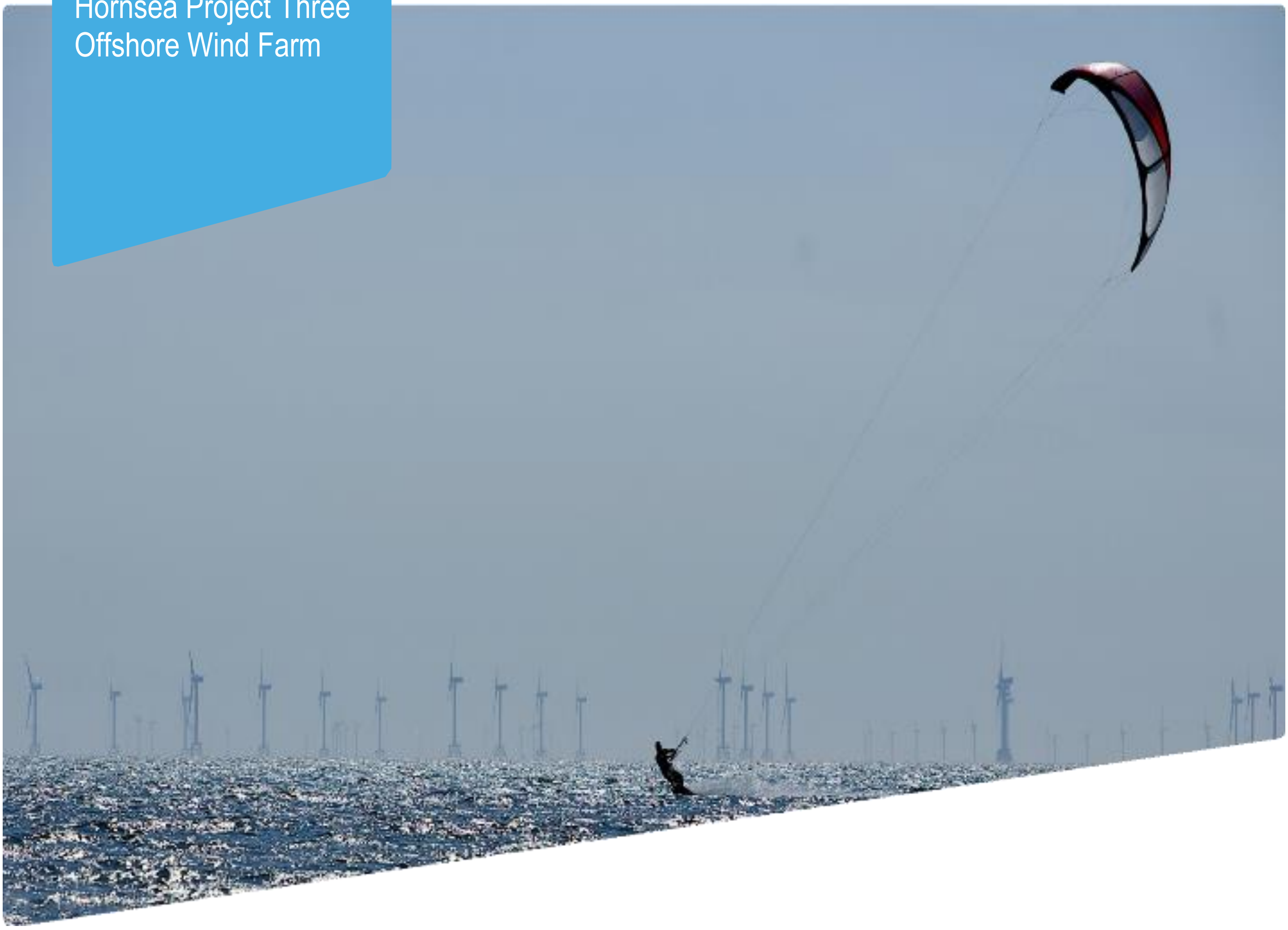
Hornsea Project Three
Offshore Wind Farm



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Appendix 8 to Deadline I submission – Baseline Characterisation Sensitivity Testing Clarification Note

Date: 7th November 2018

Hornsea 3
Offshore Wind Farm

Ørsted

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Front cover picture: Kite surfer near a UK offshore wind farm © Ørsted Hornsea Project Three (UK) Ltd., 2018.

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1. Baseline Characterisation Sensitivity Testing

Introduction

1.1 Aerial surveys of Hornsea Three have been undertaken to provide data to characterise the baseline environment (as it relates to seabirds). Surveys were completed for twenty months (April 2016 to November 2017) meaning that, for eight months of the year, there are data from two consecutive years. For the remaining four months (December to March), that represent the non-breeding period for all but one of the key species, a single year of data was collected with assessments undertaken for Hornsea Three indicated that these months do not contribute a significant proportion of the total annual impact (8% for gannet and 3% for kittiwake, for example).

1.2 The former Hornsea Zone is one of the most surveyed offshore areas around the UK coast. So, in addition to the aerial surveys specifically conducted for Hornsea Three, there are also data available from the extensive programme of boat-based surveys conducted between March 2010 and February 2013 to support the application processes for the Hornsea Project One and Hornsea Project Two offshore wind farms. Some of these surveys included the Hornsea Three area.

1.3 The primary reason for aiming to collect multiple years of data from a site is to reflect the variability inherent in the distribution and abundance of seabird populations. In those months for which only one year of aerial surveys was undertaken it was proposed that a 'meta-analysis' of existing data collected within the former Hornsea Zone be conducted. The use of a meta-analysis was first proposed by Natural England with both Natural England and the RSPB providing input on the scope of the meta-analysis and the methodologies to be employed as part of the Evidence Plan process.

1.4 This meta-analysis produced population estimates and densities using a hierarchical classification approach, classifying datasets used in the meta-analysis based on the confidence and representativeness associated with the relevant dataset. However, there has been disagreement between the Applicant and Natural England in relation to various aspects of the meta-analysis including potential differences between survey platforms and the hierarchical approach applied.

1.5 This report therefore considers the following aspects of the approach taken to characterise the ornithological baseline at Hornsea Three:

- Does the aerial survey programme undertaken at Hornsea Three provide an adequate baseline characterisation?;
- Is there likely to be significant inter-annual variation in those months for which there is only one year of aerial survey data?;
- Does the application of an alternative hierarchical approach, considered to be more robust by Natural England, have implications for the assessments presented in the Hornsea Three Environmental Statement (ES) or Report to Inform Appropriate Assessment (RIAA)?

Background

Baseline characterisation of Hornsea Three

1.6 It is generally recommended that two years of baseline survey data are required to adequately capture the inherent inter-annual variability present in seabird populations present at an offshore wind farm. Aerial surveys at Hornsea Three were undertaken covering twenty months (April 2016 to November 2017) and as such, only one year of data exists for four months (December to March).

1.7 It was originally proposed by the Applicant that only twelve months of survey data would be collected for Hornsea Three and it was therefore suggested, during Expert Working Group (EWG) meetings undertaken as part of the Hornsea Three Evidence Plan process (see Consultation Report Annex 1 – Evidence Plan (Document 5.1.1)), that a meta-analysis of existing data be undertaken to provide a full baseline characterisation of Hornsea Three.

1.8 The approach to baseline characterisation of Hornsea Three has undergone extensive consultation between the Applicant, Natural England and the RSPB (Table 1.1). As part of this consultation the following overarching issues were raised:

- The comparability between abundance metrics calculated from datasets collected using different survey platforms; and
- The confidence that could be placed in different datasets and the resulting hierarchical approach applied to calculate abundance metrics.

1.9 Natural England also disagreed with aspects of the modelling undertaken to predict bird abundance for Hornsea Three. However, as these predictions were not used in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) or the RIAA (Document 5.2) (see Table 1.1 for a summary of the issues), this issue is not addressed further in this note.

Table 1.1: Timeline of events in relation to the proposed approach to characterising the baseline environment at Hornsea Three

Event	Discussions
March 2016 – EWG meeting	Ørsted (formerly DONG Energy) indicate that twelve to eighteen months of site-specific baseline data will be collected.

Event	Discussions
April 2016 – EWG meeting	Discussions were held in relation to the scope of the meta-analysis including the inclusion of analysis of flight height data, the co-variates to be included in modelling. Natural England and RSPB stated that the purpose of the meta-analysis was to answer two questions, • will 12-months of data be sufficient to inform the HOW03 assessment, • if not how can we integrate the existing dataset into the data collected for HOW03? The proposed survey methodology (aerial surveys) was agreed following discussions relating to survey coverage and transect orientation.
November 2016 – EWG meeting	Ørsted indicated that it would be possible to include data from aerial surveys undertaken up to August or September 2017 due to ES submission deadlines and therefore include two breeding seasons
March 2017 – EWG meeting	Ørsted outlined the temporal extent of aerial survey data to be included in various documents: • PEIr to include data from April 2016 to January 2017 with the PEIr to represent a draft run of the process whilst presenting detailed methodologies; • Draft ES/HRA to include data from April 2016 to July 2017; • Final ES/HRA to include data up to September or October 2017.
June 2017 – EWG meeting focussing on the meta-analysis	Overview of the data included in the meta-analysis and analytical methods applied presented. Results of the modelling conducted using boat-based data presented. Modelling conducted using boat-based data covering Hornsea Three identified as not providing robust results. As eighteen months of survey data were to be included in the final assessments the focus of the meta-analysis would be the non-breeding season.
June 2017 – PEIr submission	PEIr submitted including eleven months of aerial survey data from April 2016 to February 2017.
June 2017	Meta-analysis submitted to Natural England and RSPB

Event	Discussions
June 2017	Natural England provided comments on the meta-analysis. The following key issues were identified: • A number of the models were not a good fit for the data; • The extent to which data obtained from aerial surveys and boat-based surveys can be compared
September 2017 – Section 42 comments	Section 42 (PEIr) comments received from Natural England. No issues additional to those discussed in EWG meetings.
November 2017 - Draft ES/HRA submission	Draft ES/HRA submitted including eighteen months of aerial survey data (April 2016 to September 2017) supported by meta-analysis of existing data.
November 2017 – EWG meeting	Approach to ranking the different data sources (hierarchical approach) presented. Natural England queried whether the limited number of boat-based transects were sufficient to generate a robust density estimate. Hi-Def confirmed that boast-based transect data was sufficient to generate robust density estimates with variability and that the density estimates were generally comparable with those calculated from aerial data. Natural England queried whether survey coverage was comparable between boat-based and aerial surveys. It was confirmed that there were no major differences It was explained that the hierarchical approach applied in winter months only. Natural England queried the spatial extent of data used to derive abundance metrics. It was confirmed that data from Hornsea Three alone was used for CRM densities and Hornsea Three plus a 2 km buffer was used for displacement populations Worked examples for displacement populations and collision densities were presented Natural England queried how confidence intervals were calculated. It was agreed that a worked example would be included in the meta-analysis

Event	Discussions
December 2017 – Comments on the meta-analysis from Natural England	Comments received on meta-analysis from Natural England. The following key issues were identified: • Coverage of Hornsea Three by boat-based surveys; • The methodology used to identify abundance metrics for use in assessments; • The ranking of different datasets as part of the hierarchical approach; • Potential differences in the abundance metrics calculated from different survey platforms.
February 2018 – EWG meeting	Ørsted confirmed that twenty months (April 2016 to November 2017) of aerial survey data would be incorporated into the final application. The EWG agreed that the baseline had been agreed for April to November. Natural England stated that they were not satisfied that there was a complete baseline as they had concerns over the hierarchical approach applied. Natural England considered that the use of boat-based data from the whole Hornsea Zone would be more robust (Ørsted's approach used boat-based data from Hornsea Three only). Hi-Def considered that the Hornsea Zone had the lowest associated confidence. It was agreed that data for all areas would be presented in the final version of the meta-analysis. Natural England also highlighted concerns with survey platform differences and combining confidence intervals.
June 2018 - Application submission	Application submitted containing data from twenty months of aerial surveys supported by results of the meta-analysis.

Survey programme

1.10 Hornsea Three had originally proposed to conduct a single year of baseline surveys (April 2016 to March 2017) in order to inform the assessments required as part of the EIA and RIAA process. The survey programme was subsequently extended to eighteen months (April 2016 to September 2017) to include two breeding seasons and finally to twenty months (April 2016 to November 2017) capturing as much data as possible before the submission of the application. There are therefore four months (December, January, February and March) where a single year of aerial survey were obtained (Table 1.2).

Table 1.2: Aerial survey coverage at Hornsea Three

Year	Survey undertaken (Y/N)?											
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
2016/17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2017/18	Y	Y	Y	Y	Y	Y	Y	Y	**N**	**N**	**N**	**N**

1.11 Although two years of data is generally recommended for use in EIA and RIAA in order to adequately capture the variability inherent in seabird populations, many offshore wind farm projects do not achieve this level of survey coverage. It should be noted that this recommendation was originally made by Camphuysen *et al*. (2004) to address circumstances where there was little or no information available on the composition, distribution or abundance of seabirds at a proposed offshore wind farm site. For Round 3 sites such as Hornsea Three, which are brought forward in the context of zonal development and a programme of zonal data collection (in accordance with the Zonal Appraisal and Planning protocol promulgated by The Crown Estate), it is also reasonable to take account of existing relevant data that may already exist with this having been undertaken at projects in the Hornsea Zone, East Anglia Zone, Dogger Bank Zone and at the recently submitted Moray West project. It should also be noted that it is not uncommon for the baseline surveys programmes of offshore wind farms to fail to achieve a full 2 year coverage even where they have attempted to do so. This may occur for a variety of reasons, including, commonly, adverse weather conditions.

1.12 Table 1.3 identifies recent projects (including those from Round 3 and Extensions) at which survey coverage was incomplete in multiple months, including consecutive months at Beatrice, Galloper, Hornsea Project Two, Hywind, Seagreen and Walney Extension, all of which are consented projects. At Hornsea Project Two, this issue was addressed by providing abundance data with associated confidence metrics, enabling the consideration of variability in relevant assessments through the use of confidence intervals associated with density and population estimates. In addition a number of projects have collected data from different survey platforms. At Burbo Bank Extension, which only had twelve months of baseline survey data, assessments were based on analyses that incorporated abundance metrics from both aerial and boat-based surveys. In addition, at East Anglia One, assessments incorporated data from three different survey platforms. The baseline characterisation of Moray West included only twelve months of site-specific surveys with modelling undertaken using survey data that did not completely cover Moray West (boat-based and aerial surveys) from adjacent projects to allow for consideration of inter-annual variability.

1.13 It is not considered unreasonable or unprecedented, therefore, that Hornsea Three uses relevant data from zonal boat-based surveys to supplement the aerial survey programme to characterise the baseline for the purposes of environmental impact assessment.

Table 1.3: Survey coverage and survey platforms used to inform the assessments presented for various offshore wind farms

Project	Project status	Survey platform	Temporal extent	Number of months with missing or incomplete coverage	Months missed or with incomplete coverage	Data used for assessment
Aberdeen	Consented	Boat-based	Surveys undertaken from February 2007 to March 2008 and August 2010 to August 2011	4	March 2007, October, December 2010 and May 2011	Yes
Beatrice	Consented	Boat-based	22 surveys between October 2009 and September 2011	4	November 2009, January, November 2010 and March 2011	Yes
Burbo Bank Extension	Operational	Boat-based	Six surveys between April and September 2011	-	-	Both datasets used for assessment
		Aerial	Six surveys between November 2010 and April 2011	1	No survey undertaken in January, two surveys in March	
East Anglia One	Consented	Aerial (video)	Five surveys between November 2009 to March 2010	-	Unknown	Yes - Species groups recorded during surveys which were proportioned based on relative abundance in other surveys
		Aerial (digital stills)	April 2010 to October 2011	-	Unknown	Yes – combined with aerial (video) data

Project	Project status	Survey platform	Temporal extent	Number of months with missing or incomplete coverage	Months missed or with incomplete coverage	Data used for assessment
		Boat-based	May 2010 to April 2011, additional surveys in September 2010 and March 2011	-	Unknown	Yes – used to proportion birds identified to species level during aerial surveys and for flight height data
Galloper	Consented	Boat-based	February 2004 to April 2006 June 2008 to May 2010	14	October 2004, January to April, November 2005, January and March 2006 October, November 2008, November, December 2009, February and March 2010	Yes
Hornsea Project One	Consented	Boat-based	24 months – March 2010 to February 2012	1	December 2011	Yes
Hornsea Project Two	Consented	Boat-based	24 months – March 2011 to February 2013	3	December 2011, November 2012 and December 2012	Yes
Hywind	Operational	Boat-based	Surveys undertaken between June 2013 and May 2014 with additional surveys undertaken in the autumn of 2014 (July, August and September)	2	February and March 2014	Yes

Project	Project status	Survey platform	Temporal extent	Number of months with missing or incomplete coverage	Months missed or with incomplete coverage	Data used for assessment
Inch Cape	Consented	Boat-based	Monthly surveys between September 2010 to September 2012	3	September 2010 November 2010 missed, extra survey added Non-consecutive survey days in December 2010, February, August and December 2011 May 2011 delayed until June	Yes
Moray West	Application submitted	Aerial	One year of monthly aerial surveys between April 2016 and March 2017	-	-	Yes
		Boat-based surveys of the adjacent Moray East offshore wind farm	28 monthly surveys between April 2010 and March 2012	Seven surveys extended across two months (e.g. survey 7 was conducted across September and October 2010) often with large gaps between surveys December 2011		Yes
		Boat-based of the adjacent Beatrice offshore wind farm	22 surveys between October 2009 and September 2011	4	November 2009, January, November 2010 and March 2011	Yes

Project	Project status	Survey platform	Temporal extent	Number of months with missing or incomplete coverage	Months missed or with incomplete coverage	Data used for assessment
		Pre-construction aerial surveys of the adjacent Beatrice offshore wind farm	Six surveys between May and August 2015	1	Originally agreed all surveys would be completed by July 2015 however, weather conditions resulted in one survey being completed in August	Yes
Neart na Gaoithe	Consented	Boat-based	24 surveys between November 2009 and October 2011	1	November 2010	Yes
Seagreen	Consented	Boat-based	24 surveys between December 2009 to November 2011	2	January and February 2010	Yes
Walney Extension	Operational	Boat-based	12 non-consecutive surveys between June 2011 and November 2012	5	October to December 2011 April, September and December 2012	Both datasets used to support assessment
		Aerial	22 non-consecutive surveys between November 2010 and November 2012	9	January, May, September and December 2011 February, June, August, November and December 2012	

Does December to March represent a key period for seabirds at Hornsea Three?

1.14 Twenty months of aerial surveys have been conducted at Hornsea Three meaning that only one year of aerial survey data exists for December to March (Table 1.2). Table 1.4 presents the seasonal extents defined for each species in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5)and the RIAA (Document 5.2) and identifies those seasons affected by a change in the hierarchical approach applied.

Table 1.4: Seasonal definitions used as part of EIA and RIAA assessments for key species (months for which only one year of survey data exists are bordered in bold

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fulmar												
Gannet												
Kittiwake												
Lesser black-backed gull												
Great black-backed gull												
Guillemot												
Razorbill												
Puffin												
Key:												
Breeding season			Post-breeding season			Non-breeding season			Pre-breeding season			

1.15 For the species presented in Table 1.4 and in particular the interest features of the FFC pSPA (fulmar, gannet, kittiwake, guillemot, razorbill and puffin), December to March represent non-breeding seasons, with the exception of guillemot for which March forms part of the breeding season. During these seasons densities are typically lower and/or connectivity with the breeding colony is weaker as illustrated by the apportioning values used in these seasons for each species. Any mortality predicted for this period typically makes a relatively small contribution to the overall predicted impact on these breeding populations, compared to, say, effects occurring in the breeding season. This is due to birds having either migrated to wintering areas (e.g. gannet and kittiwake) or forming part of a much larger regional population that contains birds from multiple breeding colonies alongside significant populations of immature birds that are distributed over much larger sea areas meaning that potential impacts would not disproportionately affect local breeding populations (e.g. guillemot and razorbill).

1.16 Nevertheless, if it were the case that the densities of seabirds demonstrated considerably inter-annual variability in the period for which only one year of aerial survey data is available (December to March), then it might also be the case that there was potential to under- or over-estimate any potential impact on local breeding colonies. This is investigated for all key species in the species accounts.

Hierarchical approach to use of data for density/abundance estimation

1.17 During the early stages of Hornsea Three consultation meetings with Natural England and the RSPB, the limitations of using what may be considered to be incomplete baseline coverage due to the proposed one year survey programme was discussed. It was therefore proposed that due to the existence of an extensive historical dataset covering the former Hornsea Zone, an analysis would be conducted in order to support the aerial survey data to be collected for the Hornsea Three application. This was conducted and is presented in Volume 5, Annex 5.4: Data Hierarchy Report (Document 6.5.5.4).

1.18 As part of this meta-analysis, population estimates and densities were calculated for use in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) by applying the hierarchical approach presented in Table 1.5.

Table 1.5: Hierarchical approach applied in Volume 5, Annex 5.4: Data Hierarchy Report (Document 6.5.5.4).

Dataset	Data type and hierarchy	Decision-making process for using lower ranked data for any given month
1	Digital Aerial Survey Data	• If two years of data available, use both of these for all purposes; • For collision risk modelling (CRM): ○ when only one year of data available, if the confidence limits for the density estimate overlap the confidence limits for each of the equivalent Hornsea Three density boat-based estimates, or if the digital aerial survey (DAS) mean density estimate falls between the equivalent boat-based mean densities, then use just the single year of DAS density estimate for that month; ○ if there are no boat-based density estimates for Hornsea Three, compare with former Hornsea Zone boat-based density estimates instead; ○ if the DAS density falls outside the variation in the equivalent boat-based density estimates, calculate a monthly mean and 95% CIs for the second year using equivalent suitable boat-based survey data based on the descriptions in the next boxes; and • For displacement analysis: in months without two years of DAS data, proceed to next available data source.
2	Monthly boat-based density or population estimates for HOW03 only	• Monthly density must be based on month/years when at least four long transects are present; • The location of those transects must not be spatially biased either entirely in the east or west half †; • Calculate the mean value across all years of suitable data for birds in flight for CRM; and • Select the peak value in each season in which at least 50% of months have sufficient data, and calculate the annual mean of birds on the water and in flight for displacement assessment.
3	Monthly boat-based density or population estimates for former Hornsea Zone	• Monthly density must be based on month/years when at least 15 transects are present and over 100 km^2 has been achieved; • Calculate the mean value across all years of suitable data for birds in flight; • Population estimates need to be calculated from the density for the former Hornsea Zone and converted to a population estimate by multiplying up by the surface area of the Hornsea Three site; • Select the peak value in each season in which at least 50% of months have sufficient data, and calculate the annual mean of birds on the water and in flight for displacement assessment.

Dataset	Data type and hierarchy	Decision-making process for using lower ranked data for any given month
4	Predicted density from modelled boat-based data for the former Hornsea Zone	Should not be required
5	Predicted density from modelled boat-based data for HOW03	Should not be used
† As an example May 2012 contains five long transects which are biased to the West, but extend across the East-West half-way line therefore could be included (although there are already two years of DAS for this month and would be used as a priority). Effort in October 2012 consists of only two transect in the Hornsea Three area (with no buffer) and all of these occur in the western half of the study area, therefore estimates for this month will not be used. Effort in January 2013 is based on four long transects which are centred mainly in the middle or eastern half of Hornsea Three		

1.19 The following concerns in relation to the hierarchical approach have been outlined by Natural England as part of comments provided on the meta-analysis:

- "Natural England does not agree with the Hornsea Three boat-based estimates being ranked higher than the Hornsea Zone data in the hierarchy. This is not valid given the paucity of data and lack of coverage of Hornsea Three."

1.20 This issue has been highlighted by Natural England for a number of reasons, as explained in their comments on the meta-analysis provided in December 2017. These include:

- Survey coverage of Hornsea Three during boat-based surveys;
- The number of transects covering Hornsea Three; and
- A low number of encounters during surveys.

1.21 Natural England highlighted that they did not consider boat-based surveys to have provided good coverage of Hornsea Three, quoting a 10% preferred minimum from Buckland *et al*. (2001). However, although this arbitrary threshold is included in Buckland *et al*. (2001) there is little to no evidence to support this threshold either in Buckland *et al*. (2001) or in any other literature.

1.22 Natural England also suggested that the use of a small number of transects covering an area could bias the density estimates produced, however there is also no evidence to support this assertion. Low precision associated with an estimate does not invalidate any comparisons drawn between datasets however, it does lower the power to detect change. Similarly, low numbers of encounters during surveys does not invalidate methods for generating population sizes or densities.

1.23 These aspects of the hierarchical approach led Natural England to conclude that they do not agree with the Hornsea Three boat-based estimates being ranked higher than the boat-based estimates from the Hornsea Zone. Ørsted has responded to these criticisms during pre-application, highlighting that whilst there are more data available for analysis if surveys of the whole zone are included, these will include observations from areas that are ecologically distinct both in terms of the habitats present and the patterns of seabird density. This arises because of the scale of the zone, which extends over 130 km

1.24 To attempt to resolve this disagreement, a sensitivity test has been undertaken (and documented in this report) to explore whether placing more emphasis on zonal data, rather than data from the Hornsea Three area (essentially reversing the rankings of datasets 2 and 3 in Table 1.5, as considered by Natural England to be more robust) makes any significant difference to the impact assessment.

Methodology

Overview

1.25 The sensitivity of the impact assessment undertaken for seabirds at Hornsea Three to the assumptions made in the use of historical data to support the baseline characterisation has been tested by calculating the densities of seabirds during the months of December to March using the alternative approach proposed by Natural England (i.e. placing more emphasis on zonal data compared to the data from Hornsea Three).

1.26 The data obtained from this alternative approach and the implications for estimates of collision mortality and displacement are compared to those used in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

1.27 In addition, the sensitivity of the assessment undertaken in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2)is explored in relation to the scale of change that would be required in the prediction of an impact magnitude in order for a change in conclusion regarding the significance of that impact (i.e. to what extent would the predicted magnitude of an impact need to change in order for it to become significant (in EIA terms) for a species).

1.28 Finally, a discussion in relation to the degree of inter-annual variability (during the months of Dec – Mar) is undertaken. This is undertaken to explore the extent to which variability in bird densities is expected during the months for which fewer data are available and hence the extent to which a reduced survey frequency in those months will be representative.

1.29 The purpose of these analyses is to explore whether the differences between the preferred approaches of the Applicant and Natural England are in any way meaningful in the context of impact assessment.

1.30 These approaches are each described in the following sub-sections and their implications for the key species assessed are presented in the Species Accounts section.

Hierarchical approach sensitivity testing (December to March)

1.31 A change in the hierarchical approach applied to the selection of those data to be used in the calculation of densities for December to March only has implications for the estimation of collision risk and displacement mortality. The remaining impacts considered in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) either do not incorporate baseline data into the assessments presented or rely on the assessments produced for collision or operational displacement. This therefore limits the suite of species/SPAs considered in this report to those that were assessed for displacement and collision risk impacts presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2):

- Species for consideration:
  - Fulmar;
  - Gannet;
  - Kittiwake;
  - Lesser black-backed gull;
  - Great black-backed gull;
  - Guillemot;
  - Razorbill; and
  - Puffin.
- (p)SPAs for consideration:
  - Flamborough and Filey Coast pSPA (fulmar, gannet, kittiwake, guillemot, razorbill and puffin);

- ○ Farne Islands SPA (fulmar);
- ○ Coquet Island SPA (fulmar); and
- ○ Forth Islands SPA (fulmar).

1.32 Migratory seabirds and migratory waterbirds are also considered in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5), however, the collision risk modelling conducted for these species does not incorporate baseline data and therefore these species do not require consideration in this report.

1.33 The months affected by a change to the hierarchical approach applied are December to March. These months represent different parts of the annual cycle for the species included in this report and with the exception of guillemot, are outside of the breeding season. Table 1.4 presents the seasonal extents defined for each species in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) and identifies those seasons affected by a change in the hierarchical approach applied.

1.34 The approach to seasonal and annual assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) has been followed in the Species Accounts section utilising the same biogeographic populations (i.e. regional or pSPA populations) as included in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Collision risk

1.35 Assessment of impacts from collision risk at Hornsea Three was undertaken in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5)for gannet, kittiwake, lesser black-backed gull and great black-backed gull. In the RIAA (Document 5.2), assessments were conducted for gannet and kittiwake at FFC pSPA. The Species Accounts section includes consideration of both EIA and RIAA scale impacts for all of the species and SPAs previously considered as part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

1.36 Monthly densities are required for collision risk modelling and as such, changes to the hierarchical approach affect all species. Collision risk modelling has therefore been conducted applying the approach and associated bird and wind farm parameters described in Volume 5, Annex 5.3: Collision Risk Modelling (Document 6.5.5.3) utilising densities derived when applying the alternative hierarchical approach. The monthly densities (December to March) calculated for each hierarchical approach and used for each species are presented in Table 1.6. All species are therefore included in collision risk modelling incorporating densities calculated using the alternative hierarchical approach. The collision risk modelling methodology used is consistent with that described in Volume 5, Annex 5.3: Collision Risk Modelling (Document 6.5.5.3).

Table 1.6: Monthly densities for species considered for collision risk modelling

Species	Original hierarchical approach				Alternative hierarchical approach			
	Dec	Jan	Feb	Mar	Dec	Jan	Feb	Mar
Gannet	0.34	0.02	0.14	0.08	0.26	0.11	0.14	0.26

Species	Original hierarchical approach				Alternative hierarchical approach			
Kittiwake	1.21	0.47	0.18	1.34	0.88	0.30	0.32	0.64
Lesser black-backed gull	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Great black-backed gull	0.46	0.13	0.04	0.03	0.33	0.16	0.12	0.11

Displacement

1.37 Assessment of impacts from operational displacement from the Hornsea Three array area was undertaken in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) for fulmar, gannet, guillemot, razorbill and puffin. In the RIAA (Document 5.2), assessments were conducted for these species at FFC pSPA (all five species), Farne Islands SPA (fulmar), Coquet Island (fulmar) and Forth Islands SPA (fulmar). The Species Accounts section includes consideration of both EIA and RIAA scale impacts for all of the species and SPAs previously considered as part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

1.38 The approach to displacement analysis is consistent with that described in Volume 5, Annex 5.2: Analysis of Displacement Impacts on Seabirds (Document 6.5.5.2) and uses the mean-peak population derived when applying the alternative hierarchical approach. Table 1.7 identifies the mean-peak population estimates calculated for each of the species considered for operational displacement impacts at the Hornsea Three array area when applying the two hierarchical approaches.

Table 1.7: Mean-peak population estimates for species considered for displacement analysis

Species	Season	Mean-peak population (no. of birds)	
		Original hierarchical approach	Alternative hierarchical approach
Fulmar	Pre-breeding	525	464
Gannet	Pre-breeding	406	600
Guillemot	Breeding	13,374	13,374
	Non-breeding	17,772	23,232
Razorbill	Non-breeding	3,649	2,607
	Pre-breeding	1,236	2,218
Puffin	Non-breeding	127	1,861

1.39 The mean-peak population estimates for all species/season combinations change when applying the alternative hierarchical assessment with the exception of guillemot in the breeding season. The populations of guillemot estimated in March do not represent the peak population in the breeding season, with this occurring in either June or July. Displacement analyses are therefore conducted for all other species/seasons combinations utilising the methodology described in Volume 5, Annex 5.2: Analysis of Displacement Impacts on Seabirds (Document 6.5.5.2).

Impact magnitude

1.40 The increase in impact magnitude that would be required in order for the conclusions relating to significance reached in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) to be altered have been calculated. In order to illustrate this, the 1% criteria of the baseline mortality of the relevant population is used. The level of impact required to surpass 1% of the baseline mortality of the relevant population is calculated and from this the corresponding mean-peak population or densities are calculated. These are then compared to the mean-peak population or densities incorporated into collision risk modelling or displacement analyses. This therefore provides an indication as to the mean-peak population/density of a species at Hornsea Three required to potentially result in an impact magnitude that may lead to the conclusion of a significant impact/adverse effect on site integrity. Although, the 1% criteria of baseline mortality does not represent a definitive threshold for the identification of significance or adverse effect on site integrity, it’s use in the Species Accounts section is considered appropriate to illustrate the increases that would be required to alter the conclusions reached in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Inter-annual variability

1.41 The months of December to March are not considered likely to represent a key period for those species considered in the assessments for Hornsea Three as many species of birds have migrated to wintering areas outside of the regional Offshore Ornithology study area or are less constrained in terms of area usage than would have been the case, say, for the breeding season. For those species that do not exhibit migratory behaviour, the populations present in biogeographic regions during non-breeding seasons are composed of birds associated with a much wider range of breeding colonies as there is far less affinity to breeding colonies exhibited by birds at this time of year. However, if considerably inter-annual variability were to occur then the use of only one year of aerial survey data could potentially lead to an under- or over-estimation) of potential impacts on relevant populations. Consequently, consideration has been given to the distribution and abundance of species at Hornsea Three between December to March to understand if there is likely to be a large degree of inter-annual variability in the abundance of each species.

1.42 A number of data sources that present the distribution of seabird species across large scales (e.g. UK waters) and smaller scales (the former Hornsea Zone) have been consulted. This includes:

- Distribution maps presented in the Hornsea Project Two Technical Report (SmartWind, 2015) presenting sightings from boat-based surveys undertaken across the former Hornsea Zone between March 2010 and February 2013;
- WWT Consulting and MacArthur Green (2013), which presents densities for English waters for a summer (April to September) and winter (October to March) season calculated using boat-based and aerial data collected between 1979 and 2011; and
- Stone *et al*. (1995), which presents the density of seabird species for north-west European waters, concentrating on the UK for differing temporal extents, calculated using ESAS data collected between 1980 and 1993.

1.43 The temporal periods associated with the three sources identified do not always correspond with the seasons defined for the species included in this report, especially WWT Consulting and MacArthur Green (2013) and Stone *et al*. (1995). However, discussion is provided in the relevant species accounts in this section as to why the distribution of birds presented in the three sources above may differ from the distribution that may be expected in December to March.

Species accounts

Fulmar

Overview

1.44 As illustrated in Table 1.4 the only season defined for fulmar affected by a change in the hierarchical approach applied to baseline data is the pre-breeding season (December to March). As part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), assessments that relied on baseline data were conducted for fulmar in relation to displacement impacts only. As such, the following sections consider the potential effects of displacement on fulmar in the pre-breeding season.

1.45 Likely Significant Effects (LSEs) were identified for four (p)SPAs at which fulmar is a qualifying feature. Apportioning for fulmar in the pre-breeding season calculates the impact attributable to an SPA population by deriving the contribution of the relevant SPA population to the BDMPS population as defined in Furness (2015). The apportioning values used for the four SPAs relevant to fulmar are presented in Table 1.8.

Table 1.8: Pre-breeding season apportioning values used for SPA populations relevant to fulmar

(p)SPA	(p)SPA population (breeding adults)	Pre-breeding season apportioning value (%)
Flamborough and Filey Coast pSPA	2,894	0.85
Coquet Island	125	0.04
Farne Islands	542	0.24
Forth Islands	1,596	0.81

Alternative hierarchical approach

1.46 Displacement analysis for fulmar in the pre-breeding season using a mean-peak population estimate calculated using the alternative hierarchical approach is presented in Table 1.9. Using a displacement rate range of 10-30% and a mortality rate of 1% provides a displacement mortality of 0-1 birds. This represents less than 0.01% of the regional population (957,502 individuals) and less than a 0.01% increase in the baseline mortality of the same population (61,280 individuals).

1.47 Based on the apportioning values used for the four SPAs relevant to fulmar (Table 1.8), a negligible proportion of the predicted impact will be apportioned to each SPA.

Table 1.9: Predicted displacement mortality for fulmar during the pre-breeding season when applying the alternative hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	1	2	5	9	14	19	23	28	33	37	42	46
20	1	2	5	9	19	28	37	46	56	65	74	84	93
30	1	3	7	14	28	42	56	70	84	98	111	125	139
40	2	4	9	19	37	56	74	93	111	130	149	167	186
50	2	5	12	23	46	70	93	116	139	163	186	209	232
60	3	6	14	28	56	84	111	139	167	195	223	251	279
70	3	7	16	33	65	98	130	163	195	228	260	293	325
80	4	7	19	37	74	111	149	186	223	260	297	334	371
90	4	8	21	42	84	125	167	209	251	293	334	376	418
100	5	9	23	46	93	139	186	232	279	325	371	418	464
Regional BDMPS population = 957,502 individuals Background mortality = 0.064			< 1% background mortality					> 1% background mortality					

Comparison

1.48 Comparison

1.49 The displacement mortality of fulmar in the pre-breeding season calculated using the original hierarchical approach is 1-2 birds (Table 1.10). This is higher than that predicted using the alternative hierarchical approach (Table 1.9) and therefore represents a higher proportion of the regional population and a larger increase in the baseline mortality of that population. Similarly, a larger impact is also apportioned to the four SPAs relevant to fulmar. However, the level of impact apportioned to each SPA is still considered to represent an impact of limited magnitude and a negligible proportion of each respective SPA population.

Table 1.10: Predicted displacement mortality for fulmar during the pre-breeding season when applying the original hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	1	3	5	10	16	21	26	31	37	42	47	52
20	1	2	5	10	21	31	42	52	63	73	84	94	105
30	2	3	8	16	31	47	63	79	94	110	126	142	157
40	2	4	10	21	42	63	84	105	126	147	168	189	210
50	3	5	13	26	52	79	105	131	157	184	210	236	262
60	3	6	16	31	63	94	126	157	189	220	252	283	315
70	4	7	18	37	73	110	147	184	220	257	294	331	367
80	4	8	21	42	84	126	168	210	252	294	336	378	420
90	5	9	24	47	94	142	189	236	283	331	378	425	472
100	5	10	26	52	105	157	210	262	315	367	420	472	525
Regional BDMPS population = 957,502 individuals Background mortality = 0.064			< 1% background mortality					> 1% background mortality					

Discussion

1.50 The displacement mortality calculated for the pre-breeding season when using the alternative hierarchical approach results in a displacement impact lower than that calculated when using the original hierarchical approach presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). As a result there are considered to be no implications for any of the assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) if the alternative hierarchical approach were to be applied, with no change in the conclusions reached.

1.51 In order for the conclusions drawn in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) to be altered there would need to be a considerable increase in the mean-peak population derived for the pre-breeding season. The baseline mortality criteria of 1% (of the regional population) which is used to inform the assessments conducted in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) is 613 birds. The mean-peak population of fulmar required in order to reach an impact of 613 birds would be over 204,000 birds when applying a 30% displacement rate and 1% mortality rate. Even when applying the upper rates from the range recommend by Natural England (70% displacement and 10% mortality) a population of over 8,700 birds would be required. Populations of this size have not been recorded at Hornsea Three in any season, even when including a 4 km buffer around Hornsea Three or the upper confidence limit associated with population estimates (see Table 1.12 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1).

1.52 In the RIAA (Document 5.2), the impact of displacement on fulmar is considered at four (p)SPAs with the 1% criteria of baseline mortality for these (p)SPAs between less than one bird and two birds. A mean-peak population of at least 196,000 birds would therefore be required for the apportioned impact to reach this level of impact for at least one SPA when using a displacement rate of 30% and a mortality rate of 1%. Even if using the upper rates from the range recommend by Natural England (70% displacement and 10% mortality) would require a mean-peak population of at least 8,400 birds with a population of this size not having been recorded at Hornsea Three in any season.

1.53 December to March represents the pre-breeding season for fulmar, during which time, fulmars begin to become more closely associated with breeding areas. The distribution of fulmar as recorded during boat-based surveys that covered the former Hornsea Zone indicate that few fulmar are present in this area throughout non-breeding season months (September to March) (Figure B.3.2 and B.3.4 in SmartWind, 2015).

1.54 From December to February fulmars are widely distributed across the whole North Sea. Fulmars were recorded widely throughout the North Sea between December and February, with low densities at Hornsea Three (Stone *et al*., 1995). WWT Consulting and MacArthur Green (2013) suggests moderate densities of fulmar occur at Hornsea Three in the winter (Figure 1.38 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)), although these densities are lower than those predicted in the summer. Higher densities in the summer period (April to September) as defined by WWT Consulting and MacArthur Green (2013) are reflected in the population estimates of fulmar recorded at Hornsea Three, with population estimates being highest between June and September in both survey years.

Conclusion

1.55 The changes that occur between the predicted impacts when applying the two hierarchical approaches are not considered to represent a material change in terms of either the impact magnitude or the assessment conclusions in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2)in relation to impacts from operational displacement from the Hornsea Three array area for fulmar and associated (p)SPAs.

1.56 The pre-breeding season is not considered likely to represent a period of peak abundance for fulmar at Hornsea Three with considerable inter-annual variability unlikely, especially to the degree required to significantly alter the predicted impact magnitude or assessment conclusions. The mean-peak population calculated for fulmar in the pre-breeding season using either of the two hierarchical approaches is therefore considered to provide an accurate representation of the abundance of the species at Hornsea Three during the pre-breeding season for use in displacement analyses. The use of boat-based data for December to March to support the data collected during twenty months of aerial surveys is considered to provide a robust and accurate assessment of the impacts on fulmar as a result of operational displacement in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Gannet

Overview

1.57 As illustrated in Table 1.4 the only season defined for gannet affected by a change in the hierarchical approach applied to baseline data is the pre-breeding season (December to March). As part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), assessments that relied on baseline data were conducted for gannet in relation to collision and displacement impacts only. The following sections present the results of displacement analyses and collision risk modelling when applying the alternative hierarchical approach and consider these results in terms of EIA and RIAA assessments.

Collision Risk Modelling

Alternative hierarchical approach

1.58 Collision risk modelling results for gannet calculated using the alternative hierarchical approach are presented in Table 1.11. In the pre-breeding season, 5-11 collisions are predicted representing less than 0.01% of the regional pre-breeding population and a 0.02-0.06% increase in the baseline mortality of the same population.

1.59 The annual collision risk apportioned to the FFC pSPA population of gannet is 4-8 collisions/annum with the pre-breeding season contributing approximately only 8% of this total. This represents 0.02-0.05% of the FFC pSPA population and a 0.26-0.62% increase in the baseline mortality of the FFC pSPA population.

Table 1.11: Collision risk estimates for gannet calculated using the alternative hierarchical approach (95% confidence intervals shown in brackets)

Season	Predicted no. of collisions (no apportioning)			No. of collisions apportioned to pSPA		
	Option 1 (98.9% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 3 (98% avoidance rate)	Option 1 (98.9% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 3 (98% avoidance rate)
Density						

Season	Predicted no. of collisions (no apportioning)			No. of collisions apportioned to pSPA		
Pre-breeding	5 (2-9)	11 (3-20)	5 (1-8)	0 (0-1)	1 (0-1)	0 (0-1)
Annual	19 (10-28)	41 (22-60)	17 (9-25)	4 (2-6)	8 (5-12)	4 (2-5)
Flight height distribution						
Pre-breeding	5 (15)	11 (3-25)	5 (1-13)	0 (1)	1 (0-2)	0 (0-1)
Annual	19 (56)	41 (12-90)	17 (4-46)	4 (12)	8 (3-19)	4 (1-10)

Comparison

1.60 The collision risk modelling results for gannet, incorporated into the assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) are presented in Table 1.12.

1.61 The collision risk estimates presented in Table 1.12 represent a 0.02-0.04% increase in the baseline mortality of the pre-breeding season regional population. This was deemed to be an impact of negligible or minor to minor adverse significance in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5). When compared to the FFC pSPA population, the number of apportioned collisions represent 0.02-0.05% of the pSPA population and a 0.25-0.60% increase in the baseline mortality of the pSPA population. The RIAA (Document 5.2) therefore concluded that there would be no adverse effect on the integrity of the FFC pSPA.

Table 1.12: Collision risk estimates for gannet calculated using the original hierarchical approach (95% confidence intervals shown in brackets)

Season	Predicted no. of collisions (no apportioning)			No. of collisions apportioned to pSPA		
	Option 1 (98.9% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 3 (98% avoidance rate)	Option 1 (98.9% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 3 (98% avoidance rate)
Density						
Pre-breeding	4 (1-6)	8 (3-13)	3 (1-5)	0 (0)	0 (0-1)	0 (0)
Annual	17 (10-24)	37 (21-54)	15 (9-22)	4 (2-5)	8 (5-12)	3 (2-5)
Flight height distribution						
Pre-breeding	4 (11)	8 (2-17)	3 (1-9)	0 (1)	0 (0-1)	0 (0-1)
Annual	17 (51)	37 (11-83)	15 (4-43)	4 (11)	8 (3-18)	3 (1-9)

1.62 In the pre-breeding season collision risk estimates increase by over 44% when using the alternative hierarchical approach. This leads to an increase in the annual collision risk of over 9%. Although an increase of 44% appears significant, it only represents an additional 2-3 collisions which, when apportioned to the FFC pSPA, does not result in a material change in the number of collisions when using either Option 1 or Option 2 of the Band CRM with an increase of one collision/annum when using Option 3.

1.63 In terms of the EIA assessment, the number of collisions in the pre-breeding season when using the alternative hierarchical approach represents up to 0.01% of the regional population and a 0.02-0.06% increase in the baseline mortality of that population (when using a 99.2% avoidance rate). This is 0.02% higher than that predicted when using the original hierarchical approach, however it is not considered to alter the conclusion reached in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5).

1.64 For the RIAA (Document 5.2), the total number of predicted collisions calculated when using the alternative hierarchical approach represents 0.02-0.05% of the pSPA population and a 0.26-0.62% increase in baseline mortality (when using a 99.2% avoidance rate). This therefore represents a slight increase in the proportions predicted when using the original hierarchical approach with this due to the low apportioning value used to attribute collisions to the FFC pSPA population. The conclusion reached in the RIAA (Document 5.2) is therefore considered to be unaffected by the alternative hierarchical approach.

1.65 The change in collision risk values when applying the alternative hierarchical approach is considered to be negligible in both a EIA and RIAA context. The increase in cumulative or in-combination collision risk estimates is therefore also considered to negligible with the proportion of the cumulative/in-combination impact contributed by Hornsea Three essentially equivalent to that predicted when applying the original hierarchical approach. There is therefore considered to be no change in the conclusions reached in relation to cumulative and in-combination assessments in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Displacement

<u>Alternative hierarchical approach</u>

1.66 Displacement analysis for gannet in the pre-breeding season using a mean-peak population estimate calculated using the alternative hierarchical approach is presented in Table 1.13. Using a displacement rate range of 30-70% and a mortality rate of 1% provides a displacement mortality of 2-4 birds. This represents less than 0.01% of the regional population (248,385 individuals) and up to a 0.02% increase in the baseline mortality of the same population (20,119 individuals).

1.67 In the pre-breeding season, 6.2% of the predicted displacement mortality is attributable to the FFC pSPA population of gannet, with this value calculated based on the contribution of FFC pSPA to the pre-breeding BDMPS population as defined by Furness (2015). From a displacement mortality of 2-4 birds (30-70% displacement, 1% mortality), less than one bird is attributable to the FFC pSPA population. This therefore represents a negligible proportion of the pSPA population and a negligible increase in the baseline mortality of the pSPA population.

Table 1.13: Predicted displacement mortality for gannet during the pre-breeding season when applying the alternative hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	1	3	6	12	18	24	30	36	42	48	54	60
20	1	2	6	12	24	36	48	60	72	84	96	108	120
30	2	4	9	18	36	54	72	90	108	126	144	162	180
40	2	5	12	24	48	72	96	120	144	168	192	216	240
50	3	6	15	30	60	90	120	150	180	210	240	270	300
60	4	7	18	36	72	108	144	180	216	252	288	324	360
70	4	8	21	42	84	126	168	210	252	294	336	378	420
80	5	10	24	48	96	144	192	240	288	336	384	432	480
90	5	11	27	54	108	162	216	270	324	378	432	486	540
100	6	12	30	60	120	180	240	300	360	420	480	540	600
Regional BDMPS population = 248,385 individuals Background mortality = 0.081			< 1% background mortality					> 1% background mortality					

Comparison

1.68 The displacement mortality of gannet in the pre-breeding season calculated using the original hierarchical approach is 1-3 birds (Table 1.14). The displacement mortality calculated using the alternative hierarchical approach is therefore higher than that calculated when using the original hierarchical approach.

1.69 The original displacement mortality assessed in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) represented less than 0.01% of the regional non-breeding population and up to a 0.01% increase in the baseline mortality of the same population. The difference in these metrics when using the two different hierarchical approaches is therefore not considered to be significant with the increased displacement mortality predicted when using the alternative hierarchical approach representing only a 0.01% increase in baseline mortality

Table 1.14: Predicted displacement mortality for gannet during the pre-breeding season when applying the original hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100

	Mortality rate (%)												
10	0	1	2	4	8	12	16	20	24	28	32	37	41
20	1	2	4	8	16	24	32	41	49	57	65	73	81
30	1	2	6	12	24	37	49	61	73	85	97	110	122
40	2	3	8	16	32	49	65	81	97	114	130	146	162
50	2	4	10	20	41	61	81	102	122	142	162	183	203
60	2	5	12	24	49	73	97	122	146	171	195	219	244
70	3	6	14	28	57	85	114	142	171	199	227	256	284
80	3	6	16	32	65	97	130	162	195	227	260	292	325
90	4	7	18	37	73	110	146	183	219	256	292	329	366
100	4	8	20	41	81	122	162	203	244	284	325	366	406
Regional BDMPS population = 248,385 individuals Background mortality = 0.081				< 1% background mortality					> 1% background mortality				

1.70 Less than one bird is apportioned to FFC pSPA during the pre-breeding season when using the original or alternative hierarchical approaches. A negligible proportion of the pSPA population is therefore affected by displacement during the pre-breeding season with a negligible increase in baseline mortality of the population.

Discussion

1.71 Collision risk estimates calculated using the alternative hierarchical approach are higher than those calculated using the original hierarchical approach presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). However, the difference between resulting collision risk estimates is considered to be negligible and immaterial in terms of the assessments conducted in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). As a result there are considered to be no implications for any of the assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) if the alternative hierarchical approach were to be applied, with no change in the conclusions reached.

1.72 The collision mortality estimated for the pre-breeding season is considerably lower than the 1% criteria of baseline mortality for the regional pre-breeding season population of gannet (201 birds) when using all Band model Options and applying either hierarchical approach. A considerable increase in the densities of gannet at Hornsea Three would therefore be required in the pre-breeding season in order to surpass the 1% criteria of baseline mortality. The annual collision risk estimate apportioned to FFC pSPA in the RIAA (Document 5.2) is below the 1% criteria of baseline mortality for the gannet population at FFC pSPA (14 birds). The pre-breeding season contributes just over 8% of the annual collision risk apportioned to FFC pSPA and therefore a considerable increase in densities used in collision risk modelling would be required in the pre-breeding season to increase the overall annual collision risk estimate.

1.73 The displacement mortality calculated for the pre-breeding season when using the alternative hierarchical approach results in a displacement impact higher than that calculated when using the original hierarchical approach presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). However, the increase is not considered to represent a material change to the conclusions reached in either Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

1.74 For the conclusions drawn in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) in relation to displacement mortality to be altered there would need to be a considerable increase in the mean-peak population derived for the pre-breeding season. The baseline mortality criteria of 1% which is used to inform the assessments conducted in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) is 201 birds. The mean-peak population of gannet required in order to reach an impact of 201 birds would be over 28,000 birds when applying a 70% displacement rate and 1% mortality rate. Even when applying the upper rates from the range recommend by Natural England (70% displacement and 10% mortality) a mean-peak population of nearly 3,000 birds would be required. Populations of this size have not been recorded at Hornsea Three in any season, even when including a 4 km buffer around Hornsea Three (see Table 1.16 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)). A population of 3,000 birds was exceeded twice when considering the upper confidence limit associated with population estimates however this occurred in August and October when the population of gannets at Hornsea Three comprises breeding adult birds alongside a significant proportion of post-breeding and immature gannets.

1.75 In the RIAA (Document 5.2), the 1% criteria of baseline mortality is 14 birds, representing the baseline mortality of the gannet population at FFC pSPA. A mean-peak population of over 32,000 birds would therefore be required for the impact apportioned to FFC pSPA to reach this level of impact when using a displacement rate of 70% and a mortality rate of 1%. Even if using the upper rates from the range recommend by Natural England (70% displacement and 10% mortality) would require a mean-peak population of over 3,000 birds. The presence of this number of birds at Hornsea Three is considered unlikely based on the likely distribution and movements of gannet between December and March. Similarly, a considerable increase in the densities used in collision risk modelling would also be required to increase the overall annual collision risk estimate to a level at which 1% of baseline mortality would exceeded.

1.76 The months for which only one year of aerial survey data were collected at Hornsea Three represent the pre-breeding season for gannet. Across the former Hornsea Zone, few birds were recorded in the pre-breeding season (and post-breeding season) with no obvious trends in the distribution of these birds. The largest number of gannets recorded in the breeding season (see Figure B.3.7 and B.3.10 in SmartWind, 2015). These observations reflect the likely usage of the former Hornsea Zone across an annual cycle. Breeding adult birds are likely to be present across the former Hornsea Zone throughout the breeding season, with abundance increasing as the breeding season progresses due to the influx of failed breeders, non-breeding and immature birds. The abundance of birds would therefore be highest towards the end of the breeding season, with birds then dispersing to good foraging areas before migrating south. Pre-breeding migration occurs more quickly than post-breeding migration with the migratory population composed primarily of breeding adult birds.

1.77 WWT Consulting and MacArthur Green (2013) also suggests low densities of gannet occur at Hornsea Three in the winter (Figure 1.39 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)), with similar results presented in Stone *et al*. (1995) between November and February.

Conclusion

1.78 The changes that occur between the predicted impacts when applying the two hierarchical approaches are not considered to represent a material change in terms of either the impact magnitude or the assessment conclusions in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2)in relation to impacts from operational displacement from the Hornsea Three array area or collision risk for gannet and associated (p)SPAs.

1.79 The pre-breeding season is not considered likely to represent a period of peak abundance for gannet at Hornsea Three with considerable inter-annual variability unlikely, especially to the degree required to significantly alter the predicted impact magnitude or assessment conclusions. The mean-peak population and monthly densities calculated for gannet in the pre-breeding season using either of the two hierarchical approaches are therefore considered to provide an accurate representation of the abundance of the species at Hornsea Three during the pre-breeding season for use in either displacement analyses or collision risk modelling. The use of boat-based data for December to March to support the data collected during twenty months of aerial surveys is considered to provide a robust and accurate assessment of the impacts on gannet as a result of operational displacement and collision risk in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Kittiwake

Overview

1.80 As illustrated in Table 1.4 the post-breeding (August to December) and pre-breeding (January to March) seasons defined for kittiwake are affected by a change in the hierarchical approach applied to baseline data. As part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), assessments that relied on baseline data were conducted for kittiwake in relation to collision risk impacts only. The following sections present the results of collision risk modelling when applying the alternative hierarchical approach and consider these results in terms of EIA and RIAA assessments.

Alternative hierarchical approach

1.81 Collision risk modelling results for kittiwake calculated using the alternative hierarchical approach are presented in Table 1.15. In the post-breeding season, 10-51 collisions are predicted (using a 99.2% avoidance rate) representing 0.01% of the regional post-breeding population and a 0.01-0.04% increase in the baseline mortality of the same population. In the pre-breeding season 3-18 collisions are predicted (using a 99.2% avoidance rate) representing less than 0.01% of the regional pre-breeding population and up to a 0.02% increase in baseline mortality of the same population.

1.82 The annual collision risk apportioned to the FFC pSPA population of kittiwake is 8-41 collisions/annum using a 99.2% avoidance rate with the pre-breeding season contributing approximately only 3% of this total. This represents 0.01-0.05% of the FFC pSPA population and a 0.06-0.32% increase in the baseline mortality of the FFC pSPA population.

Table 1.15: Collision risk estimates for kittiwake calculated using Options 1 and 2 and applying the alternative hierarchical approach (95% confidence intervals shown in brackets)

Season	Predicted no. of collisions (no apportioning)				No. of collisions apportioned to pSPA			
	Option 1 (98.9% avoidance rate)	Option 1 (99.2% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 2 (99.2% avoidance rate)	Option 1 (98.9% avoidance rate)	Option 1 (99.2% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 2 (99.2% avoidance rate)
Density								
Post-breeding	13 (9-18)	10 (7-13)	70 (48-92)	51 (35-67)	1 (1-1)	1 (0-1)	4 (3-5)	3 (2-4)
Pre-breeding	5 (2-7)	3 (2-5)	25 (12-37)	18 (9-27)	0 (0)	0 (0)	2 (1-3)	1 (1-2)
Annual	41 (26-56)	30 (19-41)	217 (138-295)	158 (100-215)	11 (7-15)	8 (5-11)	56 (36-77)	41 (26-56)
Flight height distribution								

Season	Predicted no. of collisions (no apportioning)				No. of collisions apportioned to pSPA			
Post-breeding	13 (30)	10 (22)	70 (46-92)	51 (34-67)	1 (2)	1 (1)	4 (3-5)	3 (2-4)
Pre-breeding	5 (11)	3 (8)	25 (16-33)	18 (12-24)	0 (1)	0 (1)	2 (1-2)	1 (1-2)
Annual	41 (93)	30 (67)	217 (142-284)	158 (103-206)	11 (24)	8 (18)	56 (37-74)	41 (27-54)

Table 1.16: Collision risk estimates for kittiwake calculated using Option 3 and applying the alternative hierarchical approach (95% confidence intervals are shown in brackets).

Season	Predicted no. of collisions (no apportioning)	No. of collisions apportioned to pSPA
Density		
Post-breeding	25 (17-32)	1 (1-2)
Pre-breeding	9 (4-13)	1 (0-1)
Annual	75 (48-103)	20 (12-27)
Flight height distribution		
Post-breeding	25 (14-35)	1 (1-2)
Pre-breeding	9 (5-12)	1 (0-1)
Annual	75 (44-107)	20 (12-28)

Comparison

1.83 The collision risk modelling results for kittiwake, incorporated into the assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and RIAA (Document 5.2) are presented in Table 1.17.

1.84 The collision risk estimates presented in Table 1.17 for the post- and pre-breeding seasons represent 0.01-0.03% increase in the baseline mortality of the pre-breeding season regional population and 0.01-0.05% of the post-breeding season regional population. This was deemed to be an impact of minor adverse significance in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5). When compared to the FFC pSPA population, the apportioned annual collision risk represents 0.02-0.05% of the pSPA population and a 0.06-0.32% increase in the baseline mortality of the pSPA population. The RIAA (Document 5.2) therefore concluded that there would be no adverse effect on the integrity of the FFC pSPA.

Table 1.17: Collision risk estimates for kittiwake calculated using Options 1 and 2 and applying the original hierarchical approach (95% confidence intervals are shown in brackets).

Season	Predicted no. of collisions (no apportioning)				No. of collisions apportioned to pSPA			
	Option 1 (98.9% avoidance rate)	Option 1 (99.2% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 2 (99.2% avoidance rate)	Option 1 (98.9% avoidance rate)	Option 1 (99.2% avoidance rate)	Option 2 (98.9% avoidance rate)	Option 2 (99.2% avoidance rate)
Density								
Post-breeding	14 (10-19)	11 (7-14)	76 (52-99)	55 (38-72)	1 (1-1)	1 (0-1)	4 (3-5)	3 (2-4)
Pre-breeding	8 (4-13)	6 (3-9)	41 (21-68)	29 (15-50)	1 (0-1)	0 (0-1)	3 (2-4)	2 (1-4)
Annual	45 (29-64)	33 (21-46)	238 (150-334)	173 (109-243)	11 (7-15)	8 (5-11)	58 (38-76)	42 (27-58)
Flight height distribution								
Post-breeding	14 (32)	11 (24)	76 (50-99)	55 (36-72)	1 (2)	1 (1)	4 (3-5)	3 (2-4)
Pre-breeding	8 (17)	6 (13)	41 (27-53)	29 (19-39)	1 (1)	0 (1)	3 (1-5)	2 (1-3)
Annual	45 (102)	33 (74)	238 (156-213)	173 113-227)	11 (25)	8 (18)	58 (36-80)	42 (27-55)

Table 1.18: Collision risk estimates for kittiwake calculated using Option 3 and applying the original hierarchical approach (95% confidence intervals are shown in brackets).

Season	Predicted no. of collisions (no apportioning)	No. of collisions apportioned to pSPA
Density		
Post-breeding	26 (18-35)	1 (1-2)
Pre-breeding	14 (7-24)	1 (1-2)
Annual	83 (52-116)	20 (13-28)
Flight height distribution		
Post-breeding	26 (16-37)	1 (1-2)
Pre-breeding	14 (8-20)	1 (1-1)

Season	Predicted no. of collisions (no apportioning)	No. of collisions apportioned to pSPA
Annual	83 (49-118)	20 (12-29)

1.85 In the post-breeding season collision risk estimates decrease by over 7% when using the alternative hierarchical approach with a decrease of over 38% in the pre-breeding season. This leads to a decrease in the annual collision risk of nearly 9%. These decreases are therefore potentially significant, especially when considering the collision risk estimates calculated when using Options 2 or 3. However, when apportioned to the FFC pSPA population, the reduction in the actual number of collisions is minimal with a maximum of two collisions when using Option 2 at a 98.9% avoidance rate.

1.86 When using equivalent avoidance rates as those presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) (99.2% for Options 1 and 2 and 98% for Option 3), the number of collisions predicted in the pre-breeding season when using the alternative hierarchical approach represents up to a 0.02% increase in the baseline mortality of that population. In the post-breeding season the equivalent value is 0.01-0.04%.

1.87 For the RIAA assessment purposes, the total number of predicted collisions calculated when using the alternative hierarchical approach represents 0.01-0.05% of the pSPA population and up to a 0.06-0.32% increase in baseline mortality.

1.88 The change in collision risk values when applying the alternative hierarchical approach is considered to be negligible in both a EIA and RIAA context when considered against the relevant populations and increases in baseline mortality. The increase in cumulative or in-combination collision risk estimates is therefore also considered to negligible with the proportion of the cumulative/in-combination impact contributed by Hornsea Three essentially equivalent to that predicted when applying the original hierarchical approach. There is therefore considered to be no change in the conclusions reached in relation to cumulative and in-combination assessments in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Discussion

1.89 Collision risk estimates calculated using the alternative hierarchical approach are lower than those calculated using the original hierarchical approach presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). The difference between resulting collision risk estimates is however, considered to be negligible and immaterial in terms of the assessments conducted in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). As a result there are considered to be no implications for any of the assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) with no change in the conclusions reached.

1.90 The collision mortality estimated for the pre-breeding season is considerably below the 1% criteria of baseline mortality for the regional post- and pre-breeding season populations of kittiwake (1,212 and 917 birds respectively) when using all Band model Options and applying either hierarchical approach. A considerable increase in the densities of kittiwake at Hornsea Three would therefore be required in both the post- and pre-breeding seasons in order to surpass the respective 1% criteria of baseline mortality.

1.91 The annual collision risk estimate apportioned to FFC pSPA in the RIAA (Document 5.2) is below the 1% criteria of baseline mortality for the kittiwake population at FFC pSPA (130 birds). The post-breeding season contributes 6.8% of the annual collision risk apportioned to FFC pSPA with the pre-breeding season contributing just 3.2%. A considerable increase in densities used in collision risk modelling would therefore be required in both seasons to increase the overall annual collision risk estimate. This is considered highly unlikely based on the migratory movements and distribution of kittiwake during the post- and pre-breeding seasons.

1.92 December to March includes all of the pre-breeding season and one month of the post-breeding season for kittiwake. However, it is unlikely that large numbers of kittiwake will be present in the North Sea in December with peak migratory movements to wintering areas occurring between August and November meaning the majority of birds will have moved out of the North Sea to wintering areas (Furness, 2015). Migration back to breeding colonies begins in January or February with a peak in March, as recorded from sea-watching sites around the UK (Furness, 2015). The abundance of kittiwake at Hornsea Three during this period (January to March) is therefore likely to peak in March, with this reflected in the densities used for collision risk modelling.

1.93 Migratory movements during the pre-breeding season are likely to occur quickly through UK water as breeding birds return to colonies to secure nesting sites. As such, densities are unlikely to be as high as those that may occur in the breeding season, when breeding birds are spending more time foraging and the abundance of kittiwake in UK waters is increased by non-breeding and immature birds. This trend is evident in the densities calculated for Hornsea Three and used in collision risk modelling.

1.94 Kittiwake were recorded throughout the former Hornsea Zone during the post- and pre-breeding seasons (Figures B.3.36, B.3.37, B.3.39 and B.3.40 in SmartWind, 2015) although there is no obvious trend in the distribution of birds. Numbers in these seasons are much lower than recorded in the breeding season. Similar trends are evident in the densities calculated by WWT Consulting and MacArthur Green (2013) (Figure 1.48 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)) and Stone *et al*. (1995).

Conclusion

1.95 The changes that occur between the predicted impacts when applying the two hierarchical approaches are not considered to represent a material change in terms of either the impact magnitude or the assessment conclusions in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) in relation to collision risk impacts for kittiwake and associated (p)SPAs.

1.96 December to March is not considered likely to represent a period of peak abundance for kittiwake at Hornsea Three with considerable inter-annual variability unlikely, especially to the degree required to significantly alter the predicted impact magnitude or assessment conclusions. Monthly densities calculated for kittiwake in these months using either of the two hierarchical approaches are therefore considered to provide an accurate representation of the abundance of the species at Hornsea Three for use in collision risk modelling. The use of boat-based data for December to March to support the data collected during twenty months of aerial surveys is considered to provide a robust and accurate assessment of the impacts on kittiwake as a result collision risk impacts in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Lesser black-backed gull

Overview

1.97 As illustrated in Table 1.4, the non-breeding (winter) (November to February) and pre-breeding (March to April) seasons defined for lesser black-backed gull are affected by a change in the hierarchical approach applied to baseline data. As part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), assessments that relied on baseline data were conducted for lesser black-backed gull in relation to collision risk impacts only. The following sections present the results of collision risk modelling when applying the alternative hierarchical approach and consider these results in terms of EIA and RIAA assessments.

Alternative hierarchical approach

1.98 Collision risk estimates for lesser black-backed gull calculated using the alternative hierarchical approach are presented in Table 1.19. In the non-breeding season, no collisions are predicted although up to three are predicted if applying the upper confidence limit of density. In the pre-breeding season one collision is predicted using all Options of the Band (2012) CRM with this representing less than 0.01% of the regional pre-breeding population and up to a 0.01% increase in baseline mortality of the same population.

Table 1.19: Collision risk estimates for lesser black-backed gull calculated using the alternative hierarchical approach (95% confidence intervals are shown in brackets).

Season	Predicted no. of collisions (no apportioning)		
	Option 1 (99.5% avoidance rate)	Option 2 (99.5% avoidance rate)	Option 3 (98.9% avoidance rate)
Density			
Non-breeding	0 (0-2)	0 (0-3)	0 (0-2)
Pre-breeding	1 (0-2)	1 (0-3)	1 (0-2)
Annual	15 (4-27)	18 (5-33)	12 (3-22)
Flight height distribution			
Non-breeding	0 (1)	0 (0-1)	0 (0-1)

Season	Predicted no. of collisions (no apportioning)		
Pre-breeding	1 (3)	1 (1-3)	1 (0-3)
Annual	15 (35)	18 (10-39)	12 (6-36)

Comparison

1.99 The collision risk modelling results for lesser black-backed gull, incorporated into the assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) are presented in Table 1.20. No collisions were predicted in the non-breeding season, with no birds having being recorded as part of the datasets used to calculate densities.

1.100 The predicted number of collisions in the pre-breeding season represent less than 0.01% of the regional pre-breeding population and less than a 0.01% increase in the baseline mortality of the same population. The difference in these metrics when using the two different hierarchical approaches is therefore not considered to be significant with the increased collision risk predicted when using the alternative hierarchical approach representing only a 0.01% increase in baseline mortality

Table 1.20: Collision risk estimates for lesser black-backed gull calculated using the original hierarchical approach (95% confidence intervals are shown in brackets).

Season	Predicted no. of collisions (no apportioning)		
	Option 1 (99.5% avoidance rate)	Option 2 (99.5% avoidance rate)	Option 3 (98.9% avoidance rate)
Density			
Non-breeding	0 (0)	0 (0)	0 (0)
Pre-breeding	1 (0-1)	1 (0-2)	1 (0-1)
Annual	14 (4-24)	17 (5-30)	12 (3-20)
Flight height distribution			
Non-breeding	0 (0)	0 (0)	0 (0)
Pre-breeding	1 (2)	1 (0-2)	1 (0-2)
Annual	14 (33)	17 (10-37)	12 (5-34)

Discussion

1.101 Collision risk estimates calculated using the alternative hierarchical approach are higher than those calculated using the original hierarchical approach presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). However, the difference between resulting collision risk estimates is considered to be negligible and immaterial in terms of the assessments conducted in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). As a result there are considered to be no implications for any of the assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) if the alternative hierarchical approach were to be applied, with no change in the conclusions reached.

1.102 The collision mortality estimated for the non- and pre-breeding seasons is considerably below the respective 1% criteria of baseline mortality for the relevant regional populations of lesser black-backed gull (45 and 227 birds) when using all Band model Options and applying either hierarchical approach. A considerable increase in the densities of lesser black-backed gull at Hornsea Three would therefore be required in both seasons in order to surpass the respective 1% criteria of baseline mortality. This is however considered highly unlikely based on the migratory movements and distribution of lesser black-backed gull during the non- and pre-breeding seasons.

1.103 December to March covers the majority of the non-breeding season (November to February) and one month of the pre-breeding season (March) for lesser black-backed gull. As illustrated by the densities predicted when using either of the hierarchical approaches, very few lesser black-backed gulls are recorded across the former Hornsea Zone during the non-breeding season, as almost all birds have migrated to wintering areas further south. This is further illustrated by the distribution maps produced for the former Hornsea Zone using the boat-based data incorporated into the hierarchical approaches applied above (Figure B.3.21 and B.3.25 in SmartWind, 2015).

1.104 Very few birds were also recorded across the former Hornsea Zone during the pre-breeding season, although those that were recorded appear to be concentrated in the eastern part of the former Hornsea Zone (Figure B.3.22 and B.3.26 in SmartWind, 2015). This is captured in the densities used in collision risk modelling for lesser black-backed with the densities used in the pre-breeding season higher than those in the non-breeding season. Concentrations similar to those observed in the boat-based data from the former Hornsea Zone were however not evident in the densities calculated by WWT Consulting and MacArthur Green (2013) (Figure 1.51 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)) or Stone *et al*. (1995).

Conclusion

1.105 The changes that occur between the predicted impacts when applying the two hierarchical approaches are not considered to represent a material change in terms of either the impact magnitude or the assessment conclusions in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) in relation to collision risk impacts for lesser black-backed gull.

1.106 The non- and pre-breeding season are not considered likely to represent a period of peak abundance for lesser black-backed gulls at Hornsea Three with considerable inter-annual variability unlikely, especially to the degree required to significantly alter the predicted impact magnitude or assessment conclusions. The monthly densities calculated for lesser black-backed gull in both seasons using either of the two hierarchical approaches are therefore considered to provide an accurate representation of the abundance of the species at Hornsea Three during the non- and pre-breeding seasons for use in collision risk modelling. The use of boat-based data for December to March to support the data collected during twenty months of aerial surveys is considered to provide a robust and accurate assessment of the impacts on lesser black-backed gull as a result of collision risk in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5).

Great black-backed gull

Overview

1.107 As illustrated in Table 1.4 the only season defined for great black-backed gull affected by a change in the hierarchical approach applied to baseline data is the non-breeding season (August to April). As part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), assessments that relied on baseline data were conducted for great black-backed gull in relation to collision risk impacts only. The following sections present the results of collision risk modelling when applying the alternative hierarchical approach and consider these results in terms of EIA and RIAA assessments.

Alternative hierarchical approach

1.108 Collision risk estimates for great black-backed gull calculated using the alternative hierarchical approach are presented in Table 1.21. In the non-breeding season, 26-53 collisions are predicted representing 0.03-0.06% of the regional non-breeding population and a 0.40-0.84% increase in the baseline mortality of the same population.

Table 1.21: Collision risk estimates for great black-backed gull calculated using the alternative hierarchical approach (95% confidence intervals are shown in brackets).

Season	Predicted no. of collisions (no apportioning)		
	Option 1 (99.5% avoidance rate)	Option 2 (99.5% avoidance rate)	Option 3 (98.9% avoidance rate)
Density			
Non-breeding	26 (6-43)	53 (12-90)	42 (30-102)
Annual	33 (6-58)	69 (13-121)	55 (38-132)
Flight height distribution			
Non-breeding	26 (67)	53 (42-92)	42 (10-71)
Annual	33 (87)	69 (54-120)	55 (10-96)

Comparison

1.109 The collision risk modelling results for great black-backed gull, incorporated into the assessments conducted in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) are presented in Table 1.22. The predicted number of collisions represent 0.03-0.06% of the regional non-breeding population and a 0.38-0.79% increase in the baseline mortality of the same population. The difference in these metrics when using the two different hierarchical approaches is therefore not considered to be significant with the increased collision risk predicted when using the alternative hierarchical approach representing only a 0.02-0.05% increase in baseline mortality.

Table 1.22: Collision risk estimates for great black-backed gull calculated using the original hierarchical approach (95% confidence intervals are shown in brackets).

Season	Predicted no. of collisions (no apportioning)		
	Option 1 (99.5% avoidance rate)	Option 2 (99.5% avoidance rate)	Option 3 (98.9% avoidance rate)
Density			
Non-breeding	24 (10-39)	50 (20-82)	40 (16-65)
Annual	32 (10-54)	66 (20-113)	52 (16-90)
Flight height distribution			
Non-breeding	24 (63)	50 (40-87)	40 (28-96)
Annual	32 (83)	66 (52-114)	52 (37-126)

Discussion

1.110 Collision risk estimates calculated using the alternative hierarchical approach are higher than those calculated using the original hierarchical approach presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). However, the difference between resulting collision risk estimates is considered to be negligible and immaterial in terms of the assessments conducted in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). As a result there are considered to be no implications for any of the assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) if the alternative hierarchical approach were to be applied, with no change in the conclusions reached.

1.111 The collision mortality estimated for the non-breeding season is below the 1% criteria of baseline mortality for the regional non-breeding population of great black-backed gull (64 birds) when using all Band model Options and applying either hierarchical approach. An increase in the densities of great black-backed gull at Hornsea Three would therefore be required in order to surpass the respective 1% criteria of baseline mortality.

1.112 December to March covers part of the non-breeding season defined for great black-backed gull (August to April). Great black-backed gulls breeding in the UK are only partial migrants with breeding adults remaining close to breeding areas or travelling only short distances (median distance travelled = 54 km (Wernham *et al*, 2002)). Immature birds travel slightly further than adults with a median distance of 115 km (Wernham *et al*., (2002). However, birds from northern populations (i.e. those outside of the UK) do exhibit long distance migratory movements with many from northern Norway and Russia overwintering in the North Sea (Furness, 2015).

1.113 An increase in the number of great black-backed gulls in the North Sea is reflected in the distribution maps produced for the former Hornsea Zone (see Figures B.3.31 to B.3.34 in SmartWind, 2015), with more birds present in the non-breeding season when compared to the breeding season. However, there is no obvious trend in the distribution of these birds across the former Hornsea Zone. This is also reflected in the density maps produced by WWT Consulting and MacArthur Green (2013) and Stone *et al*. (1995).

1.114 Densities of great black-backed gull recorded at Hornsea Three between January and March are low (less than 0.15 birds/km2). The population estimates of great black-backed gull calculated for Hornsea Project One and Hornsea Project Two suggest that there is, in assessment terms, limited inter-annual variability of great black-backed gull in areas adjacent to Hornsea Three between December and March. It is unlikely that Hornsea Three represents an area of higher importance to great black-backed gull when compared to Hornsea Projects One and Two and therefore it is unlikely that a high degree of inter-annual variability would occur at Hornsea Three.

Conclusion

1.115 The changes that occur between the predicted impacts when applying the two hierarchical approaches are not considered to represent a material change in terms of either the impact magnitude or the assessment conclusions in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) in relation to collision risk impacts for great black-backed gull.

1.116 Considerable inter-annual variability in the abundance of great black-backed gull at Hornsea Three is considered unlikely, especially to the degree required to significantly alter the predicted impact magnitude or assessment conclusions. The monthly densities calculated for great black-backed gull in both seasons using either of the two hierarchical approaches are therefore considered to provide an accurate representation of the abundance of the species at Hornsea Three during the non-breeding season for use in collision risk modelling. The use of boat-based data for December to March to support the data collected during twenty months of aerial surveys is considered to provide a robust and accurate assessment of the impacts on lesser black-backed gull as a result of collision risk in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5).

Guillemot

Overview

1.117 As illustrated in Table 1.4 both the breeding (March to July) and non-breeding (August to February) seasons defined for guillemot are affected by a change in the hierarchical approach applied to baseline data. As part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), assessments that relied on baseline data were conducted for guillemot in relation to displacement impacts only. As such, the following sections consider the potential effects of displacement on guillemot in the breeding and non-breeding seasons.

Alternative hierarchical approach

Breeding season

1.118 The peak population of guillemot estimated for Hornsea Three plus a 2 km buffer occurred in June and July of the two respective years of aerial surveys undertaken across Hornsea Three. The populations of guillemot estimated for Hornsea Three plus a 2 km buffer using the various data sources (Hornsea Three or the Hornsea Zone) do not surpass the two peak populations estimates and therefore the mean-peak population calculated when applying the original and alternative hierarchical approaches is the same (13,374 individuals).

Non-breeding season

1.119 Displacement analysis for guillemot in the non-breeding season using a mean-peak population estimate calculated using the alternative hierarchical approach is presented in Table 1.23. Using a displacement rate of 50% and a mortality rate of 1% provides a displacement mortality of 116 birds. This represents 0.01% of the regional population (1,617,306 individuals) and a 0.12% increase in the baseline mortality of the same population (98,656 individuals).

1.120 In the non-breeding season, 4.4% of the predicted displacement mortality is attributable to the FFC pSPA population of guillemot, with this value calculated based on the contribution of FFC pSPA to the non-breeding BDMPS population as defined by Furness (2015). From a displacement mortality of 116 birds (50% displacement, 1% mortality), five birds are attributable to the FFC pSPA population. This represents 0.01% of the pSPA population and a 0.1% increase in baseline mortality.

Table 1.23: Predicted displacement mortality for guillemot during the non-breeding season when applying the alternative hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	23	46	116	232	465	697	929	1162	1394	1626	1859	2091	2323
20	46	93	232	465	929	1394	1859	2323	2788	3253	3717	4182	4646
30	70	139	348	697	1394	2091	2788	3485	4182	4879	5576	6273	6970

	Mortality rate (%)												
40	93	186	465	929	1859	2788	3717	4646	5576	6505	7434	8364	9293
50	116	232	581	1162	2323	3485	4646	5808	6970	8131	9293	10455	11616
60	139	279	697	1394	2788	4182	5576	6970	8364	9758	11152	12545	13939
70	163	325	813	1626	3253	4879	6505	8131	9758	11384	13010	14636	16263
80	186	372	929	1859	3717	5576	7434	9293	11152	13010	14869	16727	18586
90	209	418	1045	2091	4182	6273	8364	10455	12545	14636	16727	18818	20909
100	232	465	1162	2323	4646	6970	9293	11616	13939	16263	18586	20909	23232
Regional BDMPS population = 1,617,306 individuals Background mortality = 0.061			< 1% background mortality					> 1% background mortality					

Comparison

1.121 The displacement mortality of guillemot in the non-breeding season calculated using the original hierarchical approach is 89 birds (Table 1.24). The displacement mortality calculated using the alternative hierarchical approach is therefore higher than that calculated when using the original hierarchical approach.

1.122 The original displacement mortality assessed in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) represented 0.01% of the regional non-breeding population and a 0.09% increase in the baseline mortality of the same population. The difference in these metrics when using the two different hierarchical approaches is therefore not considered to be significant with the increased displacement mortality predicted when using the alternative hierarchical approach representing only a 0.03% increase in baseline mortality

Table 1.24: Predicted displacement mortality for guillemot during the non-breeding season when applying the original hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	18	36	89	178	355	533	711	889	1066	1244	1422	1599	1777
20	36	71	178	355	711	1066	1422	1777	2133	2488	2843	3199	3554
30	53	107	267	533	1066	1599	2133	2666	3199	3732	4265	4798	5332
40	71	142	355	711	1422	2133	2843	3554	4265	4976	5687	6398	7109
50	89	178	444	889	1777	2666	3554	4443	5332	6220	7109	7997	8886
60	107	213	533	1066	2133	3199	4265	5332	6398	7464	8530	9597	10663

	Mortality rate (%)												
70	124	249	622	1244	2488	3732	4976	6220	7464	8708	9952	11196	12440
80	142	284	711	1422	2843	4265	5687	7109	8530	9952	11374	12796	14217
90	160	320	800	1599	3199	4798	6398	7997	9597	11196	12796	14395	15995
100	178	355	889	1777	3554	5332	7109	8886	10663	12440	14217	15995	17772

Regional BDMPS population = 1,617,306 individuals

Background mortality = 0.061

< 1% background mortality

> 1% background mortality

1.123 The displacement mortality attributable to the FFC pSPA guillemot population as calculated in the RIAA (Document 5.2) was four birds, representing less than 0.01% of the pSPA population and a 0.08% increase in the baseline mortality of the pSPA population. The difference in these metrics when using the two different hierarchical approaches is therefore not considered to be significant with the increased displacement mortality predicted when using the alternative hierarchical approach representing only a 0.02% increase in baseline mortality.

Discussion

1.124 For both the EIA and RIAA assessments the difference between the proportion of the relevant population represented by the impact and the increase in baseline mortality of the relevant population when using the two different hierarchical approaches is not considered to be significant. The increased displacement mortality predicted when using the alternative hierarchical approach represents only a 0.03% and 0.02% increase in the baseline mortality of the regional non-breeding and pSPA populations, respectively. The conclusions reached in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) are therefore considered to remain valid.

1.125 In order for the conclusions drawn in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) to be altered there would need to be a considerable increase in the mean-peak population of guillemot calculated for the non-breeding season. The baseline mortality criteria of 1% which is used to inform the assessments conducted in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) is 987 birds in the non-breeding season. The mean-peak population of guillemot required in order to reach an impact of 987 birds would be over 197,000 birds when applying a 50% displacement rate and 1% mortality rate. Populations of this size have not been recorded at Hornsea Three in any season, even when including a 4 km buffer around Hornsea Three or the upper confidence limit associated with population estimates (see Table 1.26 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)). When applying the upper rates from the range recommend by Natural England (70% displacement and 10% mortality) a population of over 14,000 birds would be required. Populations of this size have been recorded at Hornsea Three plus a 2 km buffer, however, it is considered highly unlikely that these displacement and mortality rates would apply to guillemot in the pre-breeding season with a mortality rate of 1% considered sufficiently precautionary for projects in Scottish waters (MS-LOT, 2017).

1.126 In the RIAA (Document 5.2), the 1% criteria of baseline mortality is 51 birds, representing the baseline mortality of the guillemot population at FFC pSPA. A mean-peak population of over 231,000 birds would therefore be required for the impact apportioned to FFC pSPA to reach this level of impact when using a displacement rate of 50% and a mortality rate of 1%. Even if using the upper rates from the range recommended by Natural England (70% displacement and 10% mortality) would require a mean-peak population of over 16,500 birds, although the application of these rates is considered to represent a considerable over-estimate of the likely displacement mortality in the pre-breeding season.

1.127 The months for which only one year of aerial survey data were collected at Hornsea Three represent part of the non-breeding season (December to February) and one month of the breeding season (March) defined for guillemot. As already discussed the lack of two years of data for March is not considered to alter the mean-peak population estimate calculated for guillemot, with March unlikely to represent the month of peak abundance for guillemot in any year.

1.128 Following the breeding season, guillemots undergo a post-breeding moult during which time birds are flightless. During this period, guillemots disperse from their breeding colonies with those breeding on east coast of the UK dispersing into the North Sea to traditional areas where foraging opportunities are presumably predictable and abundant (Wernham *et al*., 2002). This leads to increases in the abundance of guillemot in sea areas adjacent to breeding colonies, especially between August and October (Stone *et al*., 1995). Following the post-breeding moult birds, disperse widely across the North Sea.

1.129 In the non-breeding season, the use of the alternative hierarchical approach results in a considerable increase in the mean-peak population calculated for the non-breeding season, although this is deemed to be immaterial in assessment terms. The estimated populations are not, however considered to be representative of the abundance of birds at Hornsea Three. The populations derived from the alternative hierarchical approach are calculated using data from the former Hornsea Zone which stretches from approximately 40 km to 180 km from the UK east coast. Hornsea Three is located in the eastern part of the former Hornsea Zone with the western edge of Hornsea Three approximately 150 km from the UK east coast. It is therefore likely that the trends in the abundance of guillemot across the zone will differ markedly across an annual cycle, with higher densities higher closer to breeding colonies as birds remain close to breeding areas throughout an annual cycle (Furness, 2015).

1.130 The peaks in abundance obtained through aerial surveys of Hornsea Three occurred in November and December whereas in the former Hornsea Zone boat-based data peaks occurred in August or September (SmartWind, 2015). Peaks in August and September are not reflected in population estimates calculated for Hornsea Three from the two years of aerial survey data that cover this period. Peaks occurring in August and September are likely to represent the dispersal of guillemot away from colonies into the North Sea with this likely to be especially evident in sea areas located in close proximity to breeding colonies (e.g. the western area of the former Hornsea Zone). This is evident in the distribution of guillemot across the former Hornsea Zone as recorded by boat-based surveys undertaken in Year 1 for Hornsea Project Two (Figure B.3.46 in SmartWind, 2015) and by the analyses conducted by WWT Consulting and MacArthur Green (2013) (Figure 1.44 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)). It is therefore considered that the use of the alternative hierarchical approach does not provide a representative mean-peak non-breeding season for use in displacement analyses.

Conclusion

1.131 The changes that occur between the predicted impacts when applying the two hierarchical approaches are not considered to represent a material change in terms of either the impact magnitude or the assessment conclusions in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2)in relation to impacts from operational displacement from the Hornsea Three array area for guillemot and associated (p)SPAs.

1.132 The abundance of guillemot at Hornsea Three is considered unlikely to exhibit a large degree of inter-annual variability in the non-breeding season, especially not to the extent required to result in a significant impact in EIA or RIAA terms. The mean-peak population calculated for the non-breeding using the original hierarchical approach is therefore considered to accurately represent the population of guillemot at Hornsea Three and provide an accurate impact magnitude upon which assessments can be based in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Razorbill

Overview

1.133 As illustrated in Table 1.4 both the non-breeding (November to December) and pre-breeding (January to March) seasons defined for razorbill are affected by a change in the hierarchical approach applied to baseline data. As part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), assessments that relied on baseline data were conducted for razorbill in relation to displacement impacts only. As such, the following sections consider the potential effects of displacement on razorbill in the non-breeding and pre-breeding seasons

Alternative hierarchical approach

Non-breeding season

1.134 Displacement analysis for razorbill in the non-breeding season using a mean-peak population estimate calculated using the alternative hierarchical approach is presented in Table 1.25. Using a displacement rate of 40% and a mortality rate of 1% provides a displacement mortality of ten birds. This represents less than 0.01% of the regional population (218,622 individuals) and a 0.05% increase in the baseline mortality of the same population (22,955 individuals).

Table 1.25: Predicted displacement mortality for razorbill during the non-breeding season when applying the alternative hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	3	5	13	26	52	78	104	130	156	182	209	235	261
20	5	10	26	52	104	156	209	261	313	365	417	469	521
30	8	16	39	78	156	235	313	391	469	547	626	704	782
40	10	21	52	104	209	313	417	521	626	730	834	939	1043
50	13	26	65	130	261	391	521	652	782	912	1043	1173	1303
60	16	31	78	156	313	469	626	782	939	1095	1251	1408	1564
70	18	36	91	182	365	547	730	912	1095	1277	1460	1642	1825
80	21	42	104	209	417	626	834	1043	1251	1460	1668	1877	2086
90	23	47	117	235	469	704	939	1173	1408	1642	1877	2112	2346
100	26	52	130	261	521	782	1043	1303	1564	1825	2086	2346	2607
Regional BDMPS population = 218,622 individuals Background mortality = 0.105				< 1% background mortality					> 1% background mortality				

1.135 In the non-breeding season, 2.7% of the predicted displacement mortality is attributable to the FFC pSPA population of razorbill, with this value calculated based on the contribution of FFC pSPA to the non-breeding BDMPS population as defined by Furness (2015). From a displacement mortality of ten birds (40% displacement, 1% mortality), less than one bird is attributable to the FFC pSPA population. This therefore represents a negligible proportion of the pSPA population and a negligible increase in baseline mortality.

Pre-breeding season

1.136 Displacement analysis for razorbill in the pre-breeding season using a mean-peak population estimate calculated using the alternative hierarchical approach is presented in Table 1.26. Using a displacement rate of 40% and a mortality rate of 2% provides a displacement mortality of 18 birds. This represents less than 0.01% of the regional population (591,874 individuals) and a 0.03% increase in the baseline mortality of the same population (62,147 individuals).

Table 1.26: Predicted displacement mortality for razorbill during the pre-breeding season when applying the alternative hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	2	4	11	22	44	67	89	111	133	155	177	200	222
20	4	9	22	44	89	133	177	222	266	310	355	399	444
30	7	13	33	67	133	200	266	333	399	466	532	599	665
40	9	18	44	89	177	266	355	444	532	621	710	798	887
50	11	22	55	111	222	333	444	554	665	776	887	998	1109
60	13	27	67	133	266	399	532	665	798	931	1064	1197	1331
70	16	31	78	155	310	466	621	776	931	1087	1242	1397	1552
80	18	35	89	177	355	532	710	887	1064	1242	1419	1597	1774
90	20	40	100	200	399	599	798	998	1197	1397	1597	1796	1996
100	22	44	111	222	444	665	887	1109	1331	1552	1774	1996	2218
Regional BDMPS population = 591,674 individuals Background mortality = 0.105			< 1% background mortality					> 1% background mortality					

1.137 In the pre-breeding season, 3.4% of the predicted displacement mortality is attributable to the FFC pSPA population of razorbill, with this value calculated based on the contribution of FFC pSPA to the pre-breeding BDMPS population as defined by Furness (2015). From a displacement mortality of 18 birds (40% displacement, 1% mortality), less than one bird is attributable to the FFC pSPA population. This therefore represents a negligible proportion of the pSPA population and a negligible increase in the baseline mortality of the pSPA population.

Comparison

Non-breeding season

1.138 The displacement mortality of razorbill in the non-breeding season calculated using the original hierarchical approach is 15 birds (Table 1.27). This is higher than that predicted using the alternative hierarchical approach (Table 1.25) and therefore represents a higher proportion of the regional population (0.01%) and a larger increase in the baseline mortality of that population (0.06%). The difference in these metrics when using the two different hierarchical approaches is therefore not considered to be significant with the increased displacement mortality predicted when using the original hierarchical approach representing only a 0.01% increase in baseline mortality.

Table 1.27: Predicted displacement mortality for razorbill during the non-breeding season when applying the original hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	4	7	18	36	73	109	146	182	219	255	292	328	365
20	7	15	36	73	146	219	292	365	438	511	584	657	730
30	11	22	55	109	219	328	438	547	657	766	876	985	1095
40	15	29	73	146	292	438	584	730	876	1022	1168	1314	1460
50	18	36	91	182	365	547	730	912	1095	1277	1460	1642	1825
60	22	44	109	219	438	657	876	1095	1314	1533	1752	1970	2189
70	26	51	128	255	511	766	1022	1277	1533	1788	2043	2299	2554
80	29	58	146	292	584	876	1168	1460	1752	2043	2335	2627	2919
90	33	66	164	328	657	985	1314	1642	1970	2299	2627	2956	3284
100	36	73	182	365	730	1095	1460	1825	2189	2554	2919	3284	3649

Regional BDMPS population = 218,622 individuals Background mortality = 0.105	< 1% background mortality	> 1% background mortality

1.139 The level of mortality estimated to be attributable to the FFC pSPA population of razorbill in the non-breeding season (less than one bird) in the RIAA (Document 5.2) was considered to be negligible both in terms of the proportion of the pSPA population and the increase in baseline mortality of the pSPA population. This is therefore consistent with the conclusion reached when applying the alternative hierarchical approach.

Pre-breeding season

1.140 The displacement mortality of razorbill in the pre-breeding season calculated using the original hierarchical approach is ten birds (Table 1.27). The displacement mortality calculated using the alternative hierarchical approach is therefore higher than that calculated when using the original hierarchical approach.

1.141 The original displacement mortality assessed in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) represented less than 0.01% of the regional non-breeding population and a 0.02% increase in the baseline mortality of the same population. The difference in these metrics when using the two different hierarchical approaches is therefore not considered to be significant with the increased displacement mortality predicted when using the alternative hierarchical approach representing only a 0.01% increase in baseline mortality

Table 1.28: Predicted displacement mortality for razorbill during the pre-breeding season when applying the original hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	1	2	6	12	25	37	49	62	74	87	99	111	124
20	2	5	12	25	49	74	99	124	148	173	198	223	247
30	4	7	19	37	74	111	148	185	223	260	297	334	371
40	5	10	25	49	99	148	198	247	297	346	396	445	495
50	6	12	31	62	124	185	247	309	371	433	495	556	618
60	7	15	37	74	148	223	297	371	445	519	593	668	742
70	9	17	43	87	173	260	346	433	519	606	692	779	865
80	10	20	49	99	198	297	396	495	593	692	791	890	989
90	11	22	56	111	223	334	445	556	668	779	890	1001	1113
100	12	25	62	124	247	371	495	618	742	865	989	1113	1236
Regional BDMPS population = 591,674 individuals Background mortality = 0.105			< 1% background mortality					> 1% background mortality					

1.142 A negligible proportion of the FFC pSPA population is impacted when applying the alternative hierarchical approach with this translating to a negligible increase in the baseline mortality of the FFC pSPA population. This conclusion was also reached as part of the RIAA (Document 5.2) when using the original hierarchical approach.

Discussion

1.143 The displacement mortality for razorbill in the non-breeding season predicted when using the alternative hierarchical approach is lower than that predicted when using the original hierarchical approach. For both the EIA and RIAA assessments, the difference between the proportion of the relevant population represented by the impact and the increase in baseline mortality of the relevant population when using the two different hierarchical approaches in the pre-breeding season is not considered to be significant. The increased displacement mortality predicted when using the alternative hierarchical approach represents only a 0.01% increase in the baseline mortality of the regional pre-breeding population and a negligible increase in the baseline mortality of the FFC pSPA population. The conclusions reached in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) are therefore considered to remain valid.

1.144 In order for the conclusions drawn in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) to be altered there would need to be a considerable increase in the mean-peak populations of razorbill calculated for the non- and pre-breeding seasons. The baseline mortality criteria of 1% which is used to inform the assessments conducted in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) is 230 birds in the non-breeding season and 621 birds in the pre-breeding season. The mean-peak populations of razorbill required in order to reach impacts of these magnitudes would be 57,500 birds in the non-breeding season and over 77,500 birds in the pre-breeding season when applying a 40% displacement rate and either a 2% (pre-breeding season) or 1% (non-breeding season) mortality rate. Populations of this size have not been recorded at Hornsea Three in any season, even when including a 4 km buffer around Hornsea Three or the upper confidence limit associated with population estimates (see Table 1.24 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)). When applying the upper rates from the range recommended by Natural England (70% displacement and 10% mortality) a population of nearly 3,300 and 9,000 birds would be required in the non- and pre-breeding seasons respectively. Populations of over 3,300 birds (but not 9,000 birds, even when considering the upper confidence limits associated with data for Hornsea Three plus a 4 km buffer) have been recorded at Hornsea Three plus a 2 km buffer, however, it is considered highly unlikely that these displacement and mortality rates would apply to razorbill in the pre-breeding season.

1.145 In the RIAA (Document 5.2), the 1% criteria of baseline mortality is 22 birds, representing the baseline mortality of the razorbill population at FFC pSPA. A mean-peak population of over 200,000 birds in the non-breeding season and 81,000 in the pre-breeding season would therefore be required for the impact apportioned to FFC pSPA to reach this level of impact when using a displacement rate of 40% and a mortality rate of 1%. Even if using the upper rates from the range recommended by Natural England (70% displacement and 10% mortality) would require a mean-peak population of nearly 11,500 birds in the non-breeding season and over 9,300 birds in the pre-breeding season, with populations of this magnitude not recorded at Hornsea Three in any season.

1.146 The months for which only one year of aerial survey data were collected at Hornsea Three represent the one month of the non-breeding season (December) and the pre-breeding season (January to March) defined for razorbill. After the breeding season and the completion of a post-breeding moult there is a gradual movement of razorbill southwards with these movements generally completed by October or November-December (Wernham *et al*., 2002; Furness, 2015). It is therefore likely that the large majority of razorbill that breed in the UK will have moved to wintering areas by December and it is unlikely that the southern North Sea would contain large numbers of the species at this time.

1.147 The number of birds recorded in the non-breeding season across the former Hornsea Zone support this, with very few razorbill recorded during this period (SmartWind, 2015). However, it is important to note that survey coverage during this period was incomplete with this potentially affecting the abundance of birds recorded. Lower numbers of razorbill at Hornsea Three in the winter (when compared to other seasons) is also evident in the densities calculated by WWT Consulting and MacArthur Green (2013) (Figure 1.43 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)) and Stone *et al*. (1995).

1.148 From January there is a gradual northward movement of razorbills back towards breeding colonies (Wernham *et al*., 2002; Furness, 2015). This is reflected in the population estimates calculated for Hornsea Three and across the former Hornsea Zone with the abundance of razorbill increasing through this period to a peak in March. The peak pre-breeding season population estimates calculated using the former Hornsea Zone data are reasonably comparable ranging from 2,228 to 2,831 birds (Table 1.9 in Volume 5, Annex 5.4: Data Hierarchy Report (Document 6.5.5.4)), with any inter-annual variability being immaterial in terms of both the EIA and RIAA assessments. Limited inter-annual variability is also evident in the population estimates calculated for Hornsea Project Two, with the peak pre-breeding season population ranging from 1,845 to 2,515 birds (see Table 6.37 in SmartWind, 2015).

Conclusion

1.149 The changes that occur between the predicted impacts when applying the two hierarchical approaches are not considered to represent a material change in terms of either the impact magnitude or the assessment conclusions in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2)in relation to impacts from operational displacement from the Hornsea Three array area or collision risk for razorbill and associated (p)SPAs.

1.150 The non-breeding and pre-breeding seasons are not considered likely to represent a period of peak abundance for razorbill at Hornsea Three with considerable inter-annual variability unlikely, especially to the degree required to significantly alter the predicted impact magnitude or assessment conclusions. The mean-peak population calculated for razorbill in these seasons using either of the two hierarchical approaches are therefore considered to provide an accurate representation of the abundance of the species at Hornsea Three during these seasons for use in displacement analyses. The use of boat-based data for December to March to support the data collected during twenty months of aerial surveys is considered to provide a robust and accurate assessment of the impacts on razorbill as a result of operational displacement in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Puffin

Overview

1.151 As illustrated in Table 1.4 the only season defined for puffin affected by a change in the hierarchical approach applied to baseline data is the non-breeding season (August to April). As part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), assessments that relied on baseline data were conducted for puffin in relation to displacement impacts only. As such, the following sections consider the potential effects of displacement on puffin in the non-breeding season.

Alternative hierarchical approach

1.152 As illustrated in Table 1.4 the only season defined for puffin affected by a change in the hierarchical approach applied to baseline data is the non-breeding season (August to April). As part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2), assessments that relied on baseline data were conducted for puffin in relation to displacement impacts only. As such, the following sections consider the potential effects of displacement on puffin in the non-breeding season.

Table 1.29: Predicted displacement mortality for puffin during the non-breeding season when applying the alternative hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	2	4	9	19	37	56	74	93	112	130	149	167	186
20	4	7	19	37	74	112	149	186	223	260	298	335	372
30	6	11	28	56	112	167	223	279	335	391	447	502	558
40	7	15	37	74	149	223	298	372	447	521	595	670	744
50	9	19	47	93	186	279	372	465	558	651	744	837	930
60	11	22	56	112	223	335	447	558	670	781	893	1005	1116
70	13	26	65	130	260	391	521	651	781	912	1042	1172	1302
80	15	30	74	149	298	447	595	744	893	1042	1191	1340	1488
90	17	33	84	167	335	502	670	837	1005	1172	1340	1507	1675
100	19	37	93	186	372	558	744	930	1116	1302	1488	1675	1861
Regional BDMPS population = 231,957 individuals Background mortality = 0.094			< 1% background mortality					> 1% background mortality					

1.153 In the non-breeding season, 0.41% of the predicted displacement mortality is attributable to the FFC pSPA population of puffin, with this value calculated based on the contribution of FFC pSPA to the non-breeding BDMPS population as defined by Furness (2015). From a displacement mortality of nine birds (50% displacement, 1% mortality), less than one bird is attributable to the FFC pSPA population. This therefore represents a negligible proportion of the pSPA population and a negligible increase in baseline mortality.

Comparison

1.154 The displacement mortality of puffin in the pre-breeding season calculated using the original hierarchical approach is one bird (Table 1.30). The displacement mortality calculated using the alternative hierarchical approach is therefore higher than that calculated when using the original hierarchical approach.

1.155 The original displacement mortality assessed in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) represented less than 0.01% of the regional non-breeding population and less than a 0.01% increase in the baseline mortality of the same population. The overall conclusion of significance for displacement impacts on puffin from Hornsea Three was therefore considered to represent no more than an impact of minor adverse significance.

1.156 The difference in the proportion of the regional population and increase in baseline mortality of that population represented by the displacement mortality calculated when using the two different hierarchical approaches is not considered to be significant. The increased displacement mortality predicted when using the alternative hierarchical approach represents only a 0.04% increase in baseline mortality and therefore there is considered to be no change in the conclusions drawn for puffin as part of Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5).

Table 1.30: Predicted displacement mortality for puffin during the non-breeding season when applying the original hierarchical approach.

	Mortality rate (%)												
Displaced (%)	1	2	5	10	20	30	40	50	60	70	80	90	100
10	0	0	1	1	3	4	5	6	8	9	10	11	13
20	0	1	1	3	5	8	10	13	15	18	20	23	25
30	0	1	2	4	8	11	15	19	23	27	30	34	38
40	1	1	3	5	10	15	20	25	30	36	41	46	51
50	1	1	3	6	13	19	25	32	38	44	51	57	63
60	1	2	4	8	15	23	30	38	46	53	61	69	76
70	1	2	4	9	18	27	36	44	53	62	71	80	89
80	1	2	5	10	20	30	41	51	61	71	81	91	102
90	1	2	6	11	23	34	46	57	69	80	91	103	114

	Mortality rate (%)												
100	1	3	6	13	25	38	51	63	76	89	102	114	127
Regional BDMPS population = 231,957 individuals Background mortality = 0.094				< 1% background mortality					> 1% background mortality				

1.157 In the RIAA (Document 5.2), less than one bird was calculated as being attributable to the FFC pSPA puffin population in the non-breeding season. This is consistent with the number of birds considered to be attributable to FFC pSPA when using the alternative hierarchical approach.

1.158 When using both the original and alternative hierarchical approaches a negligible proportion of the FFC pSPA population is considered to be impacted by displacement during the non-breeding season. The impacts predicted using both approaches also represent a negligible increase in the baseline mortality of the FFC pSPA population.

Discussion

1.159 For both the EIA and RIAA assessments the difference between the proportion of the relevant population represented by the impact and the increase in baseline mortality of the relevant population when using the two different hierarchical approaches is not considered to be significant. The increased displacement mortality predicted when using the alternative hierarchical approach represents a negligible increase in the baseline mortality of the regional non-breeding and only a 0.04% increase in the baseline mortality of the pSPA population. The conclusions reached in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2)are therefore considered to remain valid.

1.160 In order for the conclusions drawn in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) to be altered there would need to be a considerable increase in the mean-peak population derived for the non-breeding season. The baseline mortality criteria of 1% which is used to inform the assessments conducted in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) is 218 birds. The mean-peak population of puffin required in order to reach an impact of 218 birds would be over 43,600 birds when applying a 50% displacement rate and 1% mortality rate. Even when applying the upper rates from the range recommended by Natural England (70% displacement and 10% mortality) a population of over 3,100 birds would be required. Populations of this size have not been recorded at Hornsea Three in any season, even when including a 4 km buffer around Hornsea Three or the upper confidence limit associated with population estimates (see Table 1.22 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)).

1.161 In the RIAA (Document 5.2), the 1% criteria of baseline mortality is two birds, representing the baseline mortality of the puffin population at FFC pSPA. A mean-peak population of nearly 97,000 birds would therefore be required for the impact apportioned to FFC pSPA to reach this level of impact when using a displacement rate of 50% and a mortality rate of 1%. Even if using the upper rates from the range recommended by Natural England (70% displacement and 10% mortality) would require a mean-peak population of over 6,900 birds.

1.162 December to March falls within the non-breeding season defined for puffin (August to April). It is unlikely that large numbers of puffin will be recorded at Hornsea Three throughout this period with birds having migrated to wintering areas and unlikely to occur in large numbers in the southern North Sea. Post-breeding movements of puffin begin in July with migration away from colonies largely complete by August (Furness, 2015). As such, very few puffin are present in the southern North Sea from September onwards. Migration back to breeding colonies starts in January but does not peak until March-April (Furness, 2015). As such, it is possible that the abundance of puffin may increase at Hornsea Three in March.

1.163 In the non-breeding season, the use of the alternative hierarchical approach results in a considerable increase in the mean-peak population calculated for the non-breeding season, although the magnitude of increase is deemed to be immaterial in assessment terms. The populations used to calculate this population however, are not considered to be representative of the abundance of birds at Hornsea Three. The populations used in the alternative hierarchical approach are calculated using data from the former Hornsea Zone which stretches from approximately 40 km to 180 km from the UK east coast. Hornsea Three is located in the eastern part of the former Hornsea Zone with the western edge of Hornsea Three approximately 150 km from the UK east coast. It is therefore likely that the trends in the abundance of puffin across the zone will differ markedly across an annual cycle.

1.164 Differences in the abundance of puffin across the former Hornsea Zone in the non-breeding season are illustrated in the distribution maps presented in SmartWind (2015). The distribution of puffin across the former Hornsea Zone in the non-breeding season is concentrated towards the western half of the zone (Figure B.3.60 and B.3.62 in SmartWind, 2015). The non-breeding season defined for puffin includes periods within which puffins will be dispersing from and migrating back to breeding colonies, and the trend evident in the distribution of puffin across the former Hornsea Zone may be reflective of these movements. Analyses conducted by WWT Consulting and MacArthur Green (2013) (Figure 1.42 in Volume 5, Annex 5.1: Baseline Characterisation Report (Document 6.5.5.1)) and Stone *et al*. (1995) also suggest differing trends in the abundance of puffin across the former Hornsea Zone in the relevant non-breeding periods within each report. It is therefore considered that the use of the alternative hierarchical approach does not provide a representative mean-peak non-breeding season for use in displacement analyses.

Conclusion

1.165 The changes that occur between the predicted impacts when applying the two hierarchical approaches are not considered to represent a material change in terms of either the impact magnitude or the assessment conclusions in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2)in relation to impacts from operational displacement from the Hornsea Three array area for puffin and associated (p)SPAs.

1.166 The abundance of puffin at Hornsea Three is considered unlikely to exhibit a large degree of inter-annual variability in the non-breeding season, especially not to the extent required to result in a significant impact in EIA or RIAA terms. The mean-peak population calculated for the non-breeding using the original hierarchical approach is therefore considered to accurately represent the population of puffin at Hornsea Three and provide an accurate impact magnitude upon which assessments can be based in both Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2).

Summary

1.167 This report focused on answering three questions, as outlined in the Introduction:

- Does the aerial survey programme undertaken at Hornsea Three provide an adequate baseline characterisation?;
- Is there likely to be significant inter-annual variation in those months for which there is only one year of aerial survey data?; and
- Does the application of an alternative hierarchical approach, considered to be more robust by Natural England, have implications for the assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) or RIAA (Document 5.2)?

1.168 Based on the information presented in the species accounts it is considered unlikely that there would significant inter-annual variability in the abundance or distribution of seabirds at Hornsea Three between December and March. It is therefore considered that twenty months of data could provide an adequate baseline upon which assessments could be based. However, consideration has been given to an alternative hierarchical approach, considered more robust by Natural England.

1.169 The conclusions of EIA and RIAA assessments that would be drawn when applying either the original or alternative hierarchical approaches are summarised in Table 1.31. There are no changes to the conclusions drawn in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2). The population estimates and densities calculated using the original hierarchical approach are therefore considered to adequately represent the abundance of each species at Hornsea Three. Only trivial differences in species abundance are estimated between the two approaches with the exception of auks where the alternative hierarchical approach is considered likely to over-estimate the abundance. The alternative hierarchical approach relies on abundance metrics calculated using data from the former Hornsea Zone. The former Hornsea Zone covers a large geographic area with differences in habitat and patterns of seabird density evident in the variation in the abundance of auk species across this area.

1.170 It is therefore concluded that the analyses and assessments presented in Volume 2, Chapter 5 Offshore Ornithology (Document 6.2.5) and the RIAA (Document 5.2) represent an accurate appraisal of the likely impacts that will occur on the species included in this report and that the conclusions remain valid.

Table 1.31: EIA and RIAA conclusions obtained when applying the original and alternative hierarchical approaches

Species	**Season**	**Original conclusions**		**Implications from alternative hierarchical approach**		
		EIA conclusion [a]	RIAA conclusion	Impact magnitude	EIA conclusions	RIAA conclusions
Displacement						
Fulmar	Non-breeding	Magnitude = Negligible Significance = Negligible – minor adverse	No adverse effect for all SPAs	Displacement mortality lower using alternative approach	No change to conclusions presented in ES	No change to conclusions presented in RIAA
Gannet	Pre-breeding	Magnitude = Negligible Significance = Negligible – minor adverse	No adverse effect	Displacement mortality higher using alternative approach Negligible difference in impact magnitude and increase in baseline mortality between two approaches (0.01%)	No change to conclusions presented in ES	No change to conclusions presented in RIAA
Guillemot	Breeding	Magnitude = Low Significance = Minor	No adverse effect	Displacement mortality lower using alternative approach	No change to conclusions presented in ES	No change to conclusions presented in RIAA

Species	Season	Original conclusions		Implications from alternative hierarchical approach		
	Non-breeding	adverse		Displacement mortality higher using alternative approach Negligible difference in impact magnitude and increase in baseline mortality between two approaches (0.04%)		
Razorbill	Non-breeding	Magnitude = Negligible Significance = Negligible – minor adverse	No adverse effect	Displacement mortality lower using alternative approach	No change to conclusions presented in ES	No change to conclusions presented in RIAA
	Pre-breeding			Displacement mortality higher using alternative approach Negligible difference in impact magnitude and increase in baseline mortality between two approaches (0.04%)		

Species	Season	Original conclusions		Implications from alternative hierarchical approach		
Puffin	Non-breeding	Magnitude = Negligible Significance = Minor	No adverse effect	Displacement mortality higher using alternative approach Negligible difference in impact magnitude and increase in baseline mortality between two approaches (0.04%)	No change to conclusions presented in ES	No change to conclusions presented in RIAA
Collision						
Gannet	Pre-breeding	Magnitude = Negligible Significance = Negligible or minor to minor adverse	-	Number of collisions increases when using alternative approach	No change to conclusions presented in ES	No change to conclusions presented in RIAA
	Annual	-	No adverse effect	-		
Kittiwake	Post-breeding	Magnitude = Negligible Significance = Minor	-	Number of collisions increases when using alternative approach	No change to conclusions presented in ES	No change to conclusions presented in RIAA
	Pre-breeding		-	Number of collisions lower when using alternative approach		
	Annual	-	No adverse effect	-		

Species	Season	Original conclusions		Implications from alternative hierarchical approach		
Lesser black-backed gull	Non-breeding	Magnitude = No change Significance = Minor		Number of collisions increases when using alternative approach Negligible difference in impact magnitude and increase in baseline mortality between two approaches	No change to conclusions presented in ES	
	Pre-breeding	Magnitude = Negligible Significance = Minor		Number of collisions increases when using alternative approach Negligible difference in impact magnitude and increase in baseline mortality between two approaches (0.01%)	No change to conclusions presented in ES	
Great black-backed gull	Non-breeding	Magnitude = Low Significance = Minor		Number of collisions increases when using alternative approach Negligible difference in impact magnitude and increase in baseline mortality between two approaches (0.02-0.05%)	No change to conclusions presented in ES	

Species	Season	Original conclusions	Implications from alternative hierarchical approach
a Significance conclusions for all species reached in the EIA include consideration of impacts occurring in other seasons. As such the significance of an impact presented here will not necessarily match the predicted magnitude (e.g. see lesser black-backed gull in the non-breeding season)			

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