table 1.12: Percentage reductions in cumulative and in-combination collision risk calculated for kittiwake

Season	Tiers	Extended model (% reduction)		Basic model (% reduction)	
		EIA	pSPA	EIA	pSPA
Breeding	1	15	26	22	32
	All	7	18	4	15
Post-breeding	1	45	46	44	44
	All	16	16	18	18
Pre-breeding	1	43	40	46	45
	All	13	13	12	12
Annual	1	40	33	43	38
	All	14	16	14	15

### Lesser black-backed gull

1.40 Table 1.7 presents the updated cumulative and in-combination collision risk estimates for lesser black-backed gull using the Extended model where available. Table 1.14 presents the same analysis but for collision risk estimates calculated using the Basic Band model. The cumulative and in-combination collision risk totals have reduced on seasonal and annual bases when totalling the risk at Tier 1 projects and all Tiers combined.

Table 1.13: Comparison of assessed and as-built predicted cumulative and in-combination collision risk for lesser black-backed gull using the Extended Band model where available

Approach	Project	Collision risk estimates as used in Hornsea Three assessments				Updated collision risk estimates			
		Breeding	Post-breeding	Non-breeding	Pre-breeding	Breeding	Post-breeding	Non-breeding	Pre-breeding
-	Hornsea Three	10	1	0	1	10	1	0	1
<b>Tier 1</b>									
1	Thanet	2	2	1	0	2	2	1	0
2	Dudgeon	4	3	4	2	4	3	4	2
	Galloper	63	24	31	22	27	10	13	9
	Humber Gateway	0	0	1	0	0	0	0	0
	Kentish Flats Extension	0	0	1	0	0	0	0	0
	Lincs	2	2	3	2	2	2	3	2
	Race Bank	11	13	27	2	6	8	15	1
	Sheringham Shoal	6	1	0	1	6	1	0	1
Westermost Rough	0	0	0	0	0	0	0	0	
3	East Anglia ONE	6	6	31	0	4	3	17	0
	Greater Gabbard	12	13	23	14	12	13	23	14
	Neart na Gaoithe		0	0	0		0	0	0

Approach	Project	Collision risk estimates as used in Hornsea Three assessments				Updated collision risk estimates			
	Triton Knoll	16	4	10	3	5	1	3	1
4	Hornsea Project One	5	2	1	1	5	2	1	1
	Hornsea Project Two	0	0	0	0	0	0	0	0
<b>Tier 1 total</b>		<b>139</b>	<b>73</b>	<b>131</b>	<b>47</b>	<b>84</b>	<b>48</b>	<b>81</b>	<b>32</b>
Tier 2									
1	Dogger Bank Creyke Beck A and B	12	1	1	4	12	1	1	4
	Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B)		8	5	0		8	5	0
	Seagreen Alpha		1	2	1		1	2	1
	Seagreen Bravo		0	1	4		0	1	4
4	East Anglia Three	2	5	2	1	2	5	2	1
<b>Tier 2 total</b>		<b>14</b>	<b>16</b>	<b>9</b>	<b>10</b>	<b>14</b>	<b>16</b>	<b>9</b>	<b>10</b>
<b>Total</b>		<b>153</b>	<b>89</b>	<b>140</b>	<b>57</b>	<b>99</b>	<b>64</b>	<b>91</b>	<b>42</b>



Table 1.14: Comparison of assessed and as-built predicted cumulative and in-combination collision risk for lesser black-backed gull using the Basic Band model

Approach	Project	Original collision risk estimates				Updated collision risk estimates			
		Breeding	Post-breeding	Non-breeding	Pre-breeding	Breeding	Post-breeding	Non-breeding	Pre-breeding
-	Hornsea Three	15	2	0	1	15	2	0	1
<b>Tier 1</b>									
1	Neart na Gaoithe		0	0	0		0	0	0
	Thanet	2	2	1	0	2	2	1	0
2	Dudgeon	4	3	4	2	4	3	4	2
	Galloper	63	24	31	22	27	10	13	9
	Humber Gateway	0	0	1	0	0	0	0	0
	Kentish Flats Extension	0	0	1	0	0	0	0	0
	Lincs	2	2	3	2	2	2	3	2
	Race Bank	11	13	27	2	6	8	15	1
	Sheringham Shoal	6	1	0	1	6	1	0	1
	Westermost Rough	0	0	0	0	0	0	0	0
3	East Anglia ONE	11	10	51	1	6	6	28	0
	Greater Gabbard	12	13	23	14	12	13	23	14
	Triton Knoll	16	4	10	3	5	1	3	1

Approach	Project	Original collision risk estimates				Updated collision risk estimates			
4	Hornsea Project One	12	5	2	2	12	5	2	2
	Hornsea Project Two	2	1	0	1	2	1	0	1
<b>Tier 1 total</b>		<b>157</b>	<b>81</b>	<b>153</b>	<b>49</b>	<b>101</b>	<b>55</b>	<b>94</b>	<b>34</b>
Tier 2									
1	Dogger Bank Creyke Beck A and B	9	1	0	3	9	1	0	3
	Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B)		5	3	0		5	3	0
	Seagreen Alpha		1	1	0		1	1	0
	Seagreen Bravo		0	0	1		0	0	1
4	East Anglia Three	4	11	4	2	4	11	4	2
<b>Tier 2 total</b>		<b>12</b>	<b>18</b>	<b>8</b>	<b>6</b>	<b>12</b>	<b>18</b>	<b>8</b>	<b>6</b>
<b>Total</b>		<b>169</b>	<b>99</b>	<b>161</b>	<b>55</b>	<b>109</b>	<b>73</b>	<b>103</b>	<b>40</b>

1.41 There are considerable differences between the collision risk estimates for lesser black-backed gull calculated using assessed turbine scenarios and those corrected to reflect the as-built turbine scenarios for relevant projects. Table 1.15 presents the approximate percentage reductions that occur between the assessed and as-built totals for the two Band model Options and for Tier 1 projects and all (Tier 1 and 2) projects.

Table 1.15: Percentage reductions in cumulative collision risk calculated for lesser black-backed gull

Season	Tiers	Extended model (% reduction)	Basic model (% reduction)
Breeding	1	40	36
	All	35	36
Post-breeding	1	34	32
	All	28	26
Non-breeding	1	38	39
	All	35	36
Pre-breeding	1	32	31
	All	26	27
Annual	1	37	35
	All	33	33

### Great black-backed gull

1.42 Table 1.16 presents the updated cumulative and in-combination collision risk estimates for great black-backed gull using the Extended model where available. Table 1.17 presents the same analysis but for collision risk estimates calculated using the Basic Band model. The cumulative and in-combination collision risk totals have reduced on seasonal and annual bases when totalling the risk at Tier 1 projects and all Tiers combined.

Table 1.16: Comparison of assessed and as-built predicted cumulative and in-combination collision risk for great black-backed gull using the Extended Band model where available

Approach	Offshore wind farm	Collision risk estimates as used in Hornsea Three assessments		Updated collision risk estimates	
		Breeding	Non-breeding	Breeding	Non-breeding
-	Hornsea Three	12	40	12	40
<b>Tier 1</b>					
1	Beatrice	5	54	9	90
	Moray East	8	15	10	18
	Thanet	0	0	0	0
2	Galloper	0	22	0	9
	Humber Gateway	2	5	1	2
	Kentish Flats Extension	0	0	0	0
	Teesside	3	41	2	28
	Westermost Rough	0	0	0	0
3	Aberdeen Demo	0	3	0	3
	East Anglia ONE	1	46	0	26
	Near na Gaoithe	0	4	0	3
	Triton Knoll	9	112	3	36
4	Blyth Demo	2	6	2	6

Approach	Offshore wind farm	Collision risk estimates as used in Hornsea Three assessments		Updated collision risk estimates	
	Hornsea Project One	5	44	5	44
	Hornsea Project Two	1	9	1	9
	Hywind	0	5	0	5
<b>Tier 1 total</b>		<b>49</b>	<b>407</b>	<b>45</b>	<b>319</b>
Tier 2					
1	Dogger Bank Creyke Beck A and B	2	27	2	27
	Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B)	3	29	3	29
	Inch Cape	0	37	0	37
	Seagreen Alpha	1	36	1	36
	Seagreen Bravo	3	27	3	27
4	East Anglia Three	2	43	2	43
<b>Tier 2 total</b>		<b>11</b>	<b>198</b>	<b>11</b>	<b>198</b>
<b>Total</b>		<b>60</b>	<b>606</b>	<b>57</b>	<b>517</b>

Table 1.17: Comparison of assessed and as-built predicted cumulative and in-combination collision risk for great black-backed gull using the Basic Band model

Approach	Offshore wind farm	Original collision risk estimates		Updated collision risk estimates	
		Breeding	Non-breeding	Breeding	Non-breeding
-	Hornsea Three	16	50	16	50
<b>Tier 1</b>					
1	Beatrice	6	62	1	9
	Moray East	7	12	11	20
	Thanet	0	0	0	0
2	Galloper	0	22	0	9
	Humber Gateway	2	5	1	2
	Kentish Flats Extension	0	0	0	0
	Teesside	3	41	2	28
	Westermost Rough	0	0	0	0
3	Aberdeen Demo	0	3	0	3
	East Anglia ONE	1	90	1	51
	Near na Gaoithe	0	4	0	4
	Triton Knoll	9	112	3	36
4	Blyth Demo	2	6	2	6
	Hornsea Project One	7	61	7	61

Approach	Offshore wind farm	Original collision risk estimates		Updated collision risk estimates	
	Hornsea Project Two	3	20	3	20
	Hywind	0	5	0	5
<b>Tier 1 total</b>		<b>56</b>	<b>495</b>	<b>46</b>	<b>305</b>
Tier 2					
1	Dogger Bank Creyke Beck A and B	2	30	2	30
	Dogger Bank Teesside A and Sofia (formerly Dogger Bank Teesside B)	4	33	4	33
	Inch Cape	0	37	0	37
	Seagreen Alpha	1	36	1	36
	Seagreen Bravo	3	27	3	27
4	East Anglia Three	3	52	3	52
<b>Tier 2 total</b>		<b>13</b>	<b>215</b>	<b>13</b>	<b>215</b>
<b>Total</b>		<b>68</b>	<b>709</b>	<b>59</b>	<b>520</b>

1.43 There are considerable differences between the collision risk estimates for great black-backed gull calculated using assessed turbine scenarios and those corrected to reflect the as-built turbine scenarios for relevant projects. Table 1.18 presents the approximate percentage reductions that occur between the assessed and as-built totals for the two Band model Options and for Tier 1 projects and all (Tier 1 and 2) projects.

Table 1.18: Percentage reductions in cumulative collision risk calculated for great black-backed gull

Season	Tiers	Extended model (% reduction)	Basic model (% reduction)
Breeding	1	8	18
	All	5	13
Non-breeding	1	22	38
	All	15	27
Annual	1	20	36
	All	14	25

### Comparison with Hornsea Three assessments

#### **Gannet**

1.44 The original assessment for gannet (using Extended model outputs where available) presented in the RIAA (Document 5.2) calculated an annual in-combination collision risk total from Tier 1 projects of 119 collisions attributable to FFC pSPA. When collision risk estimates are corrected to account for as-built turbine scenarios this results in a 36% reduction to 76 collisions/annum. When Tier 2 projects are considered a reduction of 21% occurs with total collision risk reducing from 192 collisions/annum to 151 collisions/annum.

1.45 When using collision risk estimates calculated using the Basic Band model, a reduction of 31% occurs (131 collisions/annum to 91 collisions/annum) for the total from Tier 1 projects. A reduction of 25% occurs when collision risk estimates from Tier 2 projects are included (161 collisions/annum to 120 collisions/annum).

1.46 A total in-combination impact of 192 collisions/annum was predicted for the gannet population at FFC pSPA in the RIAA (Document 5.2). This was not considered to represent an adverse effect on site integrity and would not prevent the gannet population at FFC pSPA continuing to increase. The reductions calculated in this report therefore support this conclusion and provide evidence that the cumulative/in-combination assessments are, as a minimum, highly precautionary but in all likelihood overstate the overall impact.



1.47 Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) predicted a cumulative impact of minor or moderate significance based on impact magnitudes of 197, 626 and 321 collisions in the breeding, post-breeding and pre-breeding seasons respectively. The reductions in EIA terms identified in this report (Table 1.9) support the assertions in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) that the collision risk totals were precautionary.

**Kittiwake**

1.48 The original assessment for kittiwake (using Extended model outputs where available) presented in the RIAA (Document 5.2) calculated an annual in-combination collision risk total from Tier 1 project of 58 collisions attributable to FFC pSPA. When collision risk estimates are corrected to account for as-built turbine scenarios this results in a 33% to 39 collisions/annum. When Tier 2 projects are considered a reduction of 16% occurs with total collision risk reducing from 119 collisions/annum to 100 collisions/annum.

1.49 When using collision risk estimates calculated using the Basic Band model, a reduction of 38% occurs (99 collisions/annum to 61 collisions/annum) for the total from Tier 1 projects. A reduction of 15% occurs when collision risk estimates from Tier 2 projects are included (249 collisions/annum to 212 collisions/annum) with this reflecting the much larger contribution of Tier 2 projects to the overall in-combination collision risk total. However, as these projects are yet to be built, it has not been possible to account for any changes to turbine scenario.

1.50 A total in-combination impact of 119 collisions/annum was predicted for the kittiwake population at FFC pSPA in the RIAA (Document 5.2). This was not considered to represent an adverse effect on site integrity and would not prevent the kittiwake population at FFC pSPA continuing to increase. The reductions calculated in this report therefore support this conclusion and provide evidence that the cumulative/in-combination assessments are, as a minimum, highly precautionary but in all likelihood overstate the overall impact.

1.51 Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) predicted a cumulative impact of minor significance based on impact magnitudes of 148, 673 and 446 collisions in the breeding, post-breeding and pre-breeding seasons respectively. The reductions in EIA terms identified in this report (Table 1.12) support the assertions in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) that the collision risk totals were precautionary.

**Lesser black-backed gull**

1.52 The cumulative total for lesser black-backed gull calculated from the seasonal totals in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) (using Extended model outputs where available) was 390 collisions/annum when considering Tier 1 projects only. This reduces to 245 collisions/annum when as-built scenarios are taken into account, representing a 37% reduction. When Tier 2 projects are incorporated into the cumulative total a reduction of 33% occurs (439 collisions/annum to 296 collisions/annum).

1.53 When using collision risk estimates calculated using the Basic Band model, a reduction of 35% occurs (440 collisions/annum to 284 collisions/annum) for the total from Tier 1 projects. A reduction of 33% occurs when collision risk estimates from Tier 2 projects are included (484 collisions/annum to 325 collisions/annum).

- 1.54 Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) predicted a cumulative impact of moderate significance based on impact magnitudes of 153, 89, 140 and 57 collisions in the breeding, post-breeding, non-breeding and pre-breeding seasons respectively. The reductions identified in this report (Table 1.15) support the assertions in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) that the cumulative assessments are, as a minimum, highly precautionary but in all likelihood overstate the overall impact and potentially suggest that the significance of the potential cumulative impact is lower than assessed.

#### **Great black-backed gull**

- 1.55 The cumulative total for great black-backed gull calculated from Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) (using Extended model outputs where available) was 456 collisions/annum when considering Tier 1 projects only. This reduces to 364 collisions/annum when as-built scenarios are taken into account, representing a 20% reduction. When Tier 2 projects are incorporated into the cumulative total a reduction of 14% occurs (666 collisions/annum to 574 collisions/annum).
- 1.56 When using collision risk estimates calculated using the Basic Band model, a reduction of 36% occurs (551 collisions/annum to 351 collisions/annum) for the total from Tier 1 projects. A reduction of 25% occurs when collision risk estimates from Tier 2 projects are included (777 collisions/annum to 579 collisions/annum).
- 1.57 Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) predicted a cumulative impact of moderate significance based on impact magnitudes of 60 and 606 collisions in the breeding and non-breeding seasons respectively. The reductions identified in this report (Table 1.18) support the assertions in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) that the cumulative assessments are, as a minimum, highly precautionary but in all likelihood overstate the overall impact and potentially suggest that the significance of the potential cumulative impact is lower than assessed.

### **Discussion**

#### **Validity of correction factor approach**

- 1.58 The application of the correction factors in this report is to highlight a substantial area of over-estimation in cumulative and in-combination assessments. The approach presented in MacArthur Green (2017), using ratios of assessed and as-built turbine scenarios calculated using the Band (2012) CRM, is considered to provide a suitable methodology for which such over-estimation can be quantified. It is however, important to highlight that the application of correction factors does not provide exact estimates of collision risk with the actual number potentially higher or lower although this margin of 2 is considered to be negligible, especially in assessment terms likely representing less than one bird in most cases. The level of uncertainty associated with collision risk estimates calculated using these factors is considered to be significantly less than the differences associated with cumulative/in-combination totals calculated using assessed turbine scenarios.

- 1.59 For collision risk estimates calculated using the Basic Band model (Options 1 and 2) no correction has been applied to account for differences in turbine height which would affect the proportion of birds at collision height (PCH). This would potentially result in considerable reductions in collision risk estimates, where the lower rotor tip height has been raised. Many projects will have conducted collision risk modelling based on the minimum level of clearance required (i.e. 22 m above Highest Astronomical Tide) with this representing the worst case scenario and most likely the most economic design option. However, there are a number of projects where an increase in lower rotor height has been used to reduce collision risk estimates both as part of the application process and post-consent (e.g. Hornsea Project One).
- 1.60 Due to the variation in collision risk across the rotor swept area that forms part of the Extended Band model, the correction factors applied in this report are potentially unsuitable for projects for which collision risk estimates were calculated using the Extended Band model. This applies to only two projects (Beatrice and East Anglia One) with precaution required if the results from the Extended Band model for these two projects are to be considered.
- 1.61 Turbine parameters for both assessed and as-built turbine scenarios are often not reported as part of project-specific literature. Other sources of information (e.g. 4coffshore.com and turbine specifications from manufacturers) have been consulted where required, however some parameters have had to be estimated based on information provided at other projects that use the same turbine or expert judgement. The sources from which turbine parameters were obtained are clearly identified in Appendix A.

#### **Approach 1 projects**

- 1.62 Those projects for which Approach 1 (updated project-specific collision risk estimates) was considered applicable were:
- Beatrice;
  - Dogger Bank Creyke Beck A&B;
  - Dogger Bank Teesside A&B (now Dogger Bank Teesside A and Sofia);
  - Seagreen Alpha;
  - Seagreen Bravo;
  - Inch Cape;
  - Moray East;
  - Neart na Gaoithe; and
  - Thanet.
- 1.63 For a number of these projects, although updated collision risk estimates, representing the as-built/planned turbine scenario exist it was not considered appropriate to utilise these in assessment for Hornsea Three. This is applicable to all projects included in Approach 1 with the exception of Thanet which is an operational project which was built out to consented capacity.

1.64 The submission of a non-material amendment or an updated application indicates that a developer is giving serious consideration to a different turbine scenario, with these scenarios generally representing fewer, more powerful turbines that are likely to reduce installation costs. The projects identified for Approach 1 were consented in 2014 or 2015. Offshore wind farm technology has developed considerably since these projects were consented. The most recently constructed projects (e.g. Burbo Bank Extension and Walney Extension) have deployed 8 MW and 8.25 MW turbines respectively with an 8 MW turbine being the smallest turbine being considered as part of the Hornsea Three design envelope.

*Dogger Bank projects*

1.65 As discussed in paragraphs 1.18 to 1.19 the Dogger Bank Creyke Beck A&B and Sofia projects issued non-material amendments to the Secretary of State (BEIS) in June 2018 outlining a number of proposed changes. It is considered appropriate to consider the change to collision risk estimates that would occur if the proposed turbine scenarios included in the non-material amendments are ultimately constructed.

1.66 Collision risk modelling undertaken for gannet at Dogger Bank Creyke Beck A&B indicates that collision risk estimates will reduce by approximately 18-38% when using Option 1 and by 80-83% when using Option 3. For kittiwake, reductions of 32-48% and 36-63% were calculated when using Option 1 and Option 3 respectively. For the Sofia project, reductions of approximately 28-50% were calculated for gannet representing reductions of 9-28% for the collision risk estimates presented for Dogger Bank Teesside A and Sofia in Table 1.4. For kittiwake at Sofia, reductions of approximately 26-47% were calculated with this representing a 16-29% reduction for the collision risk estimate presented for Dogger Bank Teesside A and Sofia in Table 1.10.

1.67 The contribution of the Dogger Bank projects to total in-combination collision risk estimates are considerable for some species, representing up to 30% (using the Extended model) of the total for gannet and up to 45% (using the Basic model) of the total for kittiwake. The contribution of these projects to cumulative totals is also significant representing up to 22% for gannet (Extended model) and 39% for kittiwake (Basic). As such reductions of the magnitude described above would have a material effect on the conclusions drawn as part of the cumulative and in-combination assessments undertaken for Hornsea Three. Assessments should therefore include consideration of these reductions which are likely to occur as developers deploy fewer, larger turbine scenarios.

*Firth of Forth projects*

1.68 The collision risk estimates incorporated into the original assessments for Hornsea Three for Neart na Gaoithe, Inch Cape and Seagreen Alpha and Bravo represented the predicted collision risk for the consented turbine scenarios at each project. A correction factor was applied to the collision risk estimates for Neart na Gaoithe with this representing the difference in the number of turbines for the consented and planned turbine scenarios. Collision risk estimates calculated reflecting the revised design for each of the three projects are presented in the recently submitted consent applications.

- 1.69 For collision risk estimates incorporated into the cumulative assessment for gannet in Volume 2, Chapter 5: Offshore Ornithology, those for Neart na Gaoithe, Inch Cape and Seagreen reduce by approximately 66%, 68% and 51-56% respectively. The contribution of the Firth of Forth projects to total in-combination collision risk estimates can be significant, representing approximately 10-13% of the total for gannet using either the Extended or Basic model totals. The contribution of these projects to cumulative totals is also significant representing 30% (Extended model) to 33% (Basic model). As such reductions of the magnitude described above would have a material effect on the conclusions drawn as part of the cumulative and in-combination assessments undertaken for Hornsea Three.
- 1.70 For collision risk estimates incorporated into the cumulative assessment for kittiwake in Volume 2, Chapter 5: Offshore Ornithology, those for Neart na Gaoithe, Inch Cape and Seagreen reduce by approximately 50%, 76% and 16-53% respectively. The contribution of the Firth of Forth projects to total in-combination collision risk estimates can be significant, representing approximately 18-20% of the total for kittiwake using either the Basic or Extended model totals. The contribution of these projects to cumulative totals is also significant representing 25% (Basic model) to 28% (Extended model). As such reductions of the magnitude described above would have a material effect on the conclusions drawn as part of the cumulative and in-combination assessments undertaken for Hornsea Three.

#### **Further development**

- 1.71 For some projects presented in Table 1.3, the as-built or planned turbine scenarios represent turbine scenarios that do not reflect the maximum consented capacity or turbine number included in the relevant Marine Licences/consent decisions, that is to say less than the permitted capacity/number of turbines have been or will be deployed. It therefore remains legally possible even if unlikely practically for further development at projects where the as-built or planned turbine scenarios do not represent the maximum limits for the number of turbines or total capacity included in the relevant Marine Licence/consent decision. This is understood to be the main reason for reservations on the part of UK SNCBs to accept the use of collision risk estimates calculated for as-built turbine scenarios. The potential for future development at relevant projects is investigated in Table 1.19.

Table 1.19: Consideration of the potential for further development at projects considered cumulatively/in-combination with Hornsea Three

Project	Project status	As-built/planned turbine scenario	Permitted wind farm design		Potential for further development
			Number of turbines	Total capacity (MW)	
Aberdeen (European Offshore Wind Development Centre)	Partially operational	11 x 8.4 MW	11	100	No – permitted maximum number of turbines reached
Beatrice	Under construction	84 x 7 MW	125	750	Yes – as-built scenario capacity lower than that permitted
Dudgeon	Operational	67 x 6 MW	77	560	Yes – however, the CfD award for Dudgeon One was for 402 MW, equivalent to the as-built scenario. In addition, there are restrictions in the consent for Dudgeon in relation acceptable levels of Sandwich tern mortality
East Anglia One <sup>a</sup>	Under construction	102 x 7 MW	150 (HVAC option)	750 (HVAC option)	Yes – however the CfD award for East Anglia One was for 714 MW, equivalent to the as-built scenario
Galloper Wind Farm	Operational	56 x 6.3 MW	140	504	Yes – permitted number of turbines and total capacity higher than as-built scenario
Greater Gabbard Wind Farm	Operational	140 x 3.6 MW	140	500	No – total consented capacity and number of turbines reached
Humber Gateway	Operational	73 x 3 MW	83	300	Yes – permitted number of turbines and total capacity higher than as-built scenario

Project	Project status	As-built/planned turbine scenario	Permitted wind farm design		Potential for further development
Kentish Flats Extension	Operational	15 x 3.3 MW	-	51	No – with the turbine used, no further development would be possible (i.e. current total capacity is 49.5 MW and therefore another 3.3 MW turbine could not be constructed within consent limits)
Lincs	Operational	75 x 3.6 MW <sup>b</sup>	83	250	No – permitted total capacity reached
London Array	Operational	175 x 3.6 MW	341	1000	No - Marine Licence allows to 341 turbines and a total capacity of 1000 MW however, this is for a project in two phases. The first phases comprises 175 turbines with the second phase (London Array Phase 2) having been withdrawn
Moray East	Consented	100 x 9.5 MW	186	1116	Yes – permitted total capacity lower than planned, however CfD award for Moray East was 950 MW equivalent to planned scenario
Neart na Gaoithe	Consented	56 x 8 MW	75	450	Highly unlikely – As-built total capacity equals 448 MW with total permitted capacity of 450 MW
Race Bank	Operational	91 x 6.3 MW	Not defined	580	Highly unlikely – As-built total capacity equals 573.3 MW with total permitted capacity of 580 MW
Sheringham Shoal	Operational	88 x 3.6 MW	108	316.8	No – maximum permitted capacity reached
Teesside Offshore Wind Farm	Operational	27 x 2.3 MW	30	100	Yes – permitted number of turbines and total capacity higher than as-built scenario

Project	Project status	As-built/planned turbine scenario	Permitted wind farm design		Potential for further development
Triton Knoll	Consented	90 x 9.5 MW	90	900	No - permitted maximum number of turbines reached
Westermost Rough	Operational	35 x 6 MW	80	245	Yes – permitted number of turbines and total capacity higher than as-built scenario
<p>a The Marine Licence for East Anglia One included two design scenarios, one using HVAC technology and the other using HVDC technology. The wind farm has been built using HVAC technology and as such the wind farm scenario using this scenario has been presented here</p> <p>b Includes capacity and turbines at Lynn and Inner Dowsing</p>					



- 1.72 There is no capacity for further development at the following projects based on the information presented in Table 1.19:
- Aberdeen;
  - Greater Gabbard;
  - Kentish Flats Extension;
  - Lincs;
  - London Array;
  - Sheringham Shoal; and
  - Triton Knoll.
- 1.73 The corrected collision risk estimates calculated in this report should therefore be used as part of cumulative and in-combination assessments for Hornsea Three..
- 1.74 In addition to these projects, if further development were to occur at the remaining projects, there is unlikely to be any material increases in collision risk at the following projects as the as-built capacity is close to the consented capacity: East Anglia One (where only five additional turbines could potentially be installed), Race Bank (where only one additional turbine could be installed) and Westermost Rough (where only five additional turbines could be installed). This means that there are only five projects (Beatrice, Dudgeon, Galloper, Humber Gateway and Teesside) at which future development could occur with the potential for material increases in collision risk.
- 1.75 However, there are a number of reasons why it is considered unlikely that further development would occur:
- Construction cost; and
  - Contracts for Difference and economic viability;
- 1.76 The construction of an offshore wind farm requires the deployment of multiple resources including vessels, helicopters and personnel in addition to the production of wind farm components and the establishment of construction compounds to enable the transfer of materials to site. This is a costly process and one that is highly unlikely to be restarted when the economics of such an exercise are taken into account (i.e. the value of energy production from a few additional turbines may not outweigh the construction of these turbines). This is considered applicable to East Anglia One, Neart na Gaoithe, Race Bank and potentially Westermost Rough.
- 1.77 Contracts for Difference (CfDs) are the subsidy scheme used to support investment in low-carbon electricity generation. Projects awarded a CfD are paid a fixed 'strike price' for each unit of electricity produced. If wholesale electricity prices fall below the strike price, contracted schemes receive the difference as a top-up payment. This provides a project with stable revenue generation that ensures the project is financially viable. It is therefore unlikely that a project would exceed the capacity awarded as part of the CfD as this may not be economically viable. This is considered applicable to Dudgeon, East Anglia One and Moray East.

## **Use of updated estimates in Hornsea Three assessments**

### **Summary of approaches taken for projects considered cumulatively/in-combination**

- 1.78 Table 1.20 presents a summary of the approaches applied for those projects considered cumulatively/in-combination with Hornsea Three for which updated collision risk estimates are available. In addition, a summary of the potential for further development at relevant projects (i.e. those for which Approaches 2 and 3 were applied) is also included. This information is then used to identify those projects for which the updated collision risk estimates represent the worst case scenario and should therefore be incorporated into assessments for Hornsea Three taking into account the differences between assessed and as-built scenarios and the potential for further development at each project.
- 1.79 Following the summary presented in Table 1.20, the updated collision risk estimates considered to represent the worst case scenario, using both the Basic model and Extended model, where available are presented in Table 1.21 to Table 1.28 for each species in order to identify the precaution incorporated into the cumulative and in-combination assessments presented for Hornsea Three. The final column in each table (*'Change applied'*) indicates where either updated collision risk estimates are available or a correction factor has been applied for the relevant project. This therefore represents those projects for which collision risk estimates are different to those used in Volume 2, Chapter 5: Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Table 1.20: Summary of approaches applied for projects considered cumulatively/in-combination with Hornsea Three and the worst case scenario for each project.

Project	Summary of refinements to collision risk estimates in this report	Is future development possible (Approach 2 and 3)?	Do updated collision risk estimates represent the worst case scenario?
Aberdeen (European Offshore Wind Development Centre)	Approach 3 - Correction factor derived using as-built turbine scenario	No	Yes. Project is operational. No further development is possible.
Beatrice	Approach 1 - Updated collision risk estimates for the as-built scenario available As built turbine scenario uses fewer turbines	Yes	No. Collision risk estimates from (Marine Scotland, 2017) represent the as-built scenario and therefore provide an accurate representation of the likely collision risk associated with the project however, further development is possible and therefore these may represent an underestimate if further development occurs
Blyth Offshore-Demonstration Extension	Approach 4 - No updated information available	-	N/A
Dogger Bank Creyke Beck A & B	Approach 1 - Non-material amendment under consideration, consented scenario could still be constructed	-	No. Current collision risk estimates are considered to reflect the worst case scenario at the project. The developer is however, considering different turbine scenarios that would reduce collision risk
Dogger Bank Teesside A and Sofia	Approach 1 - Non-material amendment under consideration, consented scenario could still be constructed	-	No. Current collision risk estimates are considered to reflect the worst case scenario at the project. The developer is however, considering different turbine scenarios that would reduce collision risk

Project	Summary of refinements to collision risk estimates in this report	Is future development possible (Approach 2 and 3)?	Do updated collision risk estimates represent the worst case scenario?
Dudgeon	Approach 2 - Correction factor from MacArthur Green (2017) applied As built turbine scenario uses fewer, higher capacity turbines	Yes, however future development considered unlikely as operational capacity equals CfD award and project is restricted by Sandwich tern mortality	Yes. Project is operational and updated collision risk estimates represent the as-built scenario and therefore provide an accurate representation of the likely collision risk associated with the project. Further development is considered to be unlikely.
East Anglia One	Approach 3 - Correction factor derived using as-built turbine scenario As built turbine scenario uses fewer, higher capacity turbines	Yes, however future development considered unlikely as operational capacity equals CfD award	Yes. Project is operational and updated collision risk estimates represent the as-built scenario and therefore provide an accurate representation of the likely collision risk associated with the project. Further development is considered to be unlikely.
East Anglia Three	Approach 4 - No change to consented turbine scenario	-	N/A
Seagreen Alpha	Approach 1 - None	-	New application submitted in 2018, however original consent still valid and therefore any changes in the new application should only be considered qualitatively
Seagreen Bravo	Approach 1 - None	-	New application submitted in 2018, however original consent still valid and therefore any changes in the new application should only be considered qualitatively
Galloper Wind Farm	Approach 2 - Correction factor from MacArthur Green (2017) applied As built turbine scenario uses fewer, higher capacity turbines	Yes	No. Updated collision risk estimates derived using the correction factor are considered to provide an accurate representation of the as-built scenario however, further development is possible

Project	Summary of refinements to collision risk estimates in this report	Is future development possible (Approach 2 and 3)?	Do updated collision risk estimates represent the worst case scenario?
Greater Gabbard Wind Farm	Approach 3 - Correction factor derived using as-built turbine scenario As-built turbine scenario has different parameters	No	Yes. Project is operational. No further development is possible.
Hornsea 1	Approach 4 - None	-	N/A
Hornsea 2	Approach 4 - No updated information available	-	N/A
Humber Gateway	Approach 2 - Correction factor from MacArthur Green (2017) applied As built turbine scenario uses fewer, lower capacity turbines	Yes	No. Updated collision risk estimates derived using the correction factor are considered to provide an accurate representation of the as-built scenario however, further development is possible
Hywind	Approach 4 - None	-	N/A
Inch Cape	Approach 1 - None	-	New application submitted in 2018, however original consent still valid and therefore any changes in the new application should only be considered qualitatively
Kentish Flats Extension	Approach 2 - Correction factor from MacArthur Green (2017) applied As built turbine scenario uses fewer, higher capacity turbines	No	Yes. Project is operational. No further development is possible.
Kincardine	Approach 4 - None	-	N/A

Project	Summary of refinements to collision risk estimates in this report	Is future development possible (Approach 2 and 3)?	Do updated collision risk estimates represent the worst case scenario?
Lincs	Approach 2 - Correction factor from MacArthur Green (2017) applied As built turbine scenario uses fewer, higher capacity turbines	No	Yes. Project is operational. No further development is possible.
London Array	Approach 3 - Correction factor derived using as-built turbine scenario As built turbine scenario uses fewer, higher capacity turbines	No	Yes. Project is operational. No further development is possible.
Methil	Approach 4 - None	-	N/A
Moray East	Approach 1 - Updated collision risk estimates for the as-built scenario available	Yes, however future development considered unlikely as operational capacity equals CfD award	Yes. Collision risk estimates from (Marine Scotland, 2017) represent the as-built scenario and therefore provide an accurate representation of the likely collision risk associated with the project. Further development is considered to be unlikely.
Near na Gaoithe	Approach 1 - Updated collision risk estimates for the as-built scenario available	No	Yes. Collision risk estimates from (Mainstream Renewable Power, 2015) represent the proposed as-built scenario and therefore provide an accurate representation of the likely collision risk associated with the project.
	Approach 3 - Correction factor derived using as-built turbine scenario As built turbine scenario uses fewer, higher capacity turbines	No	Yes. Collision risk estimates derived using the correction factor are considered to provide an accurate representation of the likely collision risk associated with the project.

Project	Summary of refinements to collision risk estimates in this report	Is future development possible (Approach 2 and 3)?	Do updated collision risk estimates represent the worst case scenario?
Race Bank	Approach 2 - Correction factor from MacArthur Green (2017) applied As built turbine scenario uses fewer, higher capacity turbines	Considered to be highly unlikely as operational capacity (573.3 MW) is close to consented capacity (580 MW)	Yes. Project is operational. No further development is possible.
Sheringham Shoal	Approach 2 - Correction factor from MacArthur Green (2017) applied As built turbine scenario uses fewer, higher capacity turbines	No	Yes. Project is operational. No further development is possible.
Teesside Offshore Wind Farm	Approach 2 - Correction factor from MacArthur Green (2017) applied As built turbine scenario uses fewer turbines	Yes	No. Updated collision risk estimates derived using the correction factor are considered to provide an accurate representation of the as-built scenario however, further development is possible
Thanet	Approach 1 - None	--	N/A
Triton Knoll	Approach 3 - Correction factor derived using as-built turbine scenario As built turbine scenario uses fewer, higher capacity turbines	No	Yes. Collision risk estimates derived using the correction factor are considered to provide an accurate representation of the likely collision risk associated with the project. No further development is possible with proposed as-built scenario
Westernmost Rough	Approach 2 - Correction factor from MacArthur Green (2017) applied As built turbine scenario uses fewer, higher capacity turbines	Yes	No. Updated collision risk estimates derived using the correction factor are considered to provide an accurate representation of the as-built scenario however, further development is possible

Table 1.21: Seasonal breakdown of predicted cumulative/in-combination collision mortality using results from the Extended Band model, where available, for gannet.

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
			No. of collisions	Apportioning	pSPA collisions	No. of collisions	Apportioning	pSPA collisions	No. of collisions	Apportioning	pSPA collisions	
Hornsea Three	3	98	7	40	3	5	4.8	0	3	6.2	0	None
Tier 1												
Aberdeen European Offshore Wind Deployment Centre	2	98.9				6	4.8	0	0	6.2	0	Yes
Beatrice	3	98				19	4.8	1	4	6.2	0	None
Blyth Demonstration Project	1	98.9	4	100	4	2	4.8	0	3	6.2	0	None
Dudgeon	1	98.9	10	100	10	18	4.8	1	9	6.2	1	Yes
East Anglia One	3	98				36	4.8	2	2	6.2	0	Yes
Galloper	1	98.9				28	4.8	1	11	6.2	1	None
Greater Gabbard	1	98.9				8	4.8	0	9	6.2	1	Yes
Hornsea Project One	4	98	1	72	0	2	4.8	0	1	6.2	0	None
Hornsea Project Two	4	98	5	72	4	9	4.8	0	4	6.2	0	None
Humber Gateway	1	98.9	2	100	2	1	4.8	0	1	6.2	0	None
Hywind	1	98.9				2	4.8	0	2	6.2	0	None



Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
Kentish Flats Extension	1	98.9				0	4.8	0	0	6.2	0	Yes
Lincs	1	98.9	2	100	2	1	4.8	0	2	6.2	0	Yes
London Array	1	98.9				1	4.8	0	0	6.2	0	Yes
Moray Firth Project One (MORL)	3	98				9	4.8	0	2	6.2	0	Yes
Near na Gaoithe	1	98.9				28	4.8	1	13	6.2	1	Yes
Race Bank	1	98.9	18	100	18	6	4.8	0	2	6.2	0	Yes
Sheringham Shoal	1	98.9	14	100	14	3	4.8	0	0	6.2	0	Yes
Teesside	1	98.9	5	100	5	2	4.8	0	0	6.2	0	None
Thanet	1	98.9				0	4.8	0	0	6.2	0	None
Triton Knoll	1	98.9	5	100	5	21	4.8	1	13	6.2	1	Yes
Westermost Rough	1	98.9	0	100	0	0	4.8	0	0	6.2	0	None
Tier 1 total			73		67	208		10	82		5	
Tier 2												
Dogger Bank Creyke Beck A and B	3	98	41	50	20	48	4.8	2	32	6.2	2	None
Dogger Bank Teesside A and B	3	98	56	50	28	39	4.8	2	41	6.2	3	None

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
East Anglia Three	3	98				33	4.8	2	10	6.2	1	None
Inch Cape	1	98.9				29	4.8	1	5	6.2	0	None
Kincardine	3	98				13	4.8	1	0	6.2	0	None
Methil	Unknown	98.9				0	4.8	0	0	6.2	0	None
Seagreen Alpha	3	98				91	4.8	4	33	6.2	2	None
Seagreen Bravo	3	98				64	4.8	3	37	6.2	2	None
Tier 2 total			97		48	317		15	158		10	
Overall total			170		115	525		25	241		15	

Table 1.22: Seasonal breakdown of predicted cumulative/in-combination collision mortality using results from the Basic Band model for gannet.

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
			No. of collisions	Apportioning	pSPA collisions	No. of collisions	Apportioning	pSPA collisions	No. of collisions	Apportioning	pSPA collisions	
Hornsea Three	2	98.9	18	40	7	12	4.8	1	8	6.2	0	None
Tier 1												
Aberdeen European Offshore Wind Deployment Centre	2	98.9				6	4.8	0	0	6.2	0	Yes
Beatrice	1	98.9				44	4.8	2	10	6.2	1	None
Blyth Demonstration Project	1	98.9	4	100	4	2	4.8	0	3	6.2	0	None
Dudgeon	1	98.9	10	100	10	18	4.8	1	9	6.2	1	Yes
East Anglia One	2	98.9				71	4.8	3	4	6.2	0	Yes
Galloper	1	98.9				28	4.8	1	11	6.2	1	None
Greater Gabbard	1	98.9				8	4.8	0	9	6.2	1	Yes
Hornsea Project One	1	98.9	1	72	1	3	4.8	0	2	6.2	0	None
Hornsea Project Two	2	98.9	7	72	5	14	4.8	1	6	6.2	0	None
Humber Gateway	1	98.9	2	100	2	1	4.8	0	1	6.2	0	None
Hywind	1	98.9				2	4.8	0	2	6.2	0	None

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
Kentish Flats Extension	1	98.9				0	4.8	0	0	6.2	0	Yes
Lincs	1	98.9	2	100	2	1	4.8	0	2	6.2	0	Yes
London Array	1	98.9				1	4.8	0	0	6.2	0	Yes
Moray Firth Project One (MORL)	1	98.9				24	4.8	1	11	6.2	1	Yes
Near na Gaoithe	1	98.9				48	4.8	2	24	6.2	1	Yes
Race Bank	1	98.9	18	100	18	6	4.8	0	2	6.2	0	Yes
Sheringham Shoal	1	98.9	14	100	14	3	4.8	0	0	6.2	0	Yes
Teesside	1	98.9	5	100	5	2	4.8	0	0	6.2	0	None
Thanet	1	98.9				0	4.8	0	0	6.2	0	None
Triton Knoll	1	98.9	5	100	5	21	4.8	1	13	6.2	1	Yes
Westermost Rough	1	98.9	0	100	0	0	4.8	0	0	6.2	0	None
Tier 1 total			86		73	315		15	117		7	
Tier 2												
Dogger Bank Creyke Beck A and B	2	98.9	6	50	3	7	4.8	0	4	6.2	0	None
Dogger Bank Teesside A and B	2	98.9	15	50	7	10	4.8	0	11	6.2	1	None

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
East Anglia Three	1	98.9				38	4.8	2	11	6.2	1	None
Inch Cape	1	98.9				29	4.8	1	5	6.2	0	None
Kincardine	1	98.9				8	4.8	0	1	6.2	0	None
Methil	1	98.9				0	4.8	0	0	6.2	0	None
Seagreen Alpha	1	98.9				71	4.8	5	40	6.2	2	None
Seagreen Bravo	1	98.9				101	4.8	3	37	6.2	2	None
Tier 2 total			20		10	264		13	109		7	
Overall total			106		83	578		28	226		14	

Table 1.23: Seasonal breakdown of predicted cumulative/in-combination collision mortality using results from the Extended Band model, where available, for kittiwake.

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
			No. of collisions	Apportioning	pSPA collisions	No. of collisions	Apportioning	pSPA collisions	No. of collisions	Apportioning	pSPA collisions	
Hornsea Three	3	98	42	41.7	18	26	5.4	1	14	7.2	1	None
Tier 1												
Aberdeen European Offshore Wind Deployment Centre	2	99.2				5	5.4	0	0	7.2	0	Yes
Beatrice	3	98				2	5.4	0	2	7.2	0	None
Blyth Demonstration Project	1	99.2				2	5.4	0	1	7.2	0	None
East Anglia One	3	98				9	5.4	0	3	7.2	3	Yes
Galloper	1	99.2				20	5.4	1	20	7.2	1	None
Greater Gabbard	1	99.2				6	5.4	0	13	7.2	1	Yes
Hornsea Project One	4	98	1	83	1	1	5.4	0	0	7.2	0	None
Hornsea Project Two	4	98	2	83	2	1	5.4	0	0	7.2	0	None
Humber Gateway	1	99.2	2	100	2	2	5.4	0	1	7.2	0	None
Hywind	1	99.2				2	5.4	0	0	7.2	0	None

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
Kentish Flats Extension	1	99.2				1	5.4	0	0	7.2	0	Yes
Lincs	1	99.2	1	100	1	1	5.4	0	1	7.2	0	Yes
London Array	1	99.2				1	5.4	0	1	7.2	0	Yes
Moray Firth Project One (MORL)	3	98				4	5.4	0	12	7.2	1	Yes
Near na Gaoithe	1	99.2				8	5.4	0	1	7.2	0	Yes
Race Bank	1	99.2	1	100	1	10	5.4	1	2	7.2	0	Yes
Teesside	1	99.2				18	5.4	1	2	7.2	0	None
Thanet	1	99.2				0	5.4	0	0	7.2	0	None
Triton Knoll	1	99.2	4	100	4	29	5.4	2	16	7.2	1	Yes
Westermost Rough	2	99.2	0	100	0	0	5.4	0	0	7.2	0	None
Tier 1 total			52		27	147		8	90		6	
Tier 2												
Dogger Bank Creyke Beck A and B	3	98	87	16.8	15	41	5.4	2	90	7.2	6	None
Dogger Bank Teesside A and B	3	98				28	5.4	2	66	7.2	5	None
East Anglia Three	3	98				54	5.4	3	25	7.2	2	None
Inch Cape	1	99.2				163	5.4	9	45	7.2	3	None

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
Kincardine	4	98				25	5.4	1	3	7.2	0	None
Methil	1	99.2				0	5.4	0	0	7.2	0	None
Seagreen Alpha	3	98				79	5.4	4	52	7.2	4	None
Seagreen Bravo	3	98				50	5.4	3	30	7.2	2	None
Tier 2 total			87		15	441		24	312		22	
Overall total			139		42	588		32	402		29	



Table 1.24: Seasonal breakdown of predicted cumulative/in-combination collision mortality using results from the Basic Band model for kittiwake.

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
			No. of collisions	Apportioning	pSPA collisions	No. of collisions	Apportioning	pSPA collisions	No. of collisions	Apportioning	pSPA collisions	
Hornsea Three	1	98.9	23	41.7	10	14	5.4	1	8	7.2	1	None
Tier 1												
Aberdeen European Offshore Wind Deployment Centre	2	98.9				7	5.4	0	1	7.2	0	Yes
Beatrice	1	98.9				6	5.4	0	6	7.2	0	None
Blyth Demonstration Project	1	98.9				2	5.4	0	1	7.2	0	None
East Anglia One	2	98.9				159	5.4	9	56	7.2	4	Yes
Galloper	1	98.9				28	5.4	2	27	7.2	2	None
Greater Gabbard	1	98.9				8	5.4	0	18	7.2	1	Yes
Hornsea Project One	1	98.9	3	83	2	3	5.4	0	1	7.2	0	None
Hornsea Project Two	1	98.9	16	83	14	9	5.4	0	3	7.2	0	None
Humber Gateway	1	98.9	2	100	2	3	5.4	0	2	7.2	0	None
Hywind	1	98.9				2	5.4	0	0	7.2	0	None

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
Kentish Flats Extension	1	98.9				1	5.4	0	0	7.2	0	Yes
Lincs	1	98.9	1	100	1	1	5.4	0	1	7.2	0	Yes
London Array	1	98.9				1	5.4	0	1	7.2	0	Yes
Moray Firth Project One (MORL)	1	98.9				4	5.4	0	11	7.2	1	Yes
Neart na Gaoithe	1	98.9				27	5.4	1	2	7.2	0	Yes
Race Bank	1	98.9	1	100	1	14	5.4	1	3	7.2	0	Yes
Teesside	1	98.9				25	5.4	1	3	7.2	0	None
Thanet	1	98.9				0	5.4	0	0	7.2	0	None
Triton Knoll	1	98.9	5	100	5	40	5.4	2	22	7.2	2	Yes
Westermost Rough	1	98.9	0	100	0	0	5.4	0	0	7.2	0	None
Tier 1 total			52		35	354		19	166		12	
Tier 2												
Dogger Bank Creyke Beck A and B	2	98.9	288	16.8	48	135	5.4	7	295	7.2	21	None
Dogger Bank Teesside A and B	2	98.9				91	5.4	5	217	7.2	16	None
East Anglia Three	1	98.9				64	5.4	3	31	7.2	2	None

Project	Option	Avoidance rate	Breeding season			Post-breeding season			Pre-breeding season			Change applied
Inch Cape	1	98.9				225	5.4	12	63	7.2	4	None
Kincardine	2	98.9				8	5.4	0	1	7.2	0	None
Methil	Unknown	98.9				0	5.4	0	0	7.2	0	None
Seagreen Alpha	1	98.9				171	5.4	9	112	7.2	8	None
Seagreen Bravo	1	98.9				142	5.4	8	85	7.2	6	None
Tier 2 total			288		48	837		46	804		58	
Overall total			338		81	1191		65	969		70	

Table 1.25: Seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for lesser black-backed gull.

Project	Option	Avoidance rate	Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season	Change applied
Hornsea Three	3	98.9	10	1	0	1	None
Tier 1							
Dudgeon	1	99.5	4	3	4	2	Yes
East Anglia One	3	98.9	4	3	17	0	Yes
Galloper	1	99.5	63	24	31	22	None
Greater Gabbard	1	99.5	12	13	23	14	Yes
Hornsea Project One	4	98.9	5	2	1	1	None
Hornsea Project Two	4	98.9	0	0	0	0	None
Humber Gateway	1	98.9	0	0	1	0	None
Kentish Flats Extension	1	98.9	0	0	0	0	Yes
Lincs	1	98.9	2	2	3	2	Yes
Nearr na Gaoithe	1	98.9		0	0	0	Yes
Race Bank	1	98.9	6	8	15	1	Yes
Sheringham Shoal	1	98.9	6	1	0	1	Yes
Thanet	1	98.9	2	2	1	0	None
Triton Knoll	1	98.9	5	1	3	1	Yes
Westermost Rough	1	98.9	0	0	0	0	None
Tier 1 total			120	62	99	44	
Tier 2							

Project	Option	Avoidance rate	Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season	Change applied
Dogger Bank Creyke Beck A and B	3	98	12	1	1	4	None
Dogger Bank Teesside A and B	3	98		8	5	0	None
East Anglia Three	3	98	2	5	2	1	None
Seagreen Alpha	3	98		1	2	1	None
Seagreen Bravo	3	98		0	1	4	None
Tier 2 total			14	16	9	10	
Overall total			135	78	108	54	

Table 1.26: Seasonal breakdown of predicted cumulative collision mortality using results from the Basic Band model for lesser black-backed gull.

Project	Option	Avoidance rate	Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season	Change applied
Hornsea Three	2	99.5	15	2	0	1	None
Tier 1							
Dudgeon	1	99.5	4	3	4	2	Yes
East Anglia One	1	99.5	6	6	28	0	Yes
Galloper	1	99.5	63	24	31	22	None
Greater Gabbard	1	99.5	12	13	23	14	Yes
Hornsea Project One	2	99.5	12	5	2	2	None
Hornsea Project Two	2	99.5	2	1	0	1	None
Humber Gateway	1	99.5	0	0	1	0	None
Kentish Flats Extension	1	99.5	0	0	0	0	Yes
Lincs	1	99.5	2	2	3	2	Yes
Near na Gaoithe	1	99.5		0	0	0	Yes
Race Bank	1	99.5	6	8	15	1	Yes
Sheringham Shoal	1	99.5	6	1	0	1	Yes
Thanet	1	99.5	2	2	1	0	None
Triton Knoll	1	99.5	5	1	3	1	Yes
Westermost Rough	1	99.5	0	0	0	0	None
Tier 1 total			137	68	112	46	

Project	Option	Avoidance rate	Breeding season	Post-breeding season	Non-breeding season	Pre-breeding season	Change applied
Tier 2							
Dogger Bank Creyke Beck A and B	2	99.5	9	1	0	3	None
Dogger Bank Teesside A and B	2	99.5		5	3	0	None
East Anglia Three	1	99.5	4	11	4	2	None
Seagreen Alpha	2	99.5		1	1	0	None
Seagreen Bravo	2	99.5		0	0	1	None
Tier 2 total			12	18	8	6	
Overall total			145	87	120	52	

Table 1.27: Seasonal breakdown of predicted cumulative collision mortality using results from the Extended Band model, where available, for great black-backed gull.

Project	Option	Avoidance rate	Breeding season	Non-breeding season	Change applied
Hornsea Three	3	98.9	12	40	None
Tier 1					
Aberdeen European Offshore Wind Deployment Centre	2	99.5	0	3	Yes
Beatrice	3	98.9	5	54	None
Blyth Demonstration Project	1	99.5	2	6	None
East Anglia One	3	98.9	0	26	Yes
Galloper	1	99.5	0	22	None
Hornsea Project One	4	98.9	5	44	None
Hornsea Project Two	4	98.9	1	9	None
Humber Gateway	1	99.5	2	5	None
Hywind	1	99.5	0	5	None
Kentish Flats Extension	1	99.5	0	0	Yes
Moray Firth Project One (MORL)	3	98.9	10	18	Yes
Near na Gaoithe	1	99.5	0	3	Yes
Teesside	1	99.5	3	41	None
Thanet	1	99.5	0	0	None
Triton Knoll	1	99.5	3	36	Yes
Westermost Rough	1	99.5	0	0	None
Tier 1 total			44	312	



Project	Option	Avoidance rate	Breeding season	Non-breeding season	Change applied
Tier 2					
Dogger Bank Creyke Beck A and B	3	98.9	2	27	None
Dogger Bank Teesside A and B	3	98.9	3	29	None
East Anglia Three	3	98.9	2	43	None
Inch Cape	1	99.5	0	37	None
Seagreen Alpha	2	99.5	1	36	None
Seagreen Bravo	2	99.5	3	27	None
Tier 2 total			11	198	
Overall total			55	510	

Table 1.28: Seasonal breakdown of predicted cumulative collision mortality using results from the Basic Band model for great-black-backed gull.

Project	Option	Avoidance rate	Breeding season	Non-breeding season	Change applied
Hornsea Three	1	99.5	16	50	None
Tier 1					
Aberdeen European Offshore Wind Deployment Centre	1	99.5	0	3	Yes
Beatrice	1	99.5	6	62	None
Blyth Demonstration Project	1	99.5	2	6	None
East Anglia One	2	99.5	1	51	Yes
Galloper	1	99.5	0	22	None
Hornsea Project One	2	99.5	7	61	None
Hornsea Project Two	2	99.5	3	20	None
Humber Gateway	1	99.5	2	5	None
Hywind	1	99.5	0	5	None
Kentish Flats Extension	1	99.5	0	0	Yes
Moray Firth Project One (MORL)	1	99.5	11	20	Yes
Nearr na Gaoithe	1	99.5	0	4	Yes
Teesside	1	99.5	3	41	None
Thanet	1	99.5	0	0	None
Triton Knoll	1	99.5	3	36	Yes
Westermost Rough	1	99.5	0	0	None
Tier 1 total			53	387	

Project	Option	Avoidance rate	Breeding season	Non-breeding season	Change applied
Tier 2					
Dogger Bank Creyke Beck A and B	2	99.5	2	30	None
Dogger Bank Teesside A and B	2	99.5	4	33	None
East Anglia Three	1	99.5	3	52	None
Inch Cape	1	99.5	0	37	None
Seagreen Alpha	2	99.5	1	36	None
Seagreen Bravo	2	99.5	3	27	None
Tier 2 total			13	215	
Overall total			66	602	

## 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).
- Banks, A.N., Maclean, I.M.D., Burton, N.H.K., Austin, G.E., Carter, N., Chamberlain, D.E., Holt, C. and Rehfish, M.M. (2006). *The Potential Effects on Birds of the Greater Gabbard Offshore Wind Farm Report for February 2004 to April 2006*. Thetford: British Trust for Ornithology.
- ECON (2010). Update to the ornithological assessment of the Dudgeon Offshore Wind Farm with 2009 survey data: Technical Report. Dudgeon Offshore Wind Ltd.
- ERM, East Anglia Offshore Wind Limited and APEM Limited (2012). *East Anglia ONE Offshore Windfarm Environmental Statement Volume 2 Offshore Chapter 12 Ornithology Marine and Coastal*. [Online]. Available at: <https://infrastructure.planninginspectorate.gov.uk/projects/eastern/east-anglia-one-offshore-windfarm/?ipcsection=docs> (Accessed August 2018).
- Fijn, R.C., Collier, M.P., Jonkvorst, R.J., Japink, M. and Poot, M.J.M. (2012). *Population, density and collision rate estimates of seabirds at Neart na Gaoithe*. Culmeborg: Bureau Waardenburg.
- Furness, R.W., Garthe, S., Trinder, M., Matthiopoulos, J., Wanless, S. and Jeglinski, J. (2018). Nocturnal flight activity of northern gannets *Morus bassanus* and implications for modelling collision risk at offshore wind farms. *Environmental Impact Assessment Review*. 73, pp. 1-6.
- Genesis (2012). *Aberdeen Offshore Wind Farm Ornithological Baseline and Impact Assessment Addendum*. [Online]. Available at: <http://marine.gov.scot/datafiles/lot/eowdc/ES%20addendum/Addendum/Vol%20%20Addendum/> (Accessed August 2018).
- JNCC, Natural England, Natural Resources Wales, Northern Ireland Environment Agency and Scottish Natural Heritage (2014). Joint Response from the Statutory Nature Conservation Bodies to the Marine Scotland Science Avoidance Rate Review.
- MacArthur Green (2017). *Estimates of Ornithological Headroom in Offshore Wind Farm Collision Mortality*. The Crown Estate.
- Mainstream Renewable Power (2015). *Neart na Gaoithe Offshore Wind Farm. Electricity Act 1989 – Section 36 Consent Variation. Supporting Environmental Information*. [Online]. Available at: <https://www.gov.scot/Topics/marine/Licensing/marine/scoping/Mainstream-NeartnaGaoithe/supporting-information> (Accessed August 2018).
- Marine Scotland, 2017. Marine Scotland - Licensing Operations Team Scoping Opinion Addendum: Ornithology. [Online]. Available at: <https://www.gov.scot/Resource/0052/00521151.pdf> (Accessed Oct 2018).

Natural England (2015). *Written Submission for Deadline 3: Appendix 2*. [Online]. Available at: <https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs> (Accessed August 2018).

RPS (2005). *Environmental Statement Volume 1: Offshore Works*. Coventry: London Array Limited.

RWE npower renewables (2011). *Triton Knoll Offshore Wind Farm. ES Volume 3 (Annex H)*. Swindon: Triton Knoll Offshore Wind Farm Limited.

Siemens (2015a). *Wind Turbine SWT-3.6-107. Technical Specifications*. [Online]. Available at: [https://www.siemens.com/content/dam/internet/siemens-com/global/market-specific-solutions/wind/data\\_sheets/data-sheet-wind-turbine-swt-3-6-107.pdf](https://www.siemens.com/content/dam/internet/siemens-com/global/market-specific-solutions/wind/data_sheets/data-sheet-wind-turbine-swt-3-6-107.pdf) (Accessed August 2018).

Siemens (2015b). *Wind Turbine SWT-3.6-120. Technical Specifications*. [Online]. Available at: [https://www.siemens.com/content/dam/internet/siemens-com/global/market-specific-solutions/wind/data\\_sheets/data-sheet-wind-turbine-swt-3-6-120.pdf](https://www.siemens.com/content/dam/internet/siemens-com/global/market-specific-solutions/wind/data_sheets/data-sheet-wind-turbine-swt-3-6-120.pdf) (Accessed August 2018).

Siemens (2016). *Wind Turbine SWT-7.0-154. Technical Specifications*. [Online]. Available at: [https://www.siemens.com/content/dam/internet/siemens-com/global/market-specific-solutions/wind/data\\_sheets/data-sheet-wind-turbine-swt-7.0-154.pdf](https://www.siemens.com/content/dam/internet/siemens-com/global/market-specific-solutions/wind/data_sheets/data-sheet-wind-turbine-swt-7.0-154.pdf) (Accessed August 2018).

Skov, H., Heinanen, S., Norman, T., Ward, R.M., Mendez-Roldan, S. & Ellis, I. 2018. *ORJIP Bird Collision and Avoidance Study. Final report – April 2018*. The Carbon Trust. United Kingdom. 247 pp.

SmartWind (2015). *Clarification Note – Apportioning of predicted kittiwake mortality to the Flamborough and Filey Coast pSPA population*. [Online]. Available at: <https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/hornsea-offshore-wind-farm-zone-4-project-two/?ipcsection=docs> (Accessed August 2018).

Vestas (2011). *V164 8.0 MW*. [Online]. Available at: [http://www.homepages.ucl.ac.uk/~uceseug/Fluids2/Wind\\_Turbines/Turbines/V164-8MW.pdf](http://www.homepages.ucl.ac.uk/~uceseug/Fluids2/Wind_Turbines/Turbines/V164-8MW.pdf) (Accessed August 2018).

## Appendix A Turbine parameters for projects considered cumulatively/in-combination

Table 1.29: Turbine parameters for projects considered cumulatively/in-combination for which a correction factor was derived (Approach 3). Parameters that were not available are italicised with footnotes outlining how these were obtained

Project	Assessed turbine scenario						As-built turbine scenario					
	No. of turbines	Rotor radius	Rotor speed (rpm)	Max blade width (m)	Pitch (°)	Source	No. of turbines	Rotor radius	Rotor speed (rpm)	Max blade width (m)	Pitch (°)	Source
Aberdeen	11	83.5	6.05	5.4	15	Genesis (2012)	11	82	10.5	5.4	4.3 <sup>a</sup>	Vestas (2011)
East Anglia One	325	60	9.72	4.2	10	ERM <i>et al.</i> (2012)	102	77	13	4.98 <sup>c</sup>	6	Siemens (2016)
Greater Gabbard	140	75	97	14	2	Banks <i>et al.</i> (2006)	140	53.5	13	4.2	6	Siemens (2015a)
London Array	271	75	18.4	5	15	RPS (2005)	175	60	13	4.2	6	Siemens (2015b)
Neart na Gaoithe	128	60	13	4.2	15	Fijn <i>et al.</i> (2012)	75	77	8	5	15	Mainstream Renewable Power (2015)
Triton Knoll	288	62.5	9.47	5.45	6	RWE npower renewables (2011)	90	82	9.2	5.4	4	Vestas (2011) <sup>d</sup>

Project	Assessed turbine scenario	As-built turbine scenario
a	Based on similar turbine proposed for Hornsea Three	
b	Based on generic 7 MW turbine (i.e. that used for Aberdeen as-built scenario)	
c	Using the same turbine as Beatrice and therefore same max blade width assumed	
d	It has been advised by the Orsted technical team that in the absence of parameters for the 9.5 MW turbine, the parameters for the 8.0 MW turbine should be used	