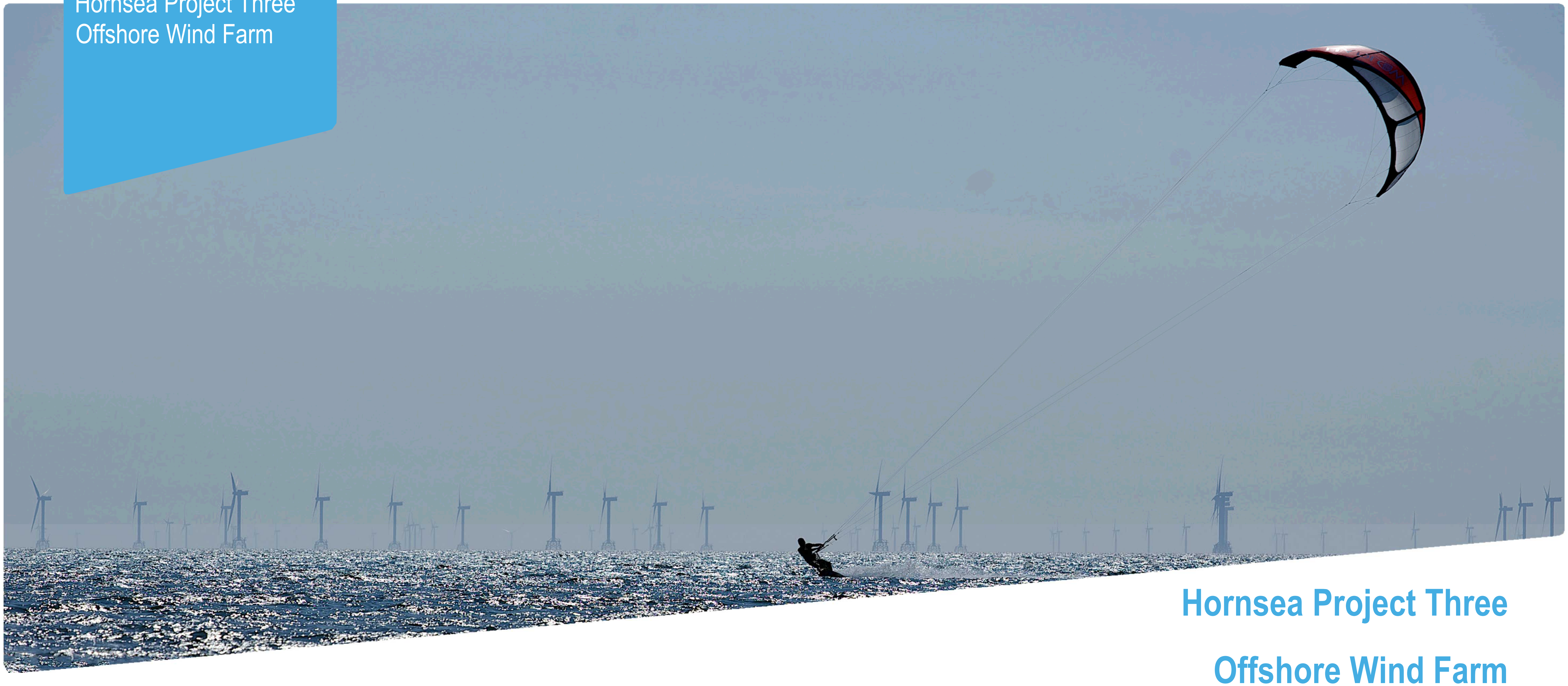
Hornsea Project Three
Offshore Wind Farm



Hornsea Project Three

Offshore Wind Farm

Report to Inform Appropriate Assessment
Annex 3 - Phenology, connectivity and apportioning for features of FFC pSPA

PINS Document Reference: A5.2.3
APFP Regulation 5(2)(g)

Date: May 2018

Hornsea 3
Offshore Wind Farm

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Habitats Regulations Assessment

Report to Inform Appropriate Assessment

Annex 3 – Phenology, connectivity and apportioning for features of FFC pSPA

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Report Number: A5.2.3

Version: Final

Date: May 2018

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1.1 Introduction

1.1.1.1 The North Sea, in which Hornsea Three is located, is an important area for seabirds with various species populations utilising the area at different times of year and different stages of their lifecycle including breeding, migration and wintering periods. In order to inform and refine impact assessments for offshore seabirds at Hornsea Three in relation to Special Protection Areas (SPAs) it is important to understand the complex ecology of the species concerned and their respective seasonal populations in the North Sea.

1.1.1.2 As part of Expert Working Group (EWG) meetings associated with the Evidence Plan process for Hornsea Three (see Annex 2 to the Hornsea Three Report to Inform Appropriate Assessment (RIAA)) discussions have been held relating to various aspects of the assessment methodology for species associated with the Flamborough and Filey Coast (FFC) pSPA including with respect to:

- Phenology – the definition of biological relevant seasons;
- Connectivity in the breeding season between FFC pSPA and the Hornsea Three site; and
- Apportioning of predicted impacts associated with Hornsea Three to the qualifying features (breeding season populations) of the FFC pSPA.

1.1.1.3 This Annex sets out the approach to each of these aspects (taking into account comments from Natural England and the RSPB) for the following species that are qualifying features of the FFC pSPA:

- Gannet;
- Kittiwake;
- Puffin;
- Razorbill; and
- Guillemot.

1.2 Phenology

1.2.1 Overview

1.2.1.1 Trends in the abundance of birds recorded during surveys associated with wind farm projects in the English North Sea have the potential to provide core information that can indicate an appropriate definition of biologically relevant seasons to apply in the assessment for Hornsea Three. The definition of seasons is required for assessments presented in this RIAA and the Environmental Impact Assessment (EIA) for Hornsea Three as the magnitude of impacts can vary temporally and spatially at different times of the year and effect different populations.

1.2.1.2 Furness (2015) presents definitions of biological seasons for a range of seabird species that occur in UK waters. The main aim of Furness (2015) was to review and define species-specific non-breeding season seabird populations at Biologically Defined Minimum Population Scales (BDMPS) thus providing both non-breeding season definitions and populations against which impacts from marine renewable developments could be apportioned.

1.2.1.3 Furness (2015) defines both a UK breeding season and a migration-free breeding season for each species. The breeding seasons presented apply to the whole of the UK and, therefore, may not precisely reflect the timing of breeding activity at a specific colony. Therefore, following advice from Natural England, colony-specific information and trends for the FFC pSPA have been analysed to identify the likely phenology of species at Hornsea Three. At the same time, however, it should be noted that the Hornsea Three site lies a considerable distance from any breeding colony. The breeding colonies associated with the FFC pSPA being the closest lying 150km west of the proposed wind farm and, therefore, beyond foraging range of most species breeding there (see Section 1.3). In addition, Hornsea Three does not represent an area that would in any way, be exclusive to birds from FFC pSPA, with regular migratory movements to and from colonies further north also likely to be observed there.

1.2.1.4 Whilst, therefore, the timing of breeding activity at FFC pSPA is of some relevance (and the RSPB as site managers were contacted for any information available on this), it should also be noted that the distant location of the proposed Hornsea Three wind farm means that other factors (i.e. migration) will have a stronger influence on the composition of birds observed there. The RSPB were unable to provide this information as although the data exists it would require an extensive amount of analysis to provide relevant information (K Clarkson, pers comm).

1.2.2 Approach

1.2.2.1 The approach taken in this section considers the appropriate biological seasons for each species based on available evidence in the North Sea including the abundance recorded during project-specific surveys undertaken at Hornsea Project One, Hornsea Project Two, Hornsea Three, Dogger Bank Creyke Beck A&B, Dogger Bank Teesside A&B and East Anglia Three. Of these data, those collected at the three Hornsea projects are considered the most relevant to defining biological seasons for use in assessments for Hornsea Three with data from other projects considered to provide a wider context showing the movements of birds through the North Sea. Trends in the abundance of each species are identified in the species-specific sections below and clear periodic peaks in particular are explained through knowledge of the movements and behaviour of each species. Data for all projects (submitted as part of the application and examination for these projects) have been taken from relevant documentation and represent the relevant project area plus a 4 km buffer (Hornsea Project One, Hornsea Project Two, Hornsea Project Three and East Anglia Three) or the project area plus a 2 km buffer (Dogger Bank Creyke Beck A&B and Dogger Bank Teesside A&B).

1.2.2.2 To understand trends in the abundance and proportion of immature and adult gannet and kittiwake, the most comprehensive data set is that collected as part of boat-based surveys at Hornsea Project Two. These data are unavailable in such detail for other projects and indeed are relatively limited through the aerial survey programme for Hornsea Three (see Section 1.4.3 for discussion in relation to this point).. Surveys for Hornsea Project Two covered a larger spatial extent than those at Hornsea Project One with more transects located both closer inshore and further offshore. Therefore in order to provide a dataset across a consistent spatial extent through a continuous time series it has been necessary to use data collected from those transects with a 2 km spacing associated with Hornsea Project Two only between March 2011 and February 2013 (Figure 1.29). The number of adults and immatures was identified for each survey month and the proportion that each of these age classes represents of the total number of aged birds was multiplied by the total number of birds recorded on the relevant survey.

1.2.3 Gannet

Trends in abundance (all birds)

1.2.3.1 The main peaks in the densities of gannet at Hornsea Project One plus a 4 km buffer and Hornsea Project Two plus a 4 km buffer occurred between July/August and November (Figure 1.1). During this period, abundance was relatively high in July or August decreasing slightly into August or September and then increasing again into September, October or November with inter-annual variability affecting the timing of the trends recorded. This is considered to reflect the autumn dispersal of breeding birds from breeding colonies and, later in this period, migration to wintering areas (Furness, 2015). Gannets observed during surveys for Hornsea Projects One and Two during this period could refer to immature birds, non-breeding birds or breeding birds associated with multiple breeding colonies including those from further north. Tracking of gannets breeding at Bass Rock has shown that birds begin to leave the colony in September (Kubetzki *et al.,* 2009). This bimodal peak in the post-breeding season is supported by Furness (2015) which states that breeding gannets do not necessarily move directly southwards in autumn but may move to areas with abundant food sources for some time in late summer before moving towards wintering areas. Nelson (2002) also states that gannets from many colonies may move into the North Sea to exploit rich foraging opportunities with many having forsaken breeding ledges in September potentially weeks after chicks have fledged. At the Dogger Bank projects plus respective 2 km buffers, the main peak in the post-breeding season occurred in October in both of the survey years whereas at East Anglia Three plus a 4 km buffer, the peak occurred slightly later in November and December potentially reflecting a slow movement of gannets through the North Sea towards southern winter areas (Figure 1.2).

1.2.3.2 Migratory movements, this time back to breeding colonies, are also considered to be the explanation for a peak in densities in March at Hornsea Projects One and Two although this peak is lower than that recorded in the post-breeding season. Peaks in the abundance of gannet in March also occurred at the Dogger Bank projects. However, at East Anglia Three, a peak was noted in April of the second survey year with no peak in the first year of surveys.

1.2.3.3 Densities during spring migration are lower for a number of reasons, including the presence of fewer immature and non-breeding birds which generally return to natal waters later in the breeding season and differences in the migration routes taken by breeding birds in spring and autumn. Tracking of gannets from Bass Rock has shown that, in autumn the majority of birds leave the North Sea through the English Channel whereas in the spring the majority of birds return to the North Sea via the west coast of Scotland (Kubetzki *et al.,* 2009; Garthe *et al.,* 2010; as summarised in, WWT Consulting *et al.,* 2012). However, these studies do show that birds associated with colonies to the north of the Hornsea projects do migrate through the southern North Sea. MacArthur Green (2014) estimated that of the total population of gannet migrating north through the North Sea (and therefore potentially interacting with the former Hornsea Zone) over 86% were associated with breeding colonies to the north of the former Hornsea Zone.

1.2.3.4 Lower densities of gannet were recorded during the breeding season (April to June/July) at all projects. At the Hornsea and Dogger Bank projects there is a general increasing trend in the densities noted during the breeding season suggesting either an increase in the number of foraging birds in the project areas or, more likely, an influx of immature age classes which return to natal waters to prospect for breeding areas.

1.2.3.5 Between December and February densities of gannet were generally low across all projects. This is not unexpected with fewer birds present in UK waters as the majority will have moved to wintering areas further south (Wernham *et al.,* 2002).

1.2.3.6 Trends in the abundance of gannet at Hornsea Three (Figure 1.3) do, in some periods, reflect the trends recorded at other projects (Figure 1.1 and Figure 1.2). For example, there was a peak in the density of gannet at Hornsea Three in July of both years with this likely representing an increase in the number of immature gannets or an increase in the use of Hornsea Projects One and Two for foraging by breeding birds from FFC pSPA. However, after July 2016 the abundance of gannets decreases at Hornsea Three, remaining low until a peak in December when in the same month at Hornsea Projects One and Two and the Dogger Bank projects densities were consistently low, although at East Anglia Three there was a peak in December in the first survey year. Despite the peak observed at East Anglia Three, it is considered likely that the peak in gannet density in December at Hornsea Three is due to surveys coinciding with an abundance of foraging birds (A. Webb, pers comm). As this represents a singular event, it is concluded to represent a chance encounter which does not indicate any particular importance for Hornsea Three as a foraging area for this species or any other for which a peak in December was observed. The densities of gannet recorded at Hornsea Three between August and October 2017 were higher than in 2016 and likely reflect post-breeding movement of gannets through the North Sea. Similar post-breeding movements of this species were also recorded at Hornsea Projects One and Two and the Dogger Bank projects. A peak in gannet abundance in March/April at Hornsea Three, reflecting spring passage of gannets through the North Sea is considered to be consistent with the trends noted at other projects in addition to the low abundances between April and June, which reflect the smaller population of birds that may interact with Hornsea Three during the breeding season.

Trends in abundance (adults and immatures)

1.2.3.7 The monthly abundance of adult or immature gannets as calculated from age class data collected during boat-based surveys of Subzone transects undertaken for Hornsea Project Two (March 2011 to February 2013) is presented in Figure 1.4. There are three notable peaks in the abundance of adults that occur in both survey years, the first occurring in March/April, the second in July/August and the third in October. The peak in March/April represents the movement of adult birds back towards breeding colonies with the peak in October representing the post-breeding movements of birds away from colonies. The reason for the peak in July is less clear representing either an increase in birds from breeding colonies foraging at Hornsea Project Two or an influx of failed breeders and non-breeding birds. Following the peak in March/April, the number of adults shows a decrease into June with this associated with adults being more closely associated with breeding colonies. The number of adults is also low in December and January when the majority of birds have moved to wintering areas.

1.2.3.8 A small proportion of both adult and immature gannet remain in UK waters throughout the year, however, the majority move south to wintering grounds off western Africa (Nelson, 2002; Wernham *et al.,* 2002). Adult birds begin their return to UK waters in December with migratory movements peaking between February and April (Furness, 2015). Immature birds return to UK waters during the breeding season with older immatures returning earlier than younger immatures. Good numbers of second year birds are recovered in UK waters between July and November, with third year birds recovered between June and October. By their fourth and fifth year, the majority of birds have returned to UK waters with recoveries, mainly at breeding colonies, between April and October (Nelson, 2002). The trend in the abundance of immature birds across Subzone transects (2011-2013) is therefore as would be expected with a gradual increase in the abundance of immatures from May peaking in September or October.

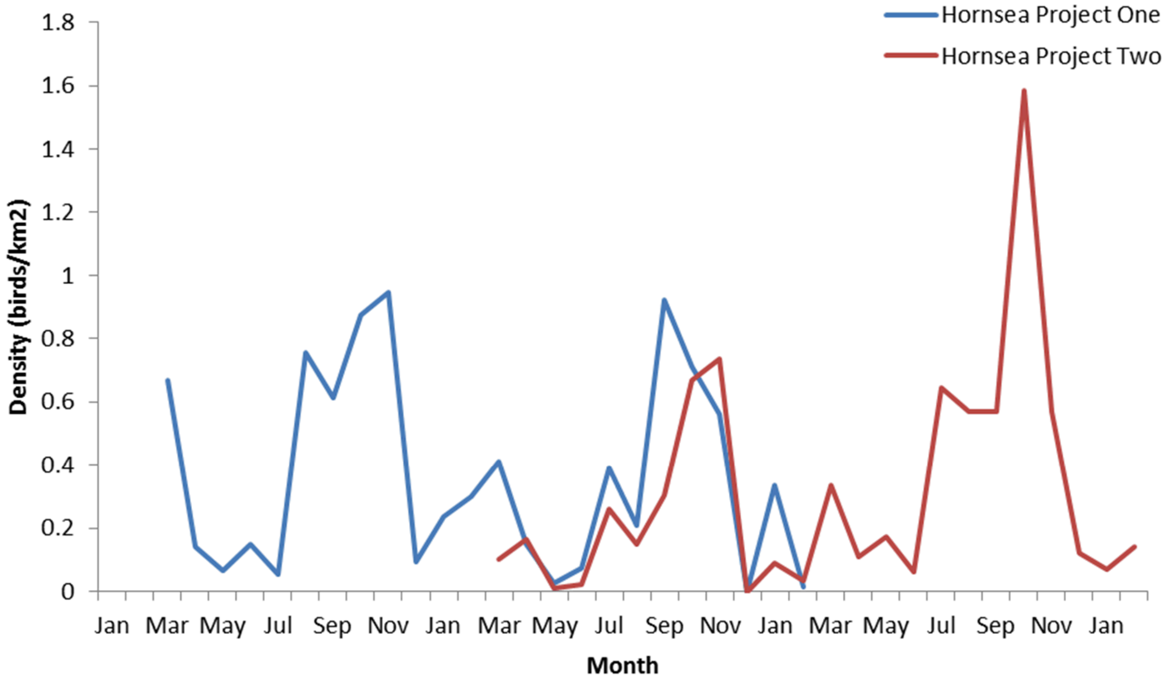

Figure 1.1: Population estimates for gannet calculated from boat-based survey data for Hornsea Project One plus a 4 km buffer between March 2010 and February 2012 and for Hornsea Project Two plus a 4 km buffer between March 2011 and February 2013.

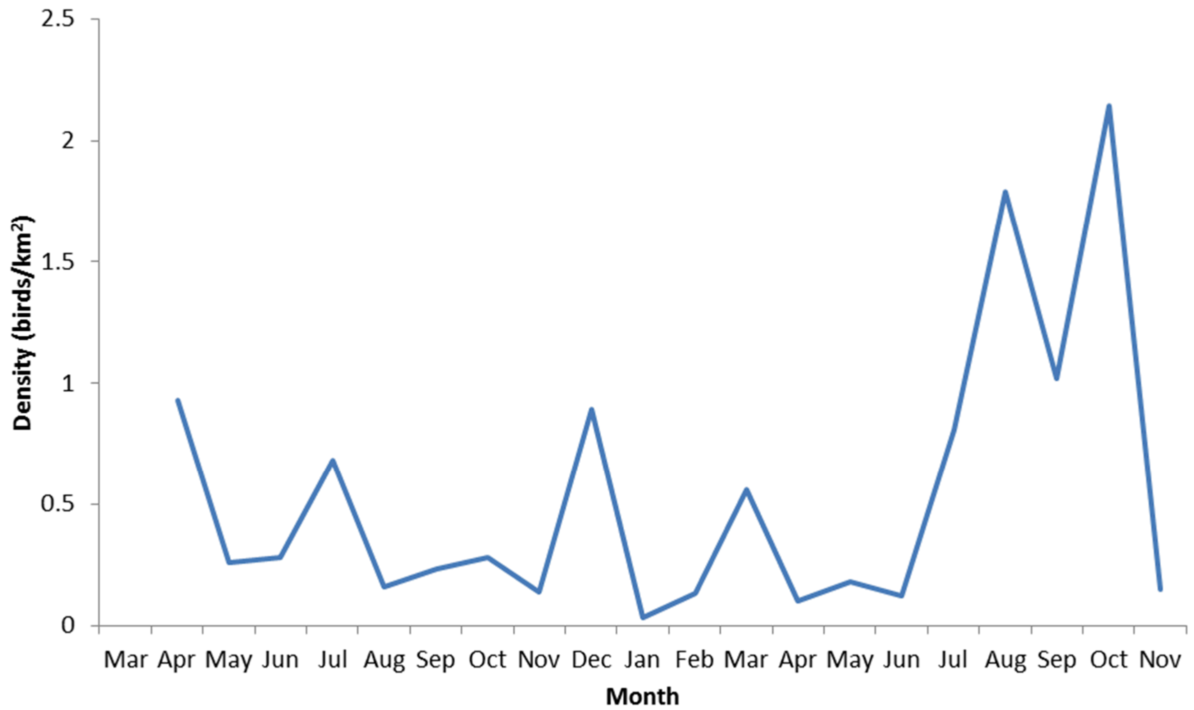

Figure 1.3: Population estimates for gannet calculated from aerial survey data for Hornsea Three plus a 4 km buffer between April 2016 and November 2017.

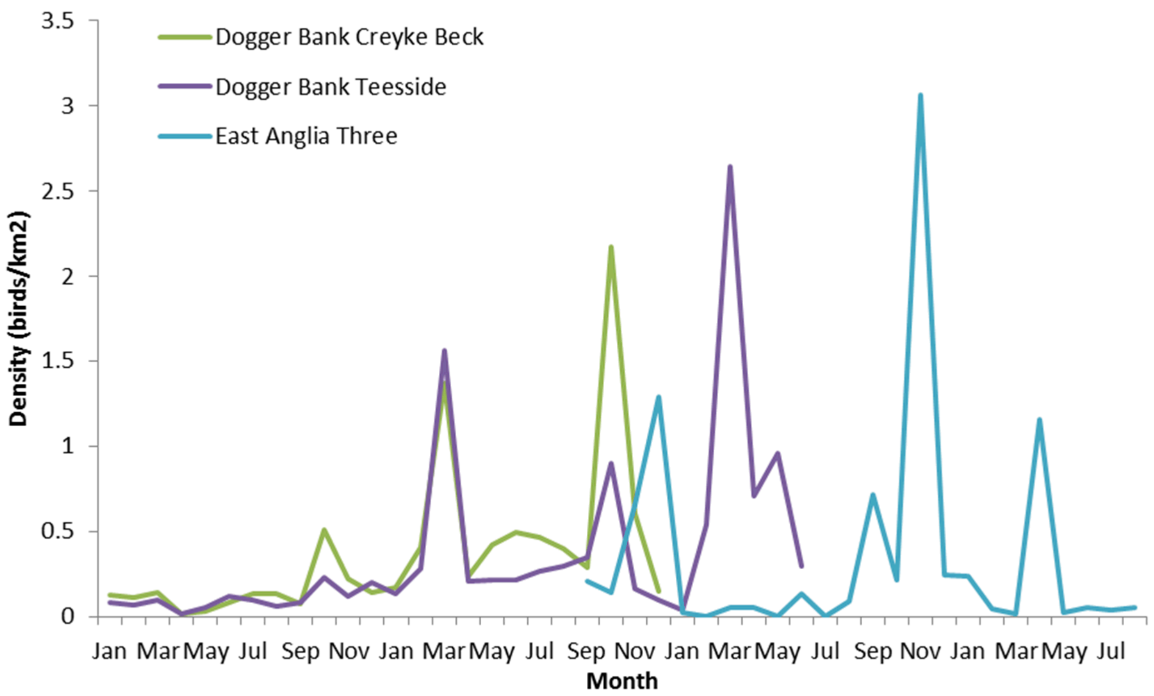

Figure 1.2: Population estimates for gannet calculated from project-specific survey data for Dogger Bank Creyke Beck A&B plus a 2 km buffer (January 2010 to December 2011), Dogger Bank Teesside A&B plus a 2 km buffer (January 2010 to June 2012) and East Anglia Three plus a 4 km buffer (September 2011 to August 2013).

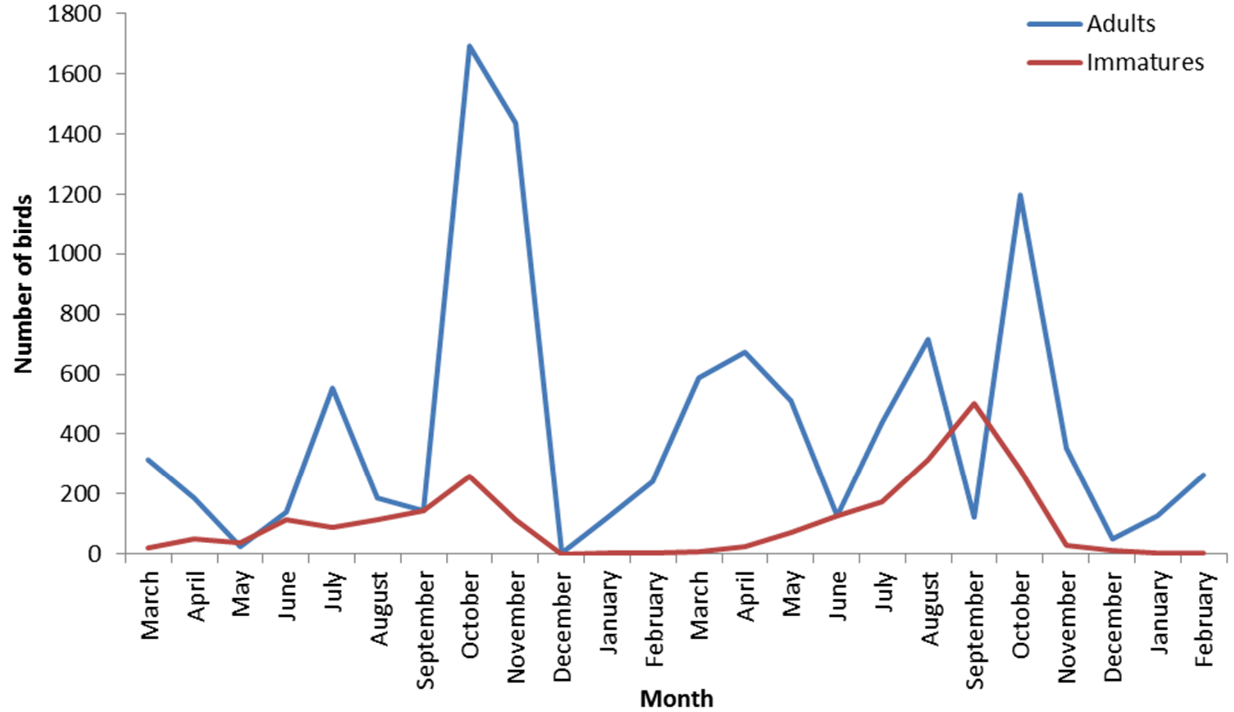

Figure 1.4: Trends in the abundance of adult and immature gannet as recorded during boat-based surveys conducted for the Hornsea Project Two development between March 2011 and February 2013.

Summary

1.2.3.9 Using the abundance data for gannet from those projects in the English North Sea incorporated into the analyses above, the following key points in relation to the phenology of gannets have been identified:

- There is a bi-modal peak in abundance of gannet between July/August and November representing firstly dispersal from breeding colonies and then migratory movements. At this time, birds at Hornsea Three may be immature, non-breeding or breeding birds from a range of colonies;
- Moderately high densities of gannet also occur in March. Birds from a range of breeding colonies may occur at Hornsea Three during this period;
- Lower densities are generally recorded between April and July with a gradual increase, caused either by the return of immatures to natal waters or increased use of relevant project areas by foraging breeding birds;
- Low densities of gannets are recorded between December and February due to the majority of birds having moved to wintering areas;
- Peaks in the number of adult birds at Hornsea Project Two occur in March/April (pre-breeding migration), July/August (foraging birds or an influx of failed breeders/non-breeding birds and October (post-breeding migration); and
- The number of immature birds increased at Hornsea Project Two as the breeding season progressed consistent with the expected phenology of immature birds as described in the literature (Nelson, 2002).

1.2.3.10 Furness (2015) identifies the breeding season for gannet in UK water as March to September and the migration-free breeding season as April to August. When using data covering an extensive temporal period (Figure 1.1) it is clear that across the three Hornsea projects and the Dogger Bank projects the peak in pre-breeding migration usually occurs in March. In 2016, there was an increased abundance of gannet in April when compared to the same month in 2017 with this increase likely caused by observations of migrating birds. Such differences are caused by inter-annual variability in the timing of pre-breeding migration and therefore April is identified as a breeding month on a precautionary basis. There is also a clear peak in the abundance of gannet in September at the two Hornsea projects with this considered to represent dispersal/migratory movements from breeding colonies. As such, September is included as part of the post-breeding season.

1.2.3.11 Using the information presented above the following biological seasons are defined for gannet:

- Breeding season - April to August;
- Post-breeding season - September to November; and
- Pre-breeding season - December to March

1.2.3.12 The biological seasons defined for the post- and pre-breeding season follow the biological seasons for non-breeding seasons defined in Furness (2015). All of the biological seasons defined for gannet are consistent with those applied in the assessments presented by both the Applicant and Natural England for the consented Hornsea Project Two offshore wind farm (see Appendix N of the Applicant's submission to Deadline 2A and Appendix 3 of Natural England's submission to Deadline 3 during the Hornsea Project Two examination) and the consented East Anglia Three offshore wind farm.

1.2.4 Kittiwake

Trends in abundance (all birds)

1.2.4.1 The peak densities of kittiwake at Hornsea Project One and Hornsea Project Two generally occurred in either August or September (Figure 1.5), associated with post-breeding dispersal/migratory movements of birds away from colonies (Furness, 2015). This peak, however, was not noted at either Dogger Bank Creyke Beck A&B, Dogger Bank Teesside A&B or East Anglia Three, with surveys in September recording some of the lowest densities at all five projects (Figure 1.6).

1.2.4.2 Following these migratory/dispersal movements, densities then sharply decreased into October at Hornsea Projects One and Two with few birds present between December and February. However, in the first year of surveys at the Dogger Bank projects, densities increased in October remaining constant until December with this representing movements of birds through the North Sea towards wintering areas (Wernham *et al.,* 2012). The highest densities recorded at East Anglia Three occurred in November and December. The recorded densities are higher than those recorded at other projects during these months and may therefore represent either delayed migratory movements or an aggregation of birds caused by increased foraging opportunities such as that observed at Hornsea Three during the December 2016 survey.

1.2.4.3 The highest densities of kittiwake recorded at the Dogger Bank projects occurred in March with increases in the abundance of kittiwake at Hornsea Project Two also occurring into March through into April. These observations are likely to reflect the movement of birds back towards colonies from wintering areas (Furness, 2015) with March clearly the peak month for these movements through the North Sea.

1.2.4.4 At the Dogger Bank projects the density of kittiwake decreased into April and slightly later (May) at Hornsea Projects One and Two. These decreases are considered to be due to breeding adults becoming more closely associated with breeding colonies as the breeding season progresses. Following the respective decreases at these projects densities then increase with such increases considered to be due to the influx of immature birds returning from wintering areas to prospect for breeding sites (Coulson, 2011). These observations are supported by the results of Robertson *et al.* (2014) (see Section 1.3.3 below for further information) which shows that the foraging range of breeding adult kittiwakes decreases between incubation and chick-rearing. This suggests that the increases in densities between May and June at Hornsea Projects One and Two and between April and June at the Dogger Bank projects are caused by the arrival of immature birds in the respective areas and not an increase in usage of the area by breeding birds as these will be more closely associated with breeding colonies and not in offshore areas such as Hornsea Projects One and Two and especially the Dogger Bank projects. Densities of kittiwake recorded at East Anglia Three are relatively low throughout the breeding season, with the lowest densities recorded in July.

1.2.4.5 In general, the trends in abundance observed at Hornsea Three reflect the patterns observed at Hornsea Projects One and Two and those at more offshore sites such as the Dogger Bank projects. This suggests some influence of proximity to the colony but less than is the case for more inshore locations . For example, in April 2016, densities were relatively high with a decrease noted into May (Figure 1.7) consistent with that observed at Hornsea Projects One and Two. However, instead of then increasing as at Hornsea Projects One and Two, densities further decreased into June consistent with the trends noted at the Dogger Bank projects, suggesting either a delayed arrival of immature birds or limited foraging trips to Hornsea Three by breeding birds from local colonies. In 2017, the abundance of kittiwake increased from February into May and then subsequently decreased into June. Densities then showed an increase into July, consistent with the arrival of immature birds and the trends observed at Hornsea Projects One and Two. Densities were low at Hornsea Three between September and October consistent with the trends at the Dogger Bank projects suggesting limited passage of kittiwake through Hornsea Three.

Trends in abundance (adults and immatures)

1.2.4.6 The monthly abundance of adult kittiwakes and immature kittiwakes (defined here as juvenile and second calendar year birds) as calculated from age class data collected during boat-based surveys of Subzone transects undertaken for Hornsea Project Two is presented in Figure 1.8. Peaks in the abundance of adult birds occur between June and August of both survey years. This appears to suggest more adult birds may be foraging in the survey area. However it should be noted that a large proportion of these birds are highly likely to be birds in their third and fourth calendar years that are indistinguishable from adult birds and are returning to natal waters (Coulson, 2011) and second calendar year birds that have also moulted into adult-type plumage. Peaks in the abundance of adult birds also occur in March and April in both survey years with this likely due to the presence of migrating birds and/or foraging birds from local colonies. After the peak in April both survey years, the abundance of adult birds then declines in May. This is likely due to the lack of migratory movements (the majority of birds will now be at colonies) and a shift in the foraging behaviour of breeding birds.

1.2.4.7 The abundance of immatures shows a general increase from March, generally peaking in June. This represents movements of second calendar year birds into natal waters. In July, the abundance of immatures drops sharply however, this is not considered to indicate that no immatures are present rather it is representative of second calendar year birds moulting into adult-type plumage making them indistinguishable from other adult birds. From July, the abundance of immature birds then increases representing the presence of recently fledged birds from local colonies. The peaks in the abundance of immature kittiwake in August/September of both survey years is in part due to the presence of fledged birds (Figure 1.8).

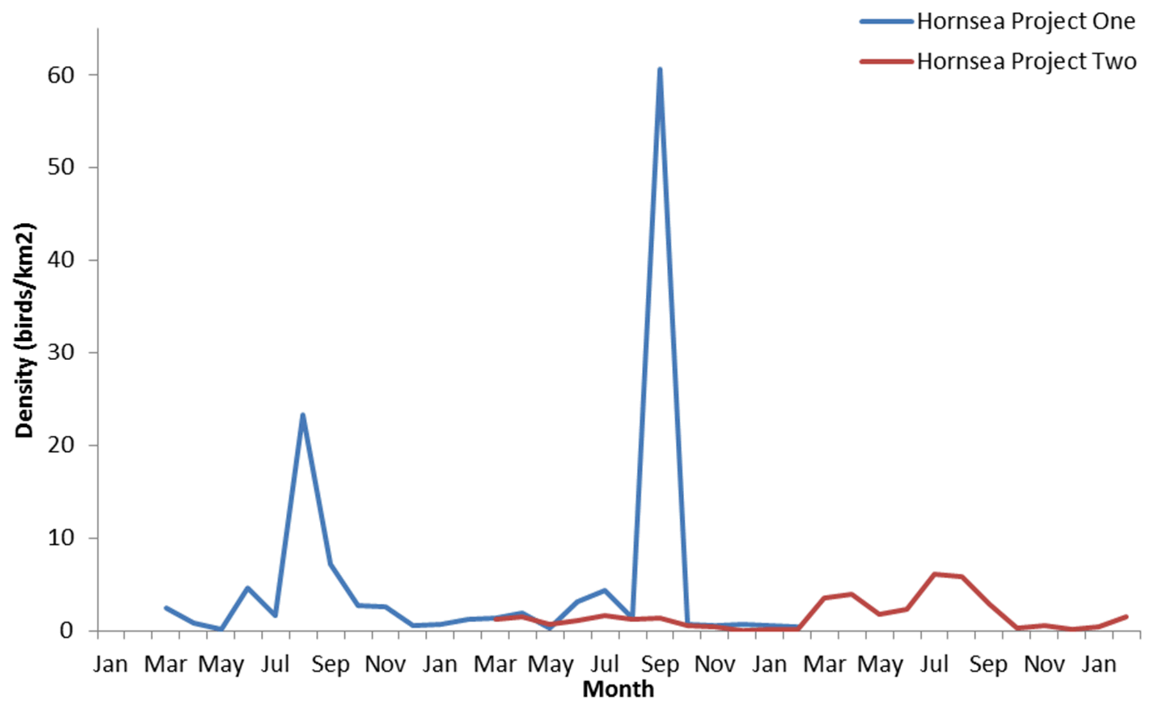

Figure 1.5: Population estimates for kittiwake calculated from boat-based survey data for Hornsea Project One plus a 4 km buffer between March 2010 and February 2012 and for Hornsea Project Two plus a 4 km buffer between March 2011 and February 2013.

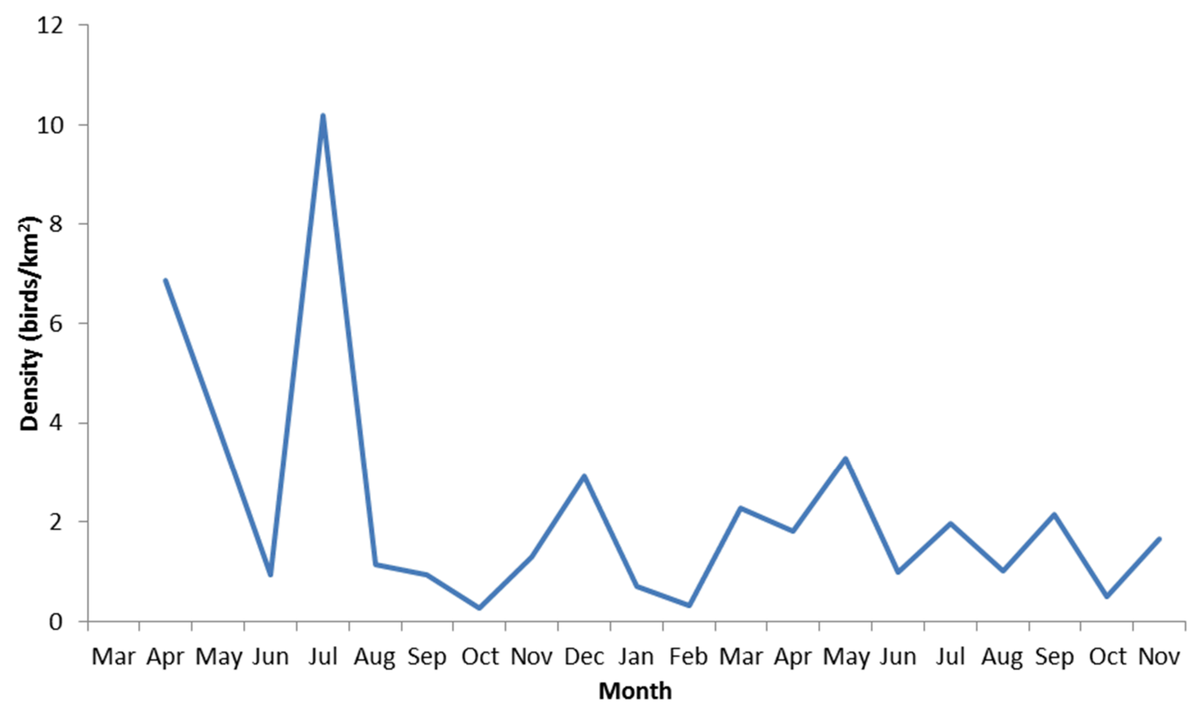

Figure 1.7: Population estimates for kittiwake calculated from aerial survey data for Hornsea Three plus a 4 km buffer between April 2016 and November 2017.

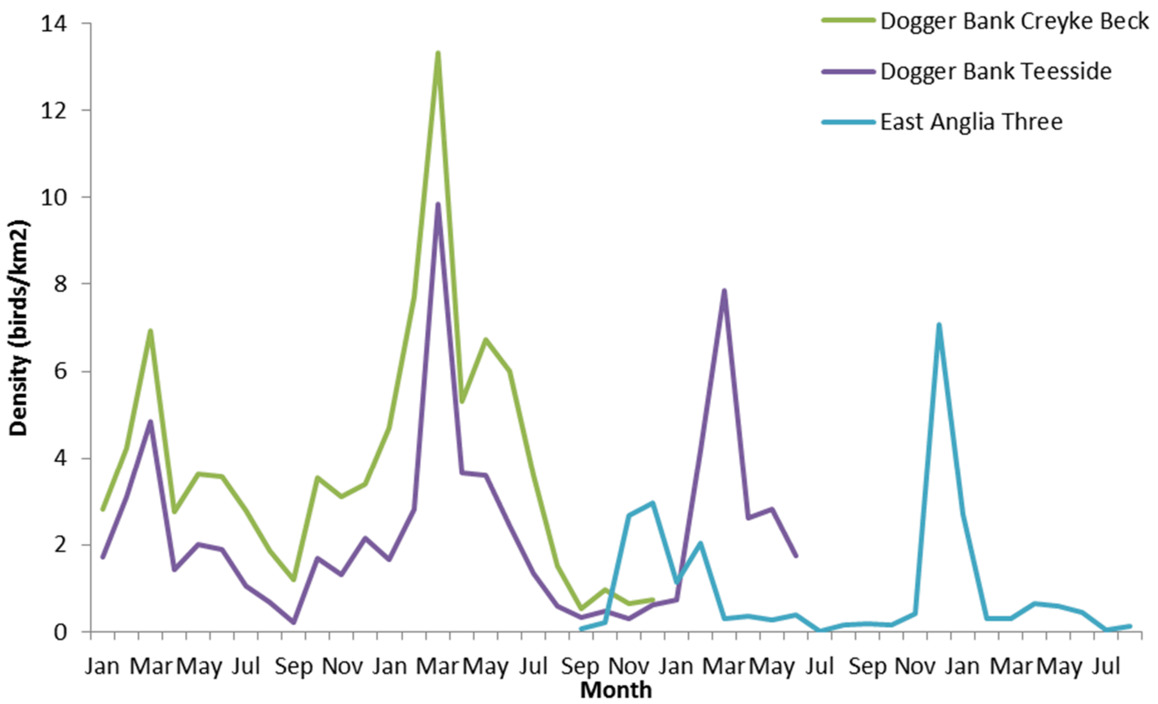

Figure 1.6: Population estimates for kittiwake calculated from project-specific survey data for Dogger Bank Creyke Beck A&B plus a 2 km buffer (January 2010 to December 2011), Dogger Bank Teesside A&B plus a 2 km buffer (January 2010 to June 2012) and East Anglia Three plus a 4 km buffer (September 2011 to August 2013).

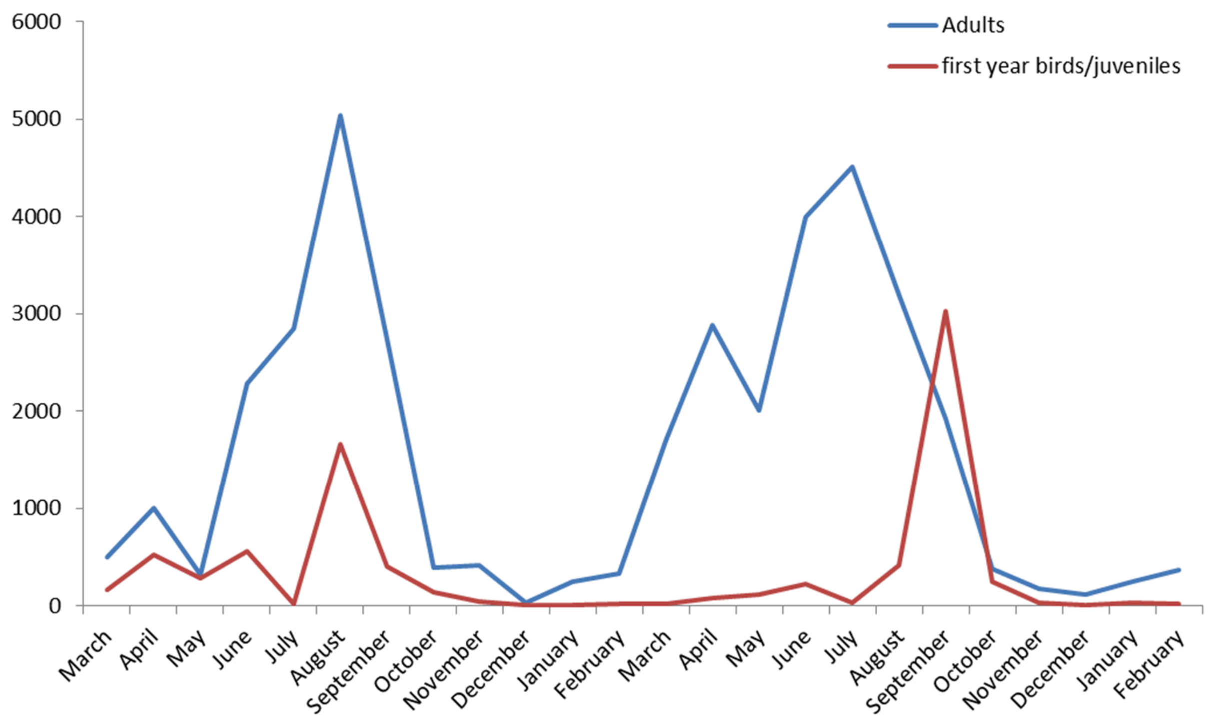

Figure 1.8: Trends in the abundance of adult and juvenile/first year kittiwake as recorded during boat-based surveys conducted for the Hornsea Project Two development between March 2010 and February 2013.

1.2.4.8 Although the number of immatures appears to be very low in Figure 1.8, it should be noted that these numbers do not account for third and fourth calendar year immatures, which are indistinguishable from adult birds. This is likely to represent an underestimation of at least 35% (see Section 1.4.3) however, this does not account for a much smaller proportion of second year birds returning to home waters when compared to third and fourth calendar year birds. Therefore the numbers presented here for immature birds are merely a representation of trends in the movements of immature birds. By mid-May kittiwakes of all ages have vacated the mid-Atlantic pelagic zone with all birds moving to shallow continental shelf areas. Second calendar year birds occur in coastal areas but do not visit colonies and may not necessarily be in natal waters (Coulson, 2011). In contrast, third calendar year birds do visit colonies, mainly in June and July. By their fourth calendar year kittiwakes are arriving at colonies by April or early May (Coulson, 2011). The movement of immatures as described by Coulson (2011) explains the trends observed both in the number of immatures at Hornsea Project Two (Figure 1.8) and the trends in overall abundance presented in Figure 1.5 and Figure 1.7.

Summary

1.2.4.9 Using the abundance data for kittiwake from those projects in the English North Sea incorporated into the analyses above, the following key points in relation to the phenology of kittiwakes have been identified:

- High densities of kittiwake at Hornsea Projects One and Two occurred in either August or September representing post-breeding movements. However, these movements were not evident at the Dogger Bank projects, East Anglia Three or Hornsea Three when movements appear to occur later;
- March is clearly the peak month for return migratory movements in the North Sea with high densities recorded at Hornsea Projects One and Two and at the Dogger Bank projects;
- The return of immature birds into natal waters was captured at Hornsea Projects One and Two; this was especially evident through observed trends in the proportions of birds identified as either adult or immature birds at Hornsea Project Two. The results of Robertson *et al.* (2014) show that increases in densities throughout the breeding season are unlikely to be due to foraging birds from breeding colonies as these birds become more spatially restricted as the breeding season progresses; and
- The trends in the densities of kittiwake recorded at Hornsea Three generally correspond with those recorded at other projects with densities reflecting return migratory movements and influxes of immature birds into natal waters as recorded at Hornsea Projects One and Two and the Dogger Bank projects.

1.2.4.10 Furness (2015) defines the migration free breeding season as May to July and the abundance of kittiwake at all Hornsea projects supports this definition. The pre-breeding season defined by Furness (2015) is January-April with this being based on the period during which substantial migration of birds through UK waters occurs. This also including the migratory movements of birds migrating to colonies located at higher latitudes that occur later than those exhibited by birds breeding at UK colonies. Data from migration sites across the UK (presented in Furness, 2015) show that the peak month for migratory movements is March. As such, it is considered that March should be included as part of the pre-breeding season as the majority of birds occurring at Hornsea Three will be migratory individuals. On a precautionary basis, it is considered that April should be included as a breeding month as it is likely that a large proportion of birds will have returned to FFC pSPA, although it should be noted that many birds recorded in this month will be individuals migrating to colonies located at higher latitudes with such an assertion supported by the trends in abundance across all three Hornsea projects but not at the Dogger Bank projects located further north.

1.2.4.11 The use of July as the final month of the breeding season is also considered appropriate with peaks in the abundance of kittiwake recorded across all three Hornsea projects occurring between July and September. Furness (2015) indicates that post-breeding dispersal/migration begins in July with peak migration occurring in August and September. This is further supported by Coulson (2011) who states that the last chicks to fledge in Britain tend to do so in the first week of August.

1.2.4.12 Using the information presented above the following biological seasons are defined for kittiwake:

- Breeding season - April to July;
- Post-breeding season - August to December; and
- Pre-breeding season - January to March.

1.2.4.13 These seasonal definitions are consistent with those applied in the assessments presented by Natural England for the consented Hornsea Project Two offshore wind farm (see Appendix 2 of Natural England's submission to Deadline 3 during the Hornsea Project Two examination, Natural England's submission at Deadline 5 and Appendix Q of the Applicant's response submitted for Deadline 7).

1.2.5 Puffin

Trends in abundance

1.2.5.1 There was a consistent peak in the abundance of puffin at Hornsea Project One and Hornsea Project Two in August/September (Figure 1.9) with this likely associated with post-breeding movements of birds (Furness, 2015). Peaks were also noted between November and January and again in March/April with the latter representing the movement of birds back to breeding colonies (Furness, 2015). Peaks in the abundance of puffin were also observed in the first year of surveys at Dogger Bank Creyke Beck A&B in September/October remaining high until March. Although densities of puffin did not peak at Dogger Bank Teesside A&B in September/October, densities did begin to increase towards a peak in March (Figure 1.10). Although densities were comparatively much lower at East Anglia Three (Figure 1.10), there was a peak in densities in November of the first year of surveys and a gradual increase from July in the second year of surveys.

1.2.5.2 In the breeding season, there was a degree of variability between the three years of surveys at Hornsea Projects One and Two, with high densities recorded in June of the first year of surveys and low densities recorded between May and July in the second year of surveys. At the Dogger Bank projects, densities decreased into April and remained low until at least August. At East Anglia Three, densities peaked in April and then remained relatively low until August. This suggests that migratory movements of puffin are still occurring through Hornsea Projects One and Two and East Anglia Three into April.

1.2.5.3 Densities of puffin at Hornsea Three were very low across all surveys when compared to the densities recorded during surveys at all other projects. Densities were relatively high in the April and May 2016 surveys and again in the May 2017 survey, with this possibly due to either migratory movements by breeding birds returning to colonies further north or the return of immature birds to natal waters. Re-sighting data from the Isle of May indicates that by May, many 3rd and 4th year birds are likely to have returned to natal waters in addition to a variable proportion of 2nd year birds (Harris and Wanless, 2011). It is also observed that, the post-breeding peak in densities observed in August, September and October at Hornsea Projects One and Two is not reflected in the densities recorded at Hornsea Three.

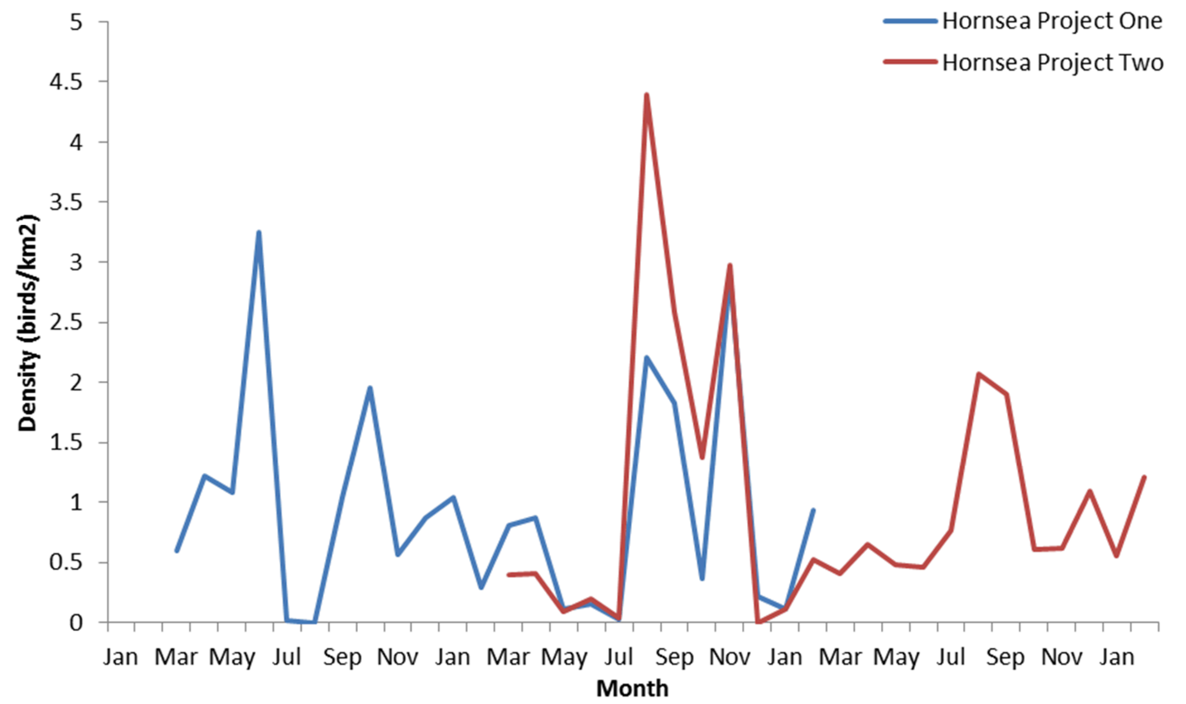

Figure 1.9: Population estimates for puffin calculated from boat-based survey data for Hornsea Project One plus a 4 km buffer between March 2010 and February 2012 and for Hornsea Project Two plus a 4 km buffer between March 2011 and February 2013.

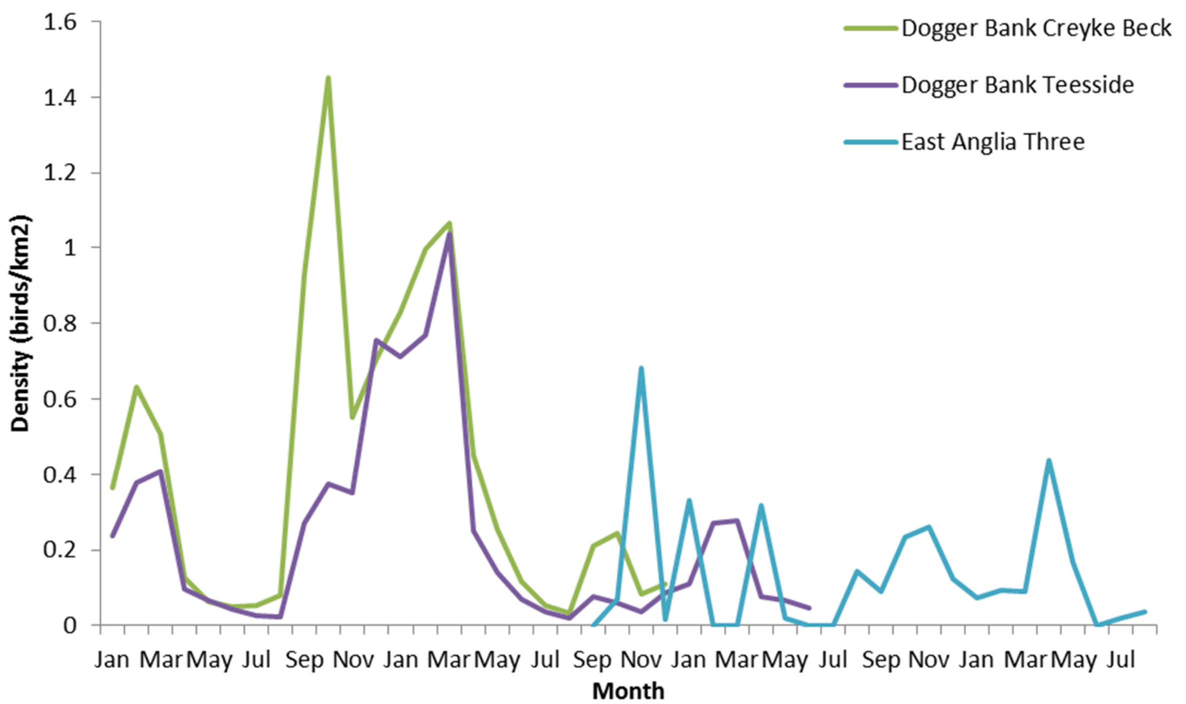

Figure 1.10: Population estimates for puffin calculated from project-specific survey data for Dogger Bank Creyke Beck A&B plus a 2 km buffer (January 2010 to December 2011), Dogger Bank Teesside A&B plus a 2 km buffer (January 2010 to June 2012) and East Anglia Three plus a 4 km buffer (September 2011 to August 2013).

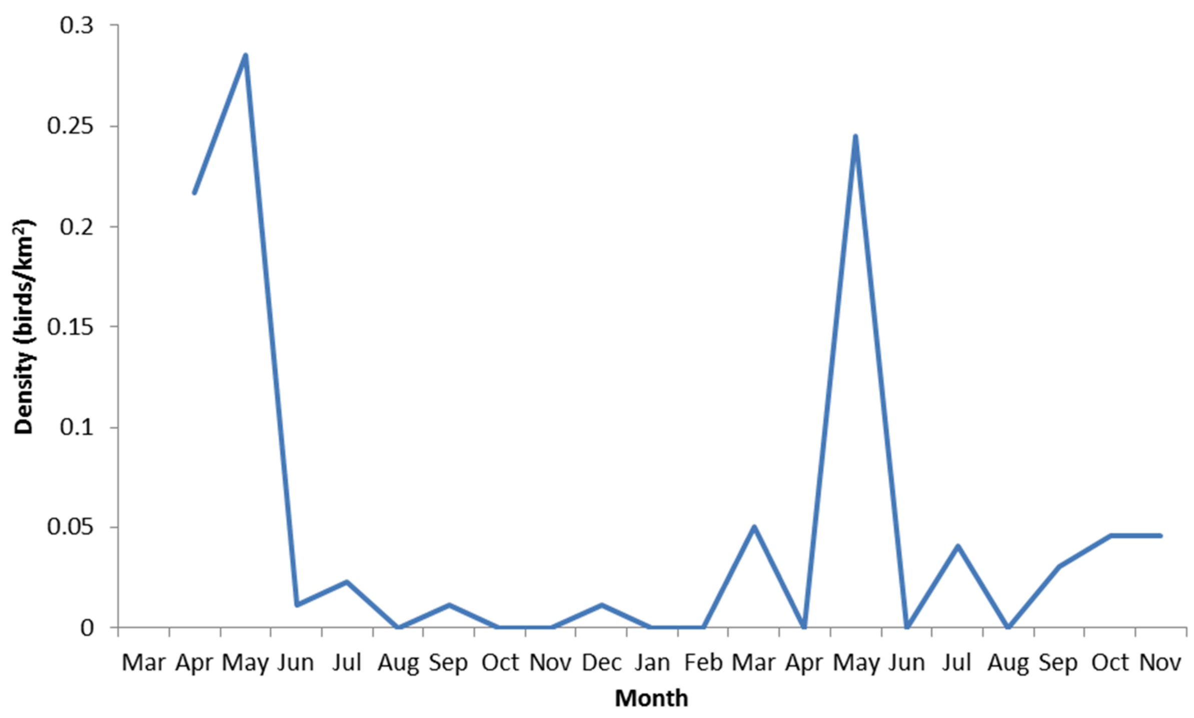

Figure 1.11: Population estimates for puffin calculated from aerial survey data for Hornsea Three plus a 4 km buffer between April 2016 and November 2017.

Summary

1.2.5.4 Using the abundance data for puffin from those projects in the English North Sea incorporated into the analyses above, the following key points in relation to the phenology of puffins have been identified:

- Densities of puffin recorded at Hornsea Three are much lower than those recorded at other projects;
- Post-breeding movements of puffins begin from August/September although very few birds are recorded at Hornsea Three during this period;
- Return migration of puffin through the North Sea occurs into April with this evident at Hornsea Projects One and Two and East Anglia Three; and
- Higher densities of puffin occurred in May at Hornsea Three potentially representing late migratory movements or the return of immature birds into natal waters.

1.2.5.5 Furness (2015) defines the migratory free breeding season for puffin as May to June and the UK breeding season as April to early-August. Peaks in the abundance of puffins at Hornsea Three occur in May of both survey years with this considered likely to be due to either immature birds returning to natal waters or breeding birds migrating to breeding colonies further north (Pennington *et al.,* 2004; Harris and Wanless, 2011). Data from migration sites around the UK (see Furness, 2015) also appear to suggest that migratory movements of puffin occur into May. Puffins are known to be present under the cliffs at FFC pSPA in late March (Babcock *et al.,* 2017) however, as the population of puffin at FFC pSPA is relatively small, and the colony is located approximately 149 km from Hornsea Three, it is considered likely that the peak in abundance at Hornsea Three in April 2016 is predominantly due to migrating birds. Therefore following the migration free breeding season in Furness (2015) May is defined as the start of the breeding season. Further information on the likelihood of breeding adult birds from FFC pSPA occurring at Hornsea Three is provided in Sections 1.3.4 and 1.4.4.

1.2.5.6 Peaks in the abundance of puffin occurred in August in all two of the three survey years at Hornsea Projects One and Two with this representative of post-breeding migratory movements however, this peak is not reflected in the surveys undertaken at Hornsea Three, where densities of puffin were low from June to February (Figure 1.11), a trend more consistent with that observed at the Dogger Bank projects in the second year of surveys. In 1978, the mean date of departure of puffins from the Isle of May was 5th-8th August with the main exodus in most years typically occurring between 1st and 10th August (Harris and Wanless, 2011). It is therefore considered appropriate to include August as a non-breeding month as the majority of birds recorded at Hornsea Three, which is located 149 km from FFC pSPA will likely be those that have dispersed from colonies. Therefore based on the information presented here May to July is considered the appropriate breeding season definition for puffin with August to April considered to be the appropriate definition in the non-breeding season.

1.2.5.7 The inclusion of April as part of the non-breeding season differs from the seasonal definitions used in the assessments applied by Natural England and the Applicant for the Hornsea Project Two project. Natural England advise that colony-specific and site-specific information should be used to identify the relevant biological seasons to be used for impact assessments. Hornsea Three is located approximately 149 km from the nearest breeding colony of puffin at FFC pSPA and it is therefore considered that the trends in the abundance of puffin at Hornsea Three, identified through site-specific survey data, are more applicable when defining biological seasons to be used in the assessment of impacts on birds that occur at Hornsea Three.

1.2.5.8 Using the information presented above the following biological seasons are defined for puffin:

- Breeding season – May to July; and
- Non-breeding season - August to April.

1.2.6 Razorbill

Trends in abundance

1.2.6.1 The highest abundance of razorbill at Hornsea Project One and Hornsea Project Two occurred in September or October in each of the three survey years shown in Figure 1.12 with the exception of the third year, although densities did show an increase. Similarly, at Dogger Bank Creyke Beck A&B and Dogger Bank Teesside A&B increased densities occurred in October of the first survey year however, densities remained relatively low throughout the post-breeding period in the second year of surveys (Figure 1.13). At East Anglia Three increased densities occurred in October/November although were lower than those observed at the Hornsea and Dogger Bank projects (Figure 1.13). These peaks reflect the migratory movements of razorbill southwards towards wintering areas (Furness, 2015).

1.2.6.2 After September/October densities of razorbill at Hornsea Projects One and Two were generally lower until February/March when birds began returning to breeding colonies with similar trends observed at the Dogger Bank projects. Peaks representing the return of razorbills to UK waters occurred in March/April at Hornsea Projects One and Two between February and April at the Dogger Bank projects. At East Anglia Three, peaks appeared to be bimodal occurring in February and April in the first survey year and January and March-April in the second survey year.

1.2.6.3 Densities in the breeding season were often low, especially in May, although increases occurred in July/August across Hornsea Projects One and Two and the Dogger Bank projects, with this likely representing immature birds returning to natal waters to prospect for breeding sites.

1.2.6.4 Consistent with the trends in abundance observed at Hornsea Projects One and Two and the Dogger Bank projects, a peak in the abundance of razorbill occurred at Hornsea Three during March 2017 with this representing the movement of birds back to breeding colonies (Figure 1.14). Densities were relatively low from April until August with this consistent with the abundance of razorbill across all projects. In addition, the post-breeding peaks in September/October observed at Hornsea Projects One and Two and the Dogger Bank projects, were also observed at Hornsea Three occurred in October/November.

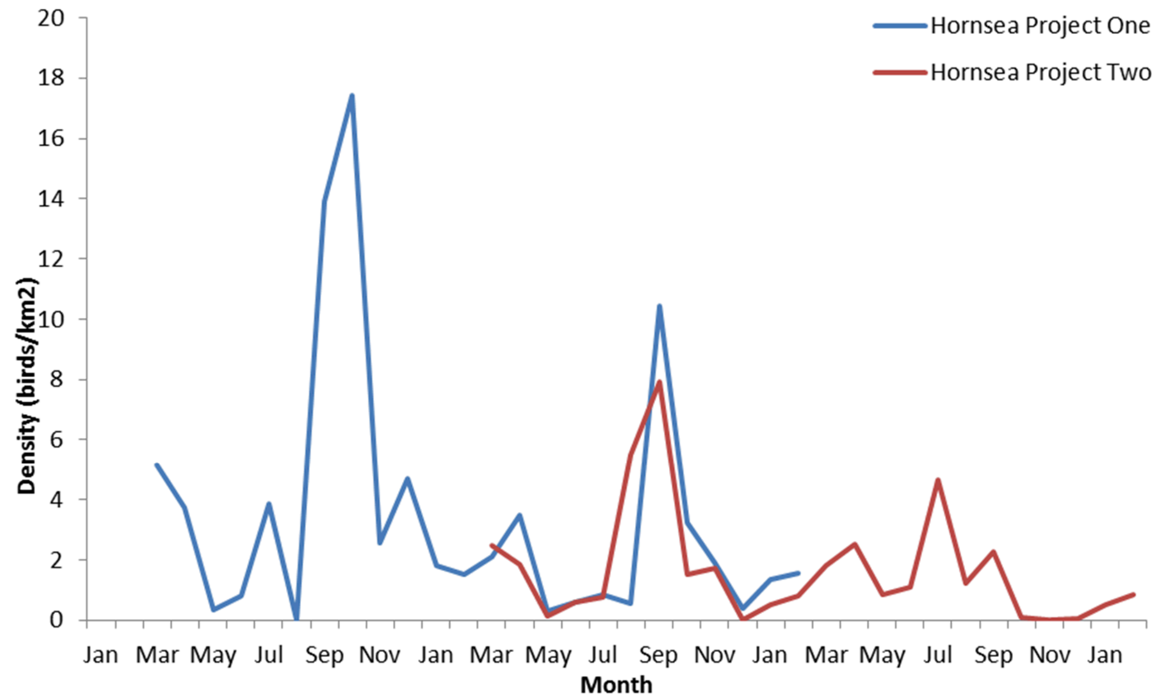

Figure 1.12: Population estimates for razorbill calculated from boat-based survey data for Hornsea Project One plus a 4 km buffer between March 2010 and February 2012 and for Hornsea Project Two plus a 4 km buffer between March 2011 and February 2013.

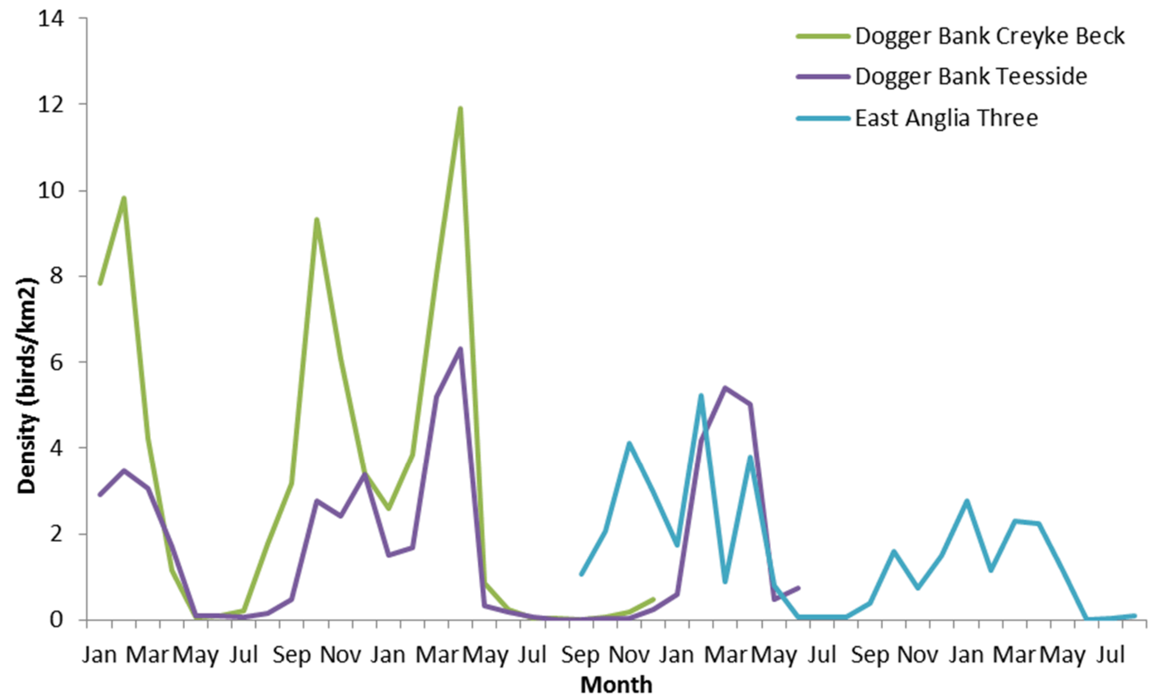

Figure 1.13: Population estimates for razorbill calculated from project-specific survey data for Dogger Bank Creyke Beck A&B plus a 2 km buffer (January 2010 to December 2011), Dogger Bank Teesside A&B plus a 2 km buffer (January 2010 to June 2012) and East Anglia Three plus a 4 km buffer (September 2011 to August 2013).

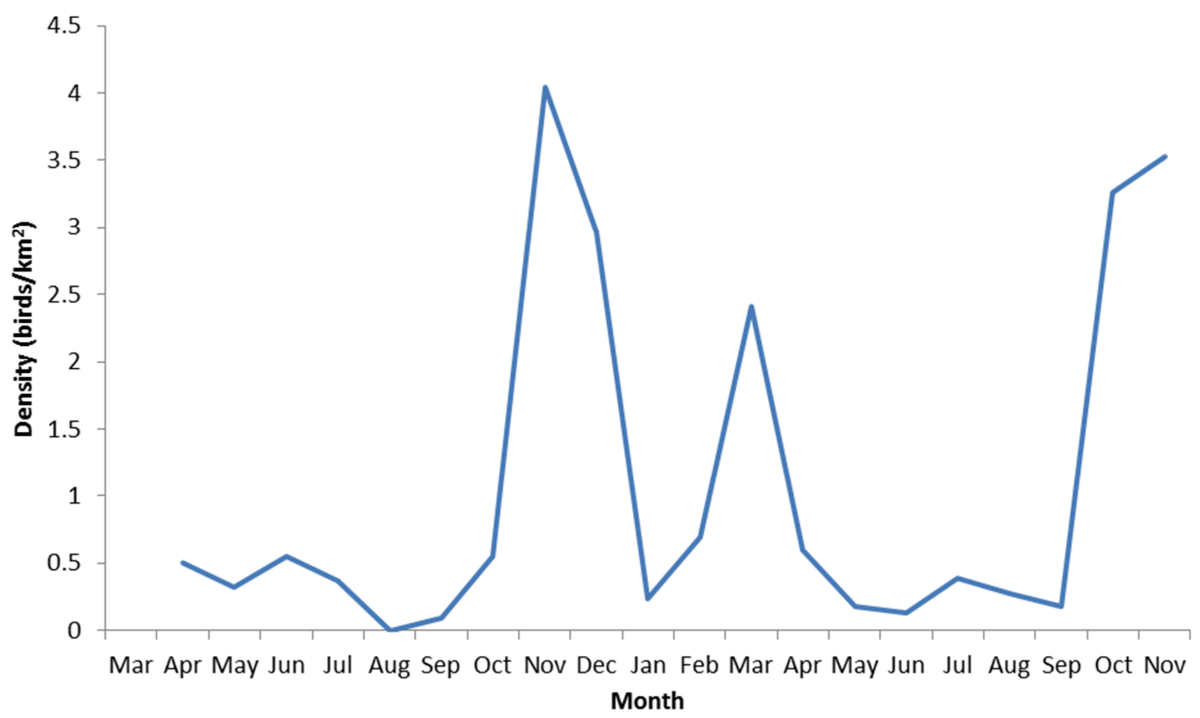

Figure 1.14: Population estimates for razorbill calculated from aerial survey data for Hornsea Three plus a 4 km buffer between April 2016 and November 2017.

Summary

1.2.6.5 Using the abundance data for razorbill from those projects in the English North Sea incorporated into the analyses above, the following key points in relation to the phenology of razorbills have been identified:

- Peak densities of razorbill generally occur between September and November reflecting post-breeding migratory movements;
- Densities of razorbill are generally lower from December with increases occurring from February into March reflecting return movements of birds to colonies; and
- Densities between May and July are generally lower, with gradual increases into July at Hornsea projects likely representing the return of immature birds to natal waters.

1.2.6.6 Furness (2015) defines the migratory free breeding season for razorbill as April to June and the UK breeding season as April to July. At Hornsea Projects One and Two, the Dogger Bank projects and East Anglia Three peaks in abundance occurred in March/April (Figure 1.12 and Figure 1.13) with a similar peak also occurring during the aerial surveys at Hornsea Three (Figure 1.14). Peaks in the densities of razorbill also occurred in July in the first and third years of surveys at Hornsea Projects One and Two although no peak was recorded in the second year of these surveys, at the Dogger Bank projects, East Anglia Three or at Hornsea Three during July 2016. However, densities did begin to increase at Hornsea Three during July 2017 potentially indicating movements of birds away from colonies through Hornsea Three.

1.2.6.7 The results from surveys indicate that movements of birds are occurring at Hornsea Three in April and July and it is therefore considered that the use of April to July as the breeding season for razorbill is suitably precautionary. Using the information presented above, the following biological seasons are defined for razorbill:

- Breeding season - April to July;
- Post-breeding season - August to October;
- Non-breeding season – November to December; and
- Pre-breeding season - January to March.

1.2.6.8 These seasonal definitions are therefore consistent with the UK breeding season, post-breeding season, non-breeding season and pre-breeding season defined by Furness (2015) and are considered appropriate and suitably precautionary for use in assessments at Hornsea Three. These seasonal definitions are also consistent with those applied in the assessments presented by both the Applicant and Natural England for the consented Hornsea Project Two offshore wind farm (see Appendix R of the Applicant's submission to Deadline 2A and Appendix 5 of Natural England's submission to Deadline 3 during the Hornsea Project Two examination).

1.2.7 Guillemot

Trends in abundance

1.2.7.1 Peaks in the abundance of guillemot occurred in September/October in all survey years covering Hornsea Project One and Hornsea Project Two (Figure 1.15) with increased densities occurring between September and November at Dogger Bank Creyke Beck A&B in the first year of surveys (Figure 1.16). This is consistent with the dispersal of birds away from breeding colonies eastwards into the North Sea (Furness, 2015; Wernham *et al.,* 2002). The densities recorded at Dogger Bank Teesside A&B in the first year of surveys and at East Anglia Three increased from August, although not to the extent observed at Hornsea Projects One and Two and Dogger Bank Creyke Beck A&B.

1.2.7.2 Following post-breeding movements at Hornsea Projects One and Two, densities showed a decrease until at least February. In contrast, at the Dogger Bank projects densities remained at similar levels until February, whereas at East Anglia densities increased from November into January.

1.2.7.3 At Hornsea Projects One and Two and the Dogger Bank projects densities increased from February generally peaking between February and April as birds returned to breeding colonies. At East Anglia Three, increased densities were also noted although these were lower or similar to those recorded earlier in the non-breeding season (e.g. January). Densities between May and June were generally lower than those recorded between February and April with increases then noted in July at Hornsea Projects One and Two but not at the Dogger Bank projects or East Anglia Three.

1.2.7.4 Trends in the abundance of guillemot as recorded during aerial surveys at Hornsea Three differ between the two breeding seasons (March to July) covered by the surveys (Figure 1.17). In 2016, densities began to increase from May and then remained high throughout the breeding season. In contrast, in 2017 densities began to increase from January remaining high throughout all breeding season months with the exception of June when a decrease was observed. Following the June 2017 survey, densities increased reflecting the post-breeding dispersal of guillemot from breeding colonies into offshore areas in the North Sea. Higher densities in these months were also observed in 2016 and at Hornsea Projects One and Two.

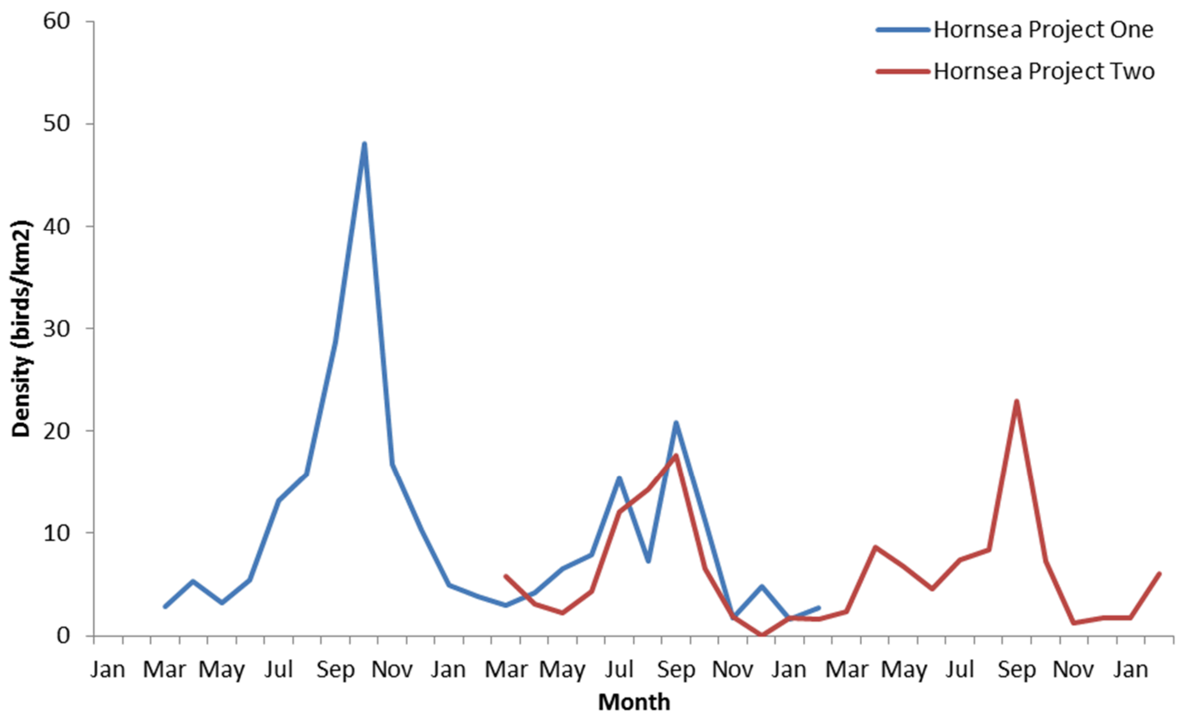

Figure 1.15: Population estimates for guillemot calculated from boat-based survey data for Hornsea Project One plus a 4 km buffer between March 2010 and February 2012 and for Hornsea Project Two plus a 4 km buffer between March 2011 and February 2013.

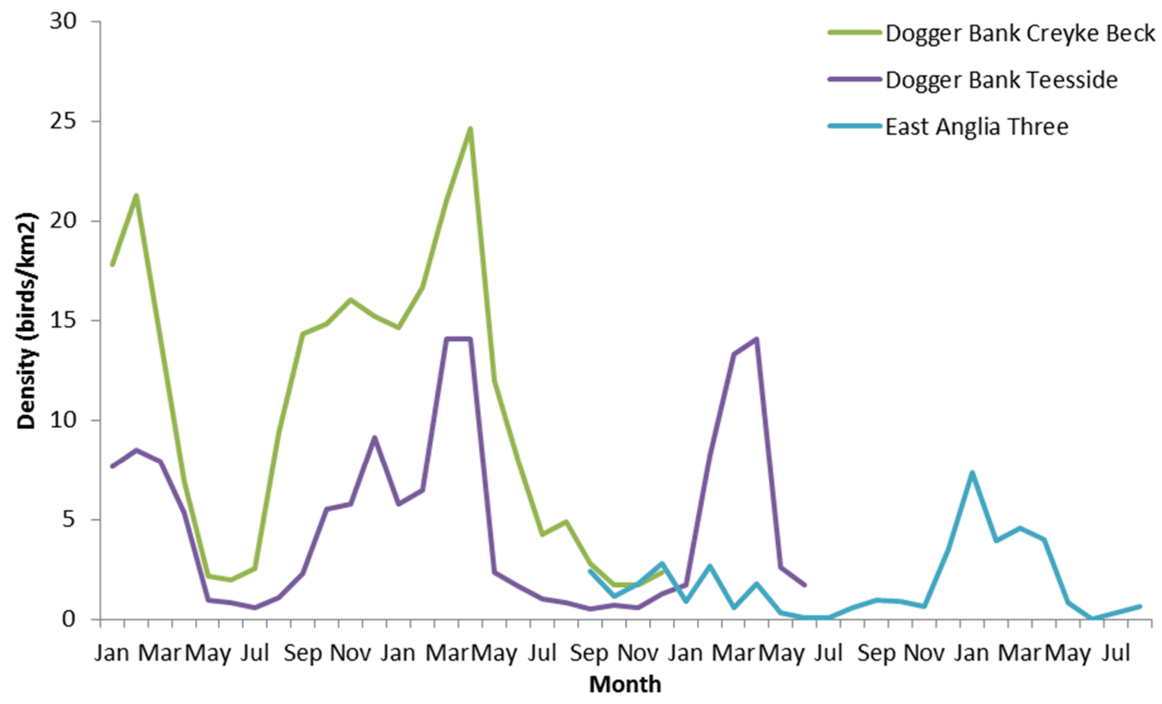

Figure 1.16: Population estimates for guillemot calculated from project-specific survey data for Dogger Bank Creyke Beck A&B plus a 2 km buffer (January 2010 to December 2011), Dogger Bank Teesside A&B plus a 2 km buffer (January 2010 to June 2012) and East Anglia Three plus a 4 km buffer (September 2011 to August 2013).

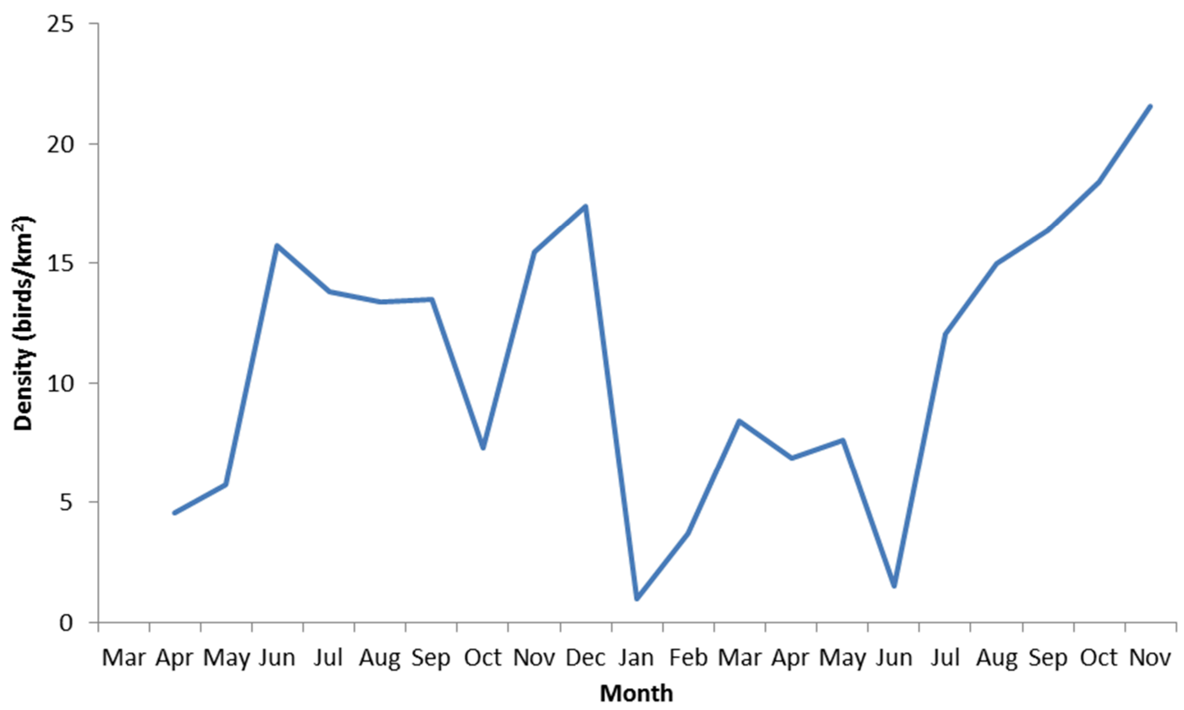

Figure 1.17: Population estimates for guillemot calculated from aerial survey data for Hornsea Three plus a 4 km buffer between April 2016 and November 2017.

Summary

1.2.7.5 Using the abundance data for guillemot from those projects in the English North Sea incorporated into the analyses above, the following key points in relation to the phenology of razorbills have been identified:

- The trends in the abundance of guillemot at Hornsea Three generally correlate with the trends observed at Hornsea Projects One and Two;
- At the three Hornsea projects peaks in the abundance of guillemot generally occurred between September and November representing the post-breeding dispersal of guillemot into the North Sea; and
- The lowest densities at the three Hornsea projects are generally recorded between December and March and then increase throughout the breeding season.

1.2.7.6 Furness (2015) defines the migratory free breeding season for guillemot as March to June and the UK breeding season as March to July. Guillemot is a dispersive, rather than a migratory species, with birds from colonies on the east coast of the UK wintering mainly in the North Sea (Wernham *et al.,* 2002). This is reflected in the surveys at all Hornsea projects with little evidence of a peak in abundance between January and April (Figure 1.15 and Figure 1.17), although densities were higher at the Dogger Bank projects (Figure 1.16) with previous surveys indicating that the Dogger Bank area is an important area for guillemot in the non-breeding season (see Annex 5.1: Baseline Characterisation Report).

1.2.7.7 Dispersal away from breeding colonies begins in July with peak movements occurring between September and October. These movements are reflected in the surveys conducted across Hornsea Projects One and Two and the in first year of surveys at the Dogger Bank projects. This peak is not reflected in the first year of surveys at Hornsea Three however, densities do increase into September in 2017.

1.2.7.8 Using the information presented above the following biological seasons are defined for guillemot:

- Breeding season - March to July; and
- Non-breeding season - August to February.

1.2.7.9 These seasonal definitions are therefore consistent with the UK breeding season and the non-breeding season defined by Furness (2015) and are therefore considered appropriate and suitably precautionary for use in assessments at Hornsea Three. These seasonal definitions are also consistent with those applied in the assessments presented by both the Applicant and Natural England for the consented Hornsea Project Two offshore wind farm (see Appendix O of the Applicant's submission to Deadline 2A and Appendix 4 of Natural England's submission to Deadline 3 during the Hornsea Project Two examination).

1.3 Connectivity between FFC pSPA seabird features and Hornsea Three in the breeding season

1.3.1 Overview

1.3.1.1 During the breeding season foraging birds may travel some distance from their breeding colonies. The information available on the distances that breeding birds will forage depends on the individual species. Typically the mean-maximum range (i.e. the mean average of the maximum foraging trips recorded) as reported by Thaxter *et al.* (2012), has been applied in Habitats Regulation Assessments (HRA) as a criterion for establishing whether there is likely to be connectivity (and hence risk of an impact) between a SPA breeding colony and a proposed wind farm development. Where the foraging ranges presented in Thaxter *et al.* (2012) are used in the Hornsea Three Habitat Regulations Assessment Screening Report (DONG Energy, 2016), the mean-maximum range ± one standard deviation has been used in order to add further precaution.

1.3.1.2 In some cases, targeted species-specific information is available from GPS/satellite tracking studies, such as, for example, the FAME/STAR initiatives for kittiwake and gannet colonies associated with the FFC pSPA. The Hornsea Three Habitat Regulations Assessment Screening Report (DONG Energy, 2016) reviewed species foraging ranges and site specific information from GPS/satellite tracking studies where information was available, to ascertain the likelihood of connectivity between SPA breeding colonies and Hornsea Three during the breeding season. On the basis of this analysis, it was considered that there was only likely to be connectivity (and hence risk of an impact) between Hornsea Three and the FFC pSPA for four species (fulmar, gannet, kittiwake and puffin). All other breeding seabird qualifying and assemblage features (including guillemot and razorbill) have mean-maximum (or maximum) foraging ranges that do not extend a sufficient distance to bring them into contact with the proposed array area and, therefore, no LSE was predicted on these features during the breeding season.

1.3.1.3 Table 1.1 identifies the foraging range information used to identify connectivity between Hornsea Three and the FFC pSPA in the HRA Screening Report.

Table 1.1: Sources of information used to define connectivity between features of FFC pSPA and Hornsea Three.

Qualifying feature	Foraging range information
Gannet	Langston *et al.* (2013); Wakefield *et al.* (2013)
Kittiwake	Tracking data obtained from the RSPB
Puffin	Thaxter *et al.* (2012)
Razorbill	Thaxter *et al.* (2012)
Guillemot	Thaxter *et al.* (2012)

1.3.1.4 Subsequent to the publication of the Hornsea Three Habitat Regulations Assessment Screening Report (DONG Energy, 2016), Natural England has advised that FFC pSPA should be screened in for guillemot and razorbill in the breeding season and evidence for connectivity with FFC pSPA during the breeding season should be considered in the HRA impact assessment (Natural England 2017: advice on the position paper issued in advance of the EWG meeting for Offshore Ornithology on 29 March 2017 as part of the Hornsea Three evidence plan process).

1.3.1.5 The screening process for Hornsea Three (DONG Energy, 2016) was based upon the best and most up to date evidence, in complete accordance with Natural England's guidance. It is pertinent to note the above mentioned advice from NE was provided in the knowledge that RSPB had through the EWG, offered to make available previously unavailable data on guillemot and razorbill from FAME and STAR projects (https://ww2.rspb.org.uk/our-work/conservation/projects/tracking-seabirds-to-inform-conservation-of-the-marine-environment). RSPB provided a summary of the previously unavailable data on guillemot and razorbill from FAME and STAR following publication of these fine-scale tracking data in July 2017 in a paper that modelled predicted spatial use by four species (including guillemot and razorbill) from unobserved colonies and thereby mapped the distribution at sea of each species at the colony (Wakefield et al. 2017). In interpreting the tracking data made available by RSPB, context is provided from recent findings in the literature from elsewhere on the foraging ranges of auks and other seabirds, to which some the FAME and STAR programmes have contributed e.g. Kuepfer (2012).

1.3.1.6 In addition to consideration of the tracking data provided by the RSPB, consideration is also given to the findings of Wakefield *et al.* (2017) in relation to the likelihood of connectivity between colonies and Hornsea Three during the breeding season for guillemot and razorbill.

1.3.1.7 The following species-specific sections therefore provide an update to the HRA screening process conducted by DONG Energy, (2016):

- Full detail of the information used to determine whether there was connectivity between the five species included in Table 1.1 and Hornsea Three in the Hornsea Three Habitat Regulations Assessment Screening Report (DONG Energy, 2016); and

1.3.1.8 Consideration of further data sources that have been provided or published following the publication of the Hornsea Three Habitat Regulations Assessment Screening Report (DONG Energy, 2016) in relation to the likelihood of connectivity between relevant breeding colonies and Hornsea Three.

1.3.2 Gannet

1.3.2.1 Langston *et al.* (2013) provides the results of three years of tracking data and presents kernel density estimation (KDE) of foraging range of gannet from FFC pSPA. Two years of the same dataset were also used in the work presented by Wakefield *et al.* (2013). Figure 1.18 **Error! Reference source not found.** indicates that although low, there is some level of usage by gannets in Hornsea Three during the breeding season. The highest density of tracking locations was within 50-100 km of the Bempton colony with a marked decline in locations beyond 150 km. The mean foraging range recorded across the three years of tracking was less than 50 km with approximately 70% of all foraging trips occurring within 50 km of the colony. On this basis, very limited connectivity between breeding birds from FFC pSPA and the Hornsea Three area was identified.

1.3.2.2 Wakefield *et al.* (2013), using tracking data from twelve colonies around the UK estimated the percentage utilization distribution of gannets in UK waters. The results showed that gannets from different colonies foraged in mutually exclusive areas. As such, it can be concluded that it is very unlikely gannets from other colonies (e.g. Bass Rock) will forage at Hornsea Three.

Conclusion

1.3.2.3 As concluded in the HRA Screening Report it is assumed for the purposes of impact assessment that there is connectivity during the breeding season between the FFC pSPA Hornsea Three based on a low level of usage by birds of the Hornsea Three area as illustrated by tracking data presented in Langston *et al.* (2013).

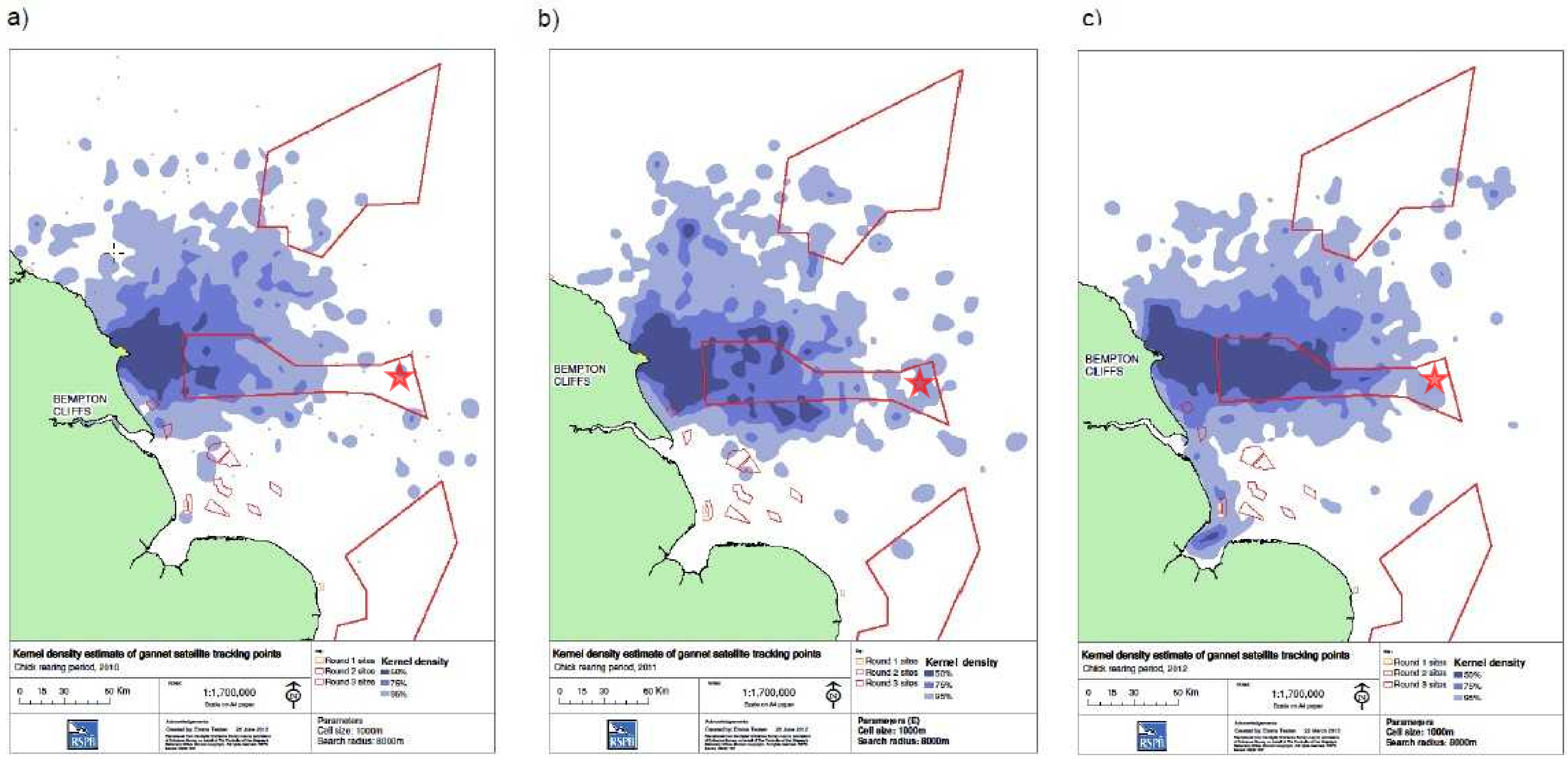

Figure 1.18: Gannet foraging range by Kernel Density Estimation during chick-rearing seasons 2010-2012 (a to c), showing 50%, 75% and 95% density contours (taken from Langston *et al*. (2013)). The figure shows boundary of the former Hornsea Zone with the approximate location of Hornsea Three indicated by the transparent red star.

1.3.3 Kittiwake

1.3.3.1 Figure 1.22 presents tracking data for kittiwake from FFC pSPA obtained from the RSPB. These data were collected during the breeding season and indicate that there is limited connectivity with Hornsea Three. Although it is likely that only a very small proportion of kittiwakes found in the Hornsea Three array area during the breeding season are foraging adults from the pSPA, connectivity between breeding birds from FFC pSPA and Hornsea Three is assumed.

1.3.3.2 By utilising the tracking data from 20 colonies around the UK, including FFC pSPA, Poisson point process habitat use models in Wakefield *et al.* (2017) suggest that Hornsea Three is located in an area outside of the boundary delineating 95% at-sea utilization distribution of breeding kittiwake during late incubation/early chick-rearing estimated as functions of colony distance, coast geometry, intra-specific competition (Figure 1.21). This is further supported by cumulative foraging range data[1] that indicates that 95% of foraging trips occur within 60 km of a colony (Figure 1.19). This therefore infers that only 5% of foraging trips would occur beyond this distance with the percentage decreasing up to a maximum foraging range of 120 km.

Figure 1.19: Cumulative frequency and proportion of birds found foraging at different distances from colony (Birdlife International, 2014).

1.3.3.3 The duration of foraging trips and maximum foraging range of many seabird species are a function of both prey abundance, with the distance travelled increasing with reduced prey abundance (Hamer *et al*., 1993; Lewis *et al*., 2006; Riou *et al*., 2006; Thaxter *et al.,* 2012). and colony size, with distance increasing with increasing colony size (Lewis *et al*., 2001; Forero *et al.,* 2002; Ainley *et al*., 2003; Wakefield *et al*., 2013) with the effect of food abundance greater than that of colony size. As such, it can be surmised that foraging trips will be of shorter duration at colonies where food availability allows high productivity. This information indicates that large foraging ranges of some kittiwake recorded at colonies in northern Scotland where breeding productivity is consistently poor due to limited foraging opportunities would not be expected at colonies on the east coast of England where breeding productivity is generally higher and foraging opportunities are more plentiful.

1.3.3.4 Daunt *et al.* (2002) suggests that central place foragers, such as seabirds, will have an upper limit associated with potential foraging range, set by time constraints associated with breeding productivity. For kittiwake, this upper limit is estimated at 73 km based on the flight speed of kittiwake and time required to catch prey for birds from the Isle of May. Coulson (2011) estimated the foraging range of kittiwakes using the average absence time from the colony and the flight speed of kittiwakes. Using an average absence time of 2 hours 48 minutes and a flight speed of 45 km/hour Coulson (2011) calculated a foraging range of 63 km. This estimate is almost identical with that estimated by Pearson (1968) for breeding kittiwakes from the colony on the Farne Islands.

1.3.3.5 The suggestion of limited use of Hornsea Three by kittiwake from FFC pSPA is supported by flight direction information collected during aerial surveys of Hornsea Three (Figure 1.20). A notable majority of birds were recorded flying in a north-westerly, westerly or south-westerly direction. However, there is no evidence of a large number of birds flying in both easterly and westerly directions, which would be expected if birds from FFC pSPA were specifically utilising the Hornsea Three area for foraging purposes.

1.3.3.6 Tracking data for kittiwake is available for the breeding colony at Coquet Island (Robertson *et al.,* 2014). Across two years (2011 and 2012) a total of 36 birds were tagged with data retrieved from 21 birds. This included 26 birds in the chick-rearing period and 10 nests during incubation. These birds provided data from a total of 106 foraging trips. Foraging ranges during both periods were calculated based on 95% volume contours and 25% volume contours (core foraging range) using fixed kernel density estimation. During the chick-rearing periods in 2011 and 2012 maximum foraging ranges of 28.02 ± 3.88 km and 9.03 ± 1.17 km were recorded respectively. During the incubation period in 2012, a maximum foraging range of 50.95 ± 12.99 km was recorded. These results indicate that there are annual differences in the foraging ranges of kittiwake however, the maximum foraging ranges recorded during the chick-rearing period in both 2011 and 2012 were shorter than the maximum foraging range recorded during incubation in 2012.

[1] Birdlife International - http://seabird.wikispaces.com/

1.3.3.7 The tracking data presented in Figure 1.22 was collected during the late incubation/chick-rearing period and indicates limited connectivity with Hornsea Three. Therefore, the peaks in the density of kittiwake at Hornsea Three during aerial surveys is likely to represent an increase in the number of immature and/or failed breeders, the numbers of which increase as the breeding season progresses.

1.3.3.8 Increases in the abundance of kittiwake occurred across all projects in the former Hornsea Zone in June/July. This trend in abundance appears to be inconsistent with the findings of Robertson *et al.* (2014) which suggest that the abundance of kittiwake in offshore areas should decrease as the breeding season progresses due to birds undertaking shorter foraging trips. However, the increases in the abundance of kittiwake across the former Hornsea Zone in June/July can be explained by the phenology of immatures. As the breeding season progresses an increasing number of immatures return to UK waters (see Section 1.2). The findings of Robertson *et al.* (2014) therefore support the assertion that the increases in kittiwake abundance across the Hornsea Zone in June/July is indicative of movements of immatures into this area and not due to the increased abundance of foraging breeding birds.

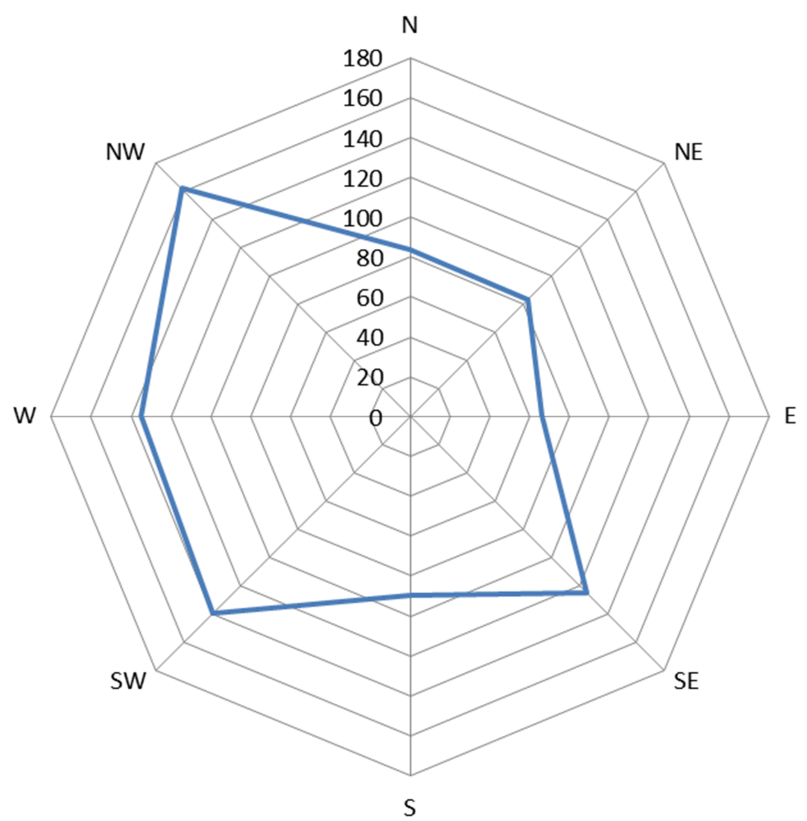

Figure 1.20: Flight direction of kittiwake recorded during aerial surveys at Hornsea Three undertaken during the breeding season (April to July).

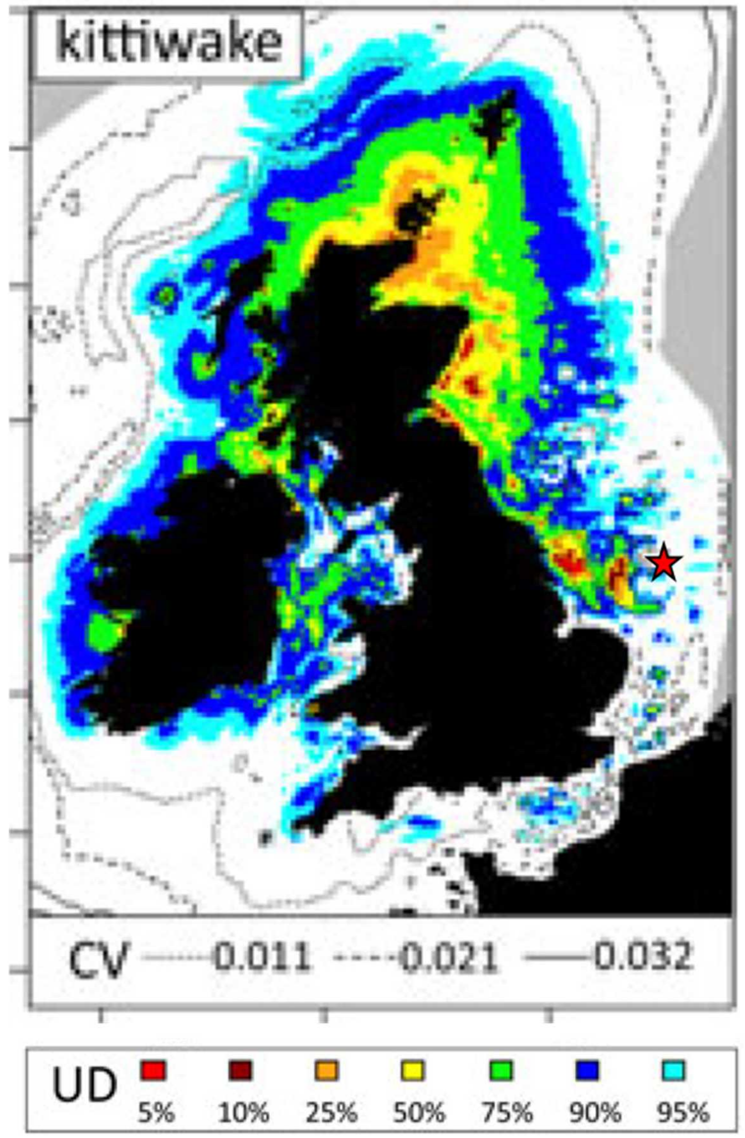

Figure 1.21: Percentage at-sea utilization distribution (UD) of kittiwake breeding within Britain and Ireland during late incubation/early chick-rearing estimated from modelling as functions of colony distance, coast geometry, intra-specific competition and habitat. Isopleths indicate relative coefficient of variation (CV) of the estimated probability density (grey = no environmental data) (reproduced from Wakefield *et al.*, 2017, annotated with red star indicating approximate location of Hornsea Three).

Conclusion

1.3.3.9 On a highly precautionary basis, connectivity between the kittiwake breeding colony at FFC pSPA has been identified based on tracking data from FFC pSPA that shows a single track from a single bird overlapping with Hornsea Three. This conclusion is consistent with the conclusion reached in the HRA Screening Report (DONG Energy, 2016).

1.3.3.10 Further information presented in this section is used to establish the likely proportion of birds present at Hornsea Three attributable to the FFC pSPA. This information indicates that it is highly unlikely that a significant proportion of breeding birds from FFC pSPA are utilising Hornsea Three as a foraging area for the following reasons

- Cumulative foraging range data (Figure 1.19) indicates that very few foraging trips (if any) would occur at a distance beyond 120 km (the maximum foraging distance reported by Thaxter *et al.* (2012) (Hornsea Three is 149 km from FFC pSPA);
- When breeding productivity is high, foraging ranges are short (Hamer *et al*., 1993; Lewis *et al*., 2006; Riou *et al*., 2006; Thaxter *et al.,* 2012). Breeding productivity at FFC pSPA is comparatively high suggesting that foraging ranges will be short;
- Based on the relationship between time constraints and breeding productivity, a number of studies have shown that the foraging ranges of kittiwake are unlikely to exceed 73 km (Daunt *et al.,* 2002; Coulson, 2011; Pearson (1968);
- At sea utilisation maps presented in Wakefield *et al.* (2017) derived utilising the tracking data used to inform the basis for connectivity between FFC pSPA and Hornsea Three suggest that the area in which Hornsea Three is located is beyond the 95% utilisation contour; and
- Site-specific flight direction data does not indicate movements of birds to and from the colony at FFC pSPA into Hornsea Three.

1.3.3.11 In addition tracking data from Robertson *et al.* (2014) indicates that the influx of birds into the former Hornsea Zone in June and July (Figure 1.5 and Figure 1.7) is indicative of the arrival of immature birds into natal waters.

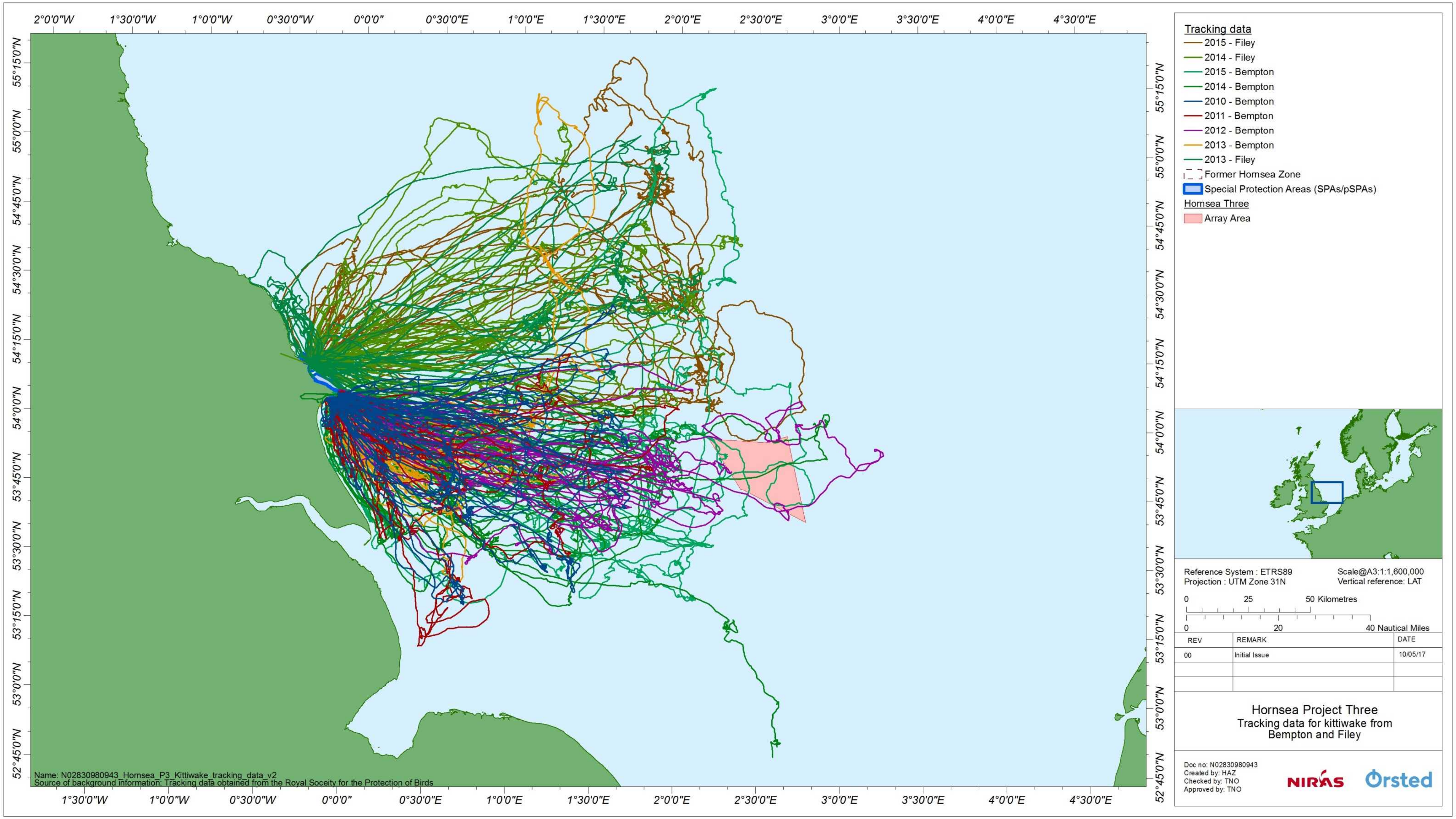

Figure 1.22: Kittiwake tracking data from the Flamborough and Filey Coast pSPA (data provided by the RSPB).

1.3.4 Puffin

1.3.4.1 In the absence of site specific tracking data for puffin from FFC pSPA, Thaxter *et al.* (2012) was used in the Hornsea Three Habitat Regulations Assessment Screening Report (DONG Energy 2016) as a criterion for establishing whether there is likely to be connectivity (and hence risk of an impact) between FFC pSPA breeding colony and Hornsea Three (DONG Energy, 2016). The mean-maximum foraging range estimate for puffin is 105.4 km (± 46 km) (Thaxter *et al.,* 2012) with a maximum foraging range of 200 km. The foraging ranges derived by Thaxter *et al.* (2012) were considered to have only a low level of associated confidence due to being supported by only limited number of studies. Hornsea Three is located approximately 149 km from FFC pSPA, the closest puffin breeding colony. Hornsea Three is beyond the mean-maximum foraging range of this species from FFC pSPA but is just inside of foraging range if the standard deviation associated with the mean-maximum foraging range is used. This therefore suggests the potential for connectivity between Hornsea Three and breeding individuals from this colony but also indicates that Hornsea Three is likely to be towards the very outer limit of the foraging range of puffins from FFC pSPA. This conclusion is consistent with Webb *et al.* (1985) that reported few observations of puffin bringing fish back to their chicks from beyond 30 km offshore from what is now FFC pSPA (Brown and Grice, 2005). These observations occurred at a time when the number of breeding puffins at FFC pSPA was over seven times higher than the size of the colony today. However, given the associated low confidence associated with the foraging ranges presented in Thaxter *et al.* (2012), connectivity between breeding puffins and Hornsea Three was identified on a precautionary basis.

1.3.4.2 It is highly unlikely that adult breeding birds will be evenly distributed throughout their defined foraging range, with the density of foraging birds likely to be highest closest to the colony as birds attempt to reduce energetic costs associated with provisioning young (MacArthur Green, 2014). Detailed cumulative foraging range data for puffin indicates that 95% of foraging trips occur within 65 km of the colony. This infers that only 5% of foraging trips would occur beyond this distance with this percentage decreasing as distance from the colony increases (Figure 1.23). Based on the frequency curve it is likely that only 1-2% of foraging trips from Flamborough and Filey Coast pSPA will occur at a distance likely to interact with Hornsea Three.

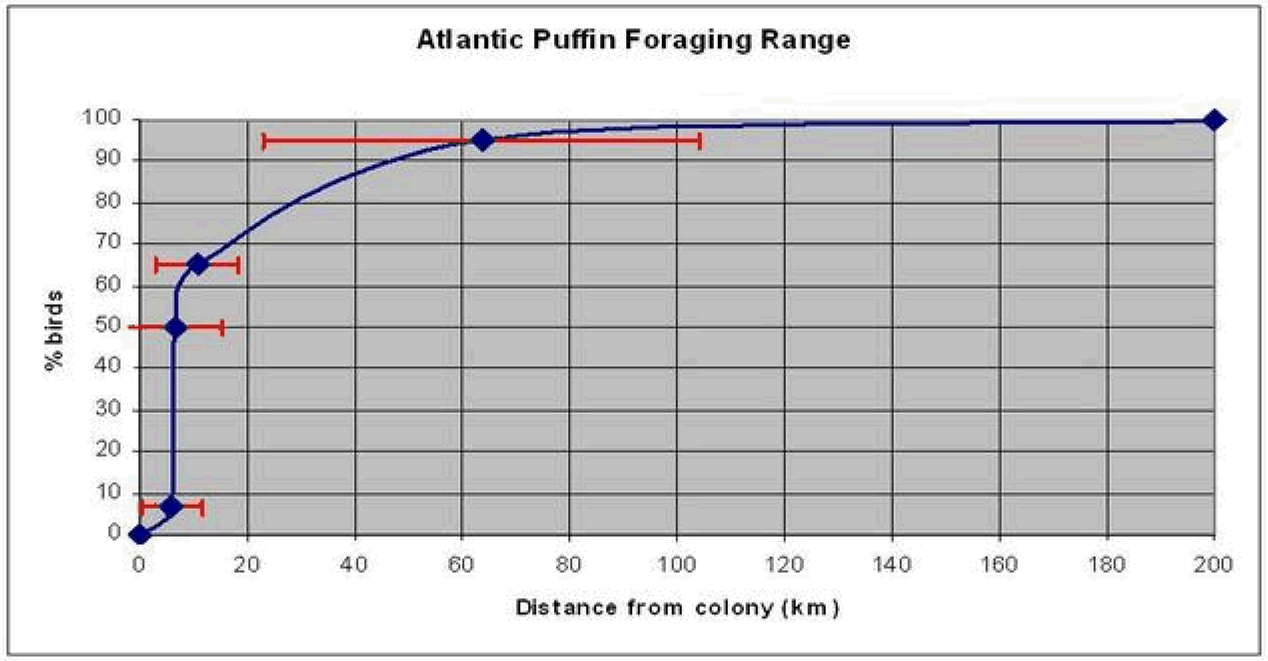

Figure 1.23: Cumulative frequency and proportion of birds found foraging at different distances from colony (Birdlife International, 2014).

1.3.4.3 It is likely that consistently foraging at distances beyond 65 km would negatively impact the productivity of the colony to such an extent as to reduce overall productivity to zero with this observed for other species of auk at colonies in Shetland and Orkney (e.g. see Heubeck and Parnaby, 2012).

1.3.4.4 Colonies on the east coast of England generally show high breeding success and have not been affected by dramatic food shortages experienced by populations in Shetland and Orkney. This implies that food supply, and as such foraging opportunities, are good. This would result in foraging breeding adults having to travel shorter distances than those cited in the literature in order to acquire food. Taking into account the relatively high productivity at colonies on the east coast of the UK, foraging trips undertaken by birds from FFC pSPA are likely to be lower than the mean maximum foraging range provided in Thaxter *et al.* (2012), with this value (105.4 km) considered to incorporate the foraging range of at least 95% of birds from the pSPA colony.

Conclusion

1.3.4.5 Connectivity between the puffin breeding colony at FFC pSPA and Hornsea Three has been identified on a precautionary basis due to the uncertainty associated with the foraging ranges presented in Thaxter *et al.* (2012). This conclusion is consistent with the conclusion reached in the HRA Screening Report (DONG Energy, 2016). However, based on the information presented above for the relationship between foraging range and breeding productivity it is considered unlikely that a significant proportion of breeding adults from the FFC pSPA will occur at Hornsea Three during the breeding season.

1.3.5 Razorbill

1.3.5.1 In the absence of site specific tracking data for razorbill from FFC pSPA, Thaxter *et al.* (2012) has been used in the Hornsea Three Habitat Regulations Assessment Screening Report (DONG Energy, 2016) as a criterion for establishing whether there is likely to be connectivity (and hence risk of an impact) between FFC pSPA breeding colony and Hornsea Three (DONG Energy, 2016). The mean-maximum foraging range estimate for razorbill is 48.5 km (Thaxter *et al.,* 2012) with a maximum foraging range of 95 km. The foraging ranges derived by Thaxter *et al.* (2012) were considered to have a moderate level of associated confidence due to being supported by a smaller number of studies than those foraging ranges awarded a higher level of confidence. Hornsea Three is located approximately 149 km from FFC pSPA, the closest razorbill breeding colony. The great distance of Hornsea Three beyond maximum foraging range of this species from FFC pSPA suggests that the potential for connectivity of breeding individuals from this colony to be present during the breeding season at Hornsea Three is extremely unlikely. This is consistent with Webb *et al.* (1985) that reported observations of high densities of razorbill recorded out to 30 km offshore from FFC pSPA (Brown and Grice, 2005) indicating that few birds may be foraging out to the maximum foraging range as presented in Thaxter *et al.* (2012).

1.3.5.2 It has been suggested by the EWG as part of the Evidence Plan process that further sources of information, namely tracking data obtained for razorbill from a number of UK breeding colonies and Wakefield *et al.* (2017) be used to identify whether there is evidence to suggest that connectivity between FFC pSPA and Hornsea Three.

1.3.5.3 Wakefield *et al.* (2017) GPS-tracked a sample of four seabird species that included 281 razorbills from 14 colonies in the UK. The sample of colonies were drawn from throughout the geographical, environmental and colony size range of the study species in Britain and Ireland. The sample of colonies did not include FFC pSPA. The GPS tracking was carried out during May-July, 2010 – 2014, when the study species were either approaching the end of the incubation period or raising small chicks.

1.3.5.4 Using Poisson point process habitat use models, Wakefield *et al.* (2017) showed that distribution at sea is dependent on: (i) density-dependent competition among sympatric conspecifics (all species) and parapatric conspecifics (guillemots); (ii) habitat accessibility and coastal geometry, such that birds travel further from colonies with limited access to the sea; and (iii) regional habitat availability. Using these models, Wakefield *et al.* (2017) predicted space use by birds from unobserved colonies e.g. FFC pSPA, and thereby mapped the distribution at sea of each species at both the colony and regional level. This is presented in the form of percentage utilization distributions (UD), defined as a population's spatial probability distribution (Fieberg and Kochanny 2005). The pertinent observation from Wakefield *et al.* (2017) is that Hornsea Three lies at least twice the distance beyond FFC pSPA than the intervening boundary delineating 95% at-sea UD of breeding razorbills during late incubation/early chick-rearing estimated as functions of colony distance, coast geometry, intra-specific competition and habitat (Figure 1.24). Furthermore, space use by razorbill declined with distance from the colony, in accordance with the hypothesis that such central-place foragers minimize distance-dependent travel costs. On the basis of these findings alone, it is considered a robust assumption that Hornsea Three does not lie within the maximum foraging range of breeding razorbills from FFC pSPA when successfully breeding i.e. a distance compatible with a two parent family able to bring enough food back to keep a chick alive.

1.3.5.5 A summary of a subset of the GPS-tracking data used from the FAME and STAR programmes by Wakefield *et al.* (2017), has been made available by the RSPB in order to review whether Thaxter *et al.* (2012) is the best available evidence to identify the potential for connectivity of breeding razorbill from FFC pSPA with Hornsea Three during the breeding season. The subset of data comprises of maximum foraging distances recorded at 11 of the 14 razorbill colonies in the UK sampled (Table 1.2). The GPS tracking was carried out during May-July, 2010 – 2014, when the study species were either approaching the end of the incubation period or raising small chicks.

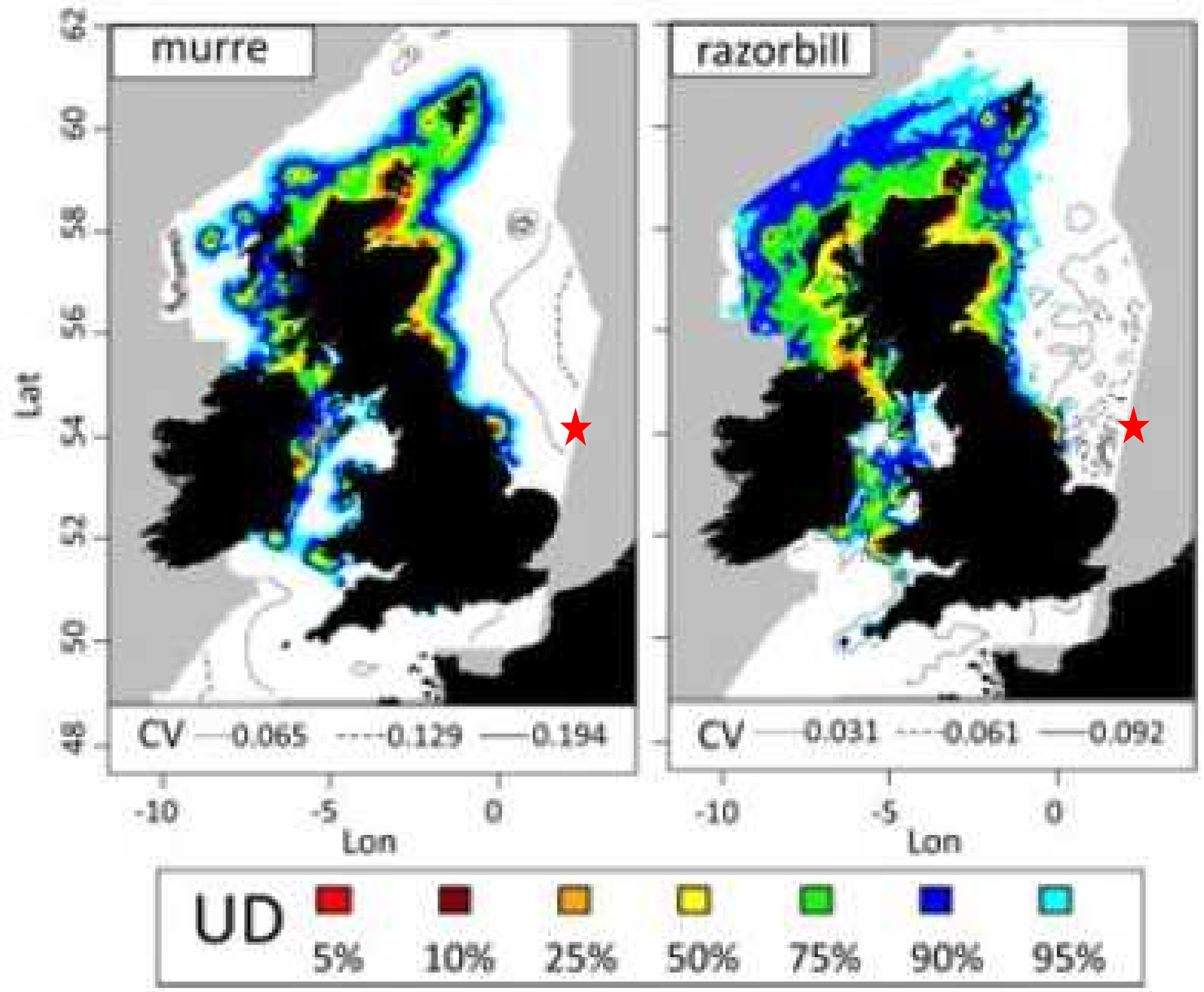

Figure 1.24: Percentage at-sea utilization distribution (UD) of guillemot (murre) and razorbill breeding within Britain and Ireland during late incubation/early chick-rearing estimated from modelling as functions of colony distance, coast geometry, intra-specific competition and habitat. Isopleths indicate relative coefficient of variation (CV) of the estimated probability density (grey = no environmental data) (reproduced from Wakefield et al. 2017, annotated with red star indicating approximate location of Hornsea Three).

Table 1.2: Maximum foraging ranges of razorbill derived from tracking data from a range of breeding colonies in the UK.

County	Colony	Maximum foraging range (km)	Number of birds sampled
Shetland	Muckle Skerry	150.24	33
Shetland	Fair Isle	312.85	79
Orkney	Copinsay	128.09	14
Orkney	Swona	191.27	11
Gwynedd	Bardsey Island	41.77	20
Co. Dublin	Lambay Island	38.62	5
Co. Antrim	Rathlin Island	74.37	1
Argyll and Bute	Colonsay	41.78	42
Argyll and Bute	Lunga	32.89	7
Outer Hebrides	Shiants	35.99	4
Outer Hebrides	Flannan Isles	92.22	4

1.3.5.6 Some greater maximum distances are recorded from individual study sites than the maximum foraging range estimates of Thaxter *et al.* (2012). Those colonies with the markedly longest trips are in Orkney and Shetland. These GPS-tracking studies occurred at a time when seabird breeding productivity in Scotland was improving following declines that primarily affected colonies in the north and east (e.g. Shetland, Isle of May; JNCC, 2016). Between 2005 and 2015 the colony at Fair Isle (the colony with the highest recorded foraging range in Table 1.2) has experienced near complete breeding failure in five of those years. In those years where fledging was achieved, breeding productivity has been above 0.5 only twice in 2014 and 2015 (JNCC, 2016). This trend is also applicable to a number of other colonies in Shetland and Orkney with this suggesting that breeding success has been low throughout the Northern Isles. This coincided with shortages in sandeels, the main prey for razorbills breeding in those areas. In contrast colonies in Ross and Cromarty and North-east Fife have been relatively successful over the same time period with averages of 0.65 and 0.59 chicks, respectively with neither colony experiencing complete breeding failure.

1.3.5.7 Hughes (2013), reported on the tracking data collected at Fair Isle and indicated that on average razorbills fed closer to Fair Isle in 2012 than they had in 2011. The average breeding success at Fair Isle in 2012 was 0.23 chicks/pair compared to 0.02 chicks/pair in 2011. This increased breeding productivity, although still being very poor, was believed to be related to slightly better feeding conditions near to Fair Isle in 2012. In relation to the large foraging ranges recorded in 2011 Bolton and Owen (2012) state that '*it is difficult to avoid the conclusion that such long trips are indicative of low food availability closer to the colony*'.

1.3.5.8 In recent decades breeding success has been notably good at colonies between Humberside and south-east Scotland. This is in contrast to colonies further north where breeding success has been comparatively low (JNCC, 2016). Across the five years during which tagging was carried out (2010 – 2014) the average productivity at the Fair Isle colony has been 0.15 (JNCC, 2016). However, at FFC pSPA the average breeding productivity across the same period was 0.70, considerably higher than the productivity recorded at colonies in Shetland and Orkney. High breeding success at colonies between Humberside and south-east Scotland implies that food supply, and as such foraging opportunities, are good. This would result in foraging breeding adults having to travel shorter distances than those cited in the tracking literature in order to acquire food.

1.3.5.9 It is therefore considered that the foraging ranges recorded for birds from colonies in Shetland and Orkney are not comparable to the likely foraging behaviour of razorbills breeding at FFC pSPA and therefore the use of the mean-maximum foraging range from Thaxter *et al.* (2012) (48.5 km), which is comparable to the maximum foraging ranges recorded at other UK colonies (see Table 1.2 of DONG Energy, 2016) is an appropriate guide to the likely foraging range of birds associated with the FFC pSPA.

1.3.5.10 BirdLife's Seabird Foraging Range Database (http://seabird.wikispaces.com/; 2012) provided cumulative frequency and proportion of birds found foraging at different distances from a colony for razorbill (Figure 1.25). This also supports a conclusion that less than 5% of foraging trips from FFC pSPA by breeding razorbill would occur beyond 25 km and that none would interact with the Hornsea Three.

1.3.5.11 Behavioural data associated with bird records collected during boat-based surveys undertaken for the Hornsea Project One and Hornsea Project Two developments have also been analysed to identify if razorbill observed at Hornsea Three may be associated with FFC pSPA. Figure 1.26 shows the percentage of razorbill observed carrying fish as recorded across Hornsea Zone transects during the breeding season. Transects are presented running from west to east. The data show that a higher percentage of birds were recorded carrying fish on transects located closer to FFC pSPA. No birds were recorded carrying fish on transects overlapping with Hornsea Three plus a 4 km buffer (HZT17 to HZT22). On the evidence presented in this section there is no indication of connectivity between razorbill from FFC pSPA and Hornsea Three.

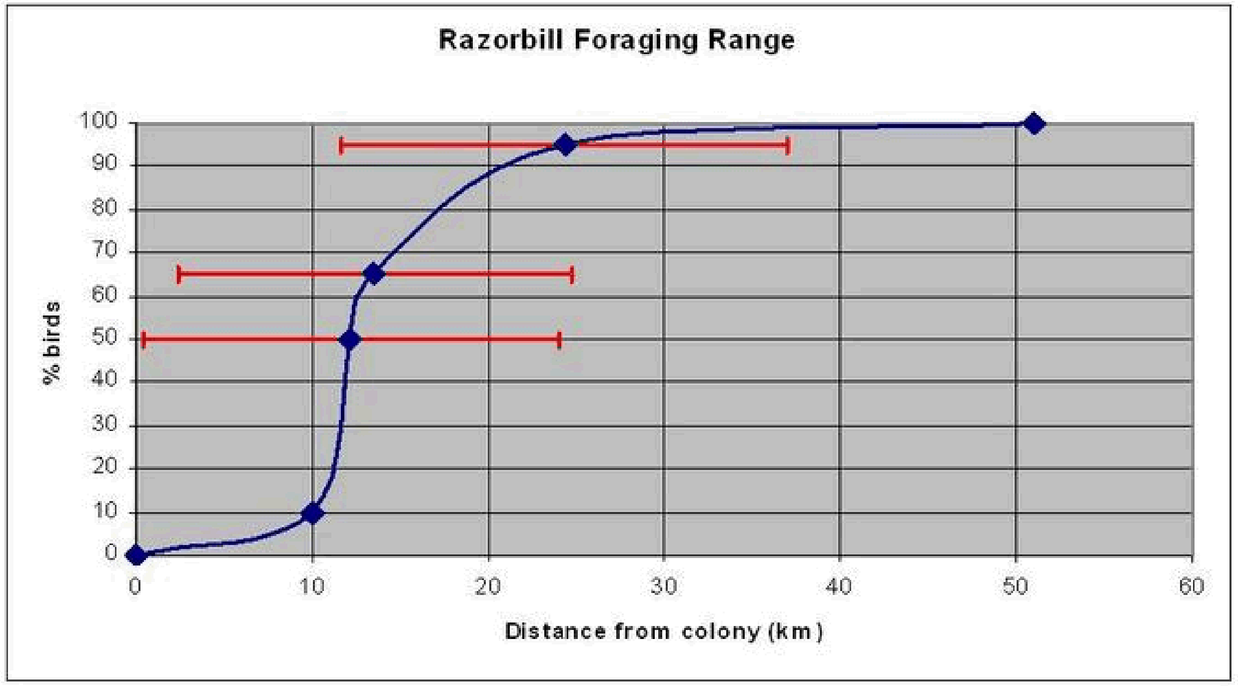

Figure 1.25: Cumulative frequency and proportion of birds found foraging at different distances from colony (Birdlife International, 2014).

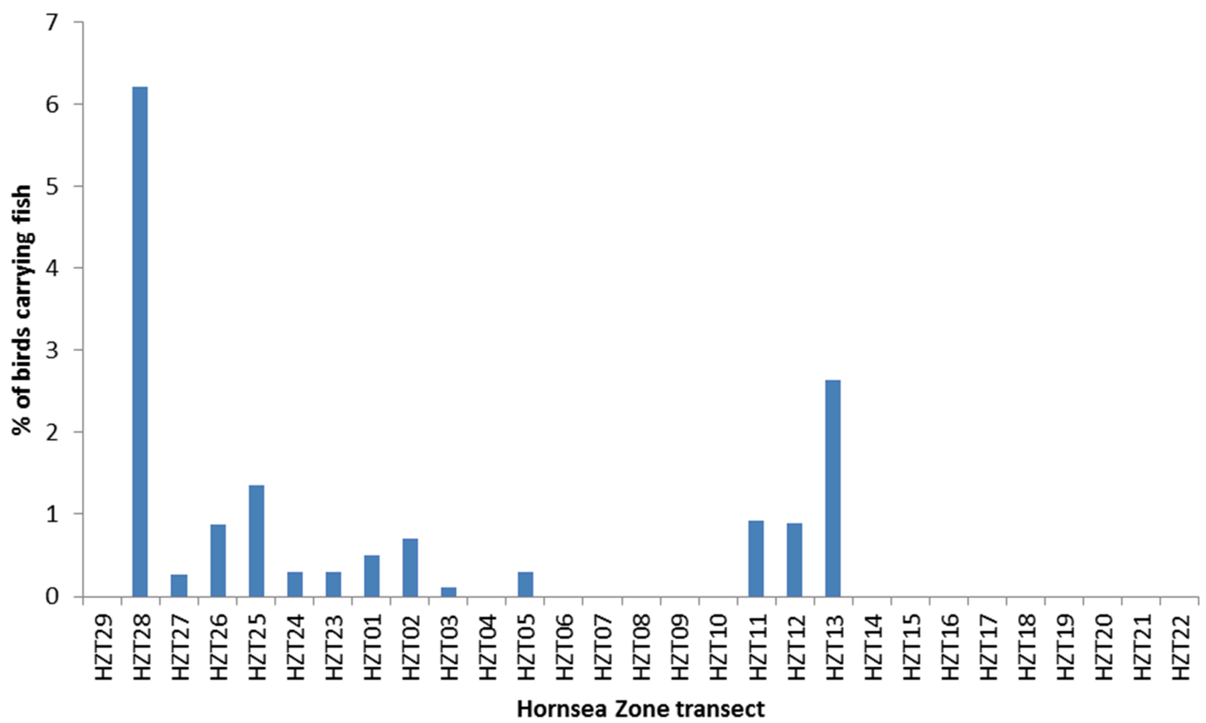

Figure 1.26: Number of razorbill recorded carrying fish during boat-based surveys undertaken for Hornsea Projects One and Two. Transects are ordered from west to east.

Conclusion

1.3.5.12 Based on the evidence presented in this section it is considered extremely unlikely that breeding razorbill from the colony at FFC pSPA will utilise Hornsea Three as a foraging area in the breeding season and therefore impacts on the species in the breeding season are screened out for FFC pSPA. This conclusion is consistent with the conclusion reached in the HRA Screening Report for Hornsea Three (DONG Energy, 2016) and is based on the following information:

- Thaxter *et al.* (2012) reports a maximum foraging range of 95 km (Hornsea Three is located 149 km from the colony at FFC pSPA);
- Cumulative foraging range data indicates that 95% of razorbill foraging trips will occur within 25 km of a colony (Figure 1.25);
- Wakefield *et al.* (2017) showed that Hornsea Three lies at least twice the distance beyond FFC pSPA than the intervening boundary delineating 95% at-sea UD of breeding razorbills (Figure 1.24);
- Wakefield *et al.* (2017) showed that space use by razorbill declined with distance from the colony, in accordance with the hypothesis that such central-place foragers minimize distance-dependent travel costs;
- Increased breeding productivity is associated with shorter foraging ranges with high breeding productivity at FFC pSPA suggesting shorter foraging ranges at FFC pSPA;
- Large maximum foraging ranges recorded at some colonies in the UK are not considered applicable to FFC pSPA due to the low levels of breeding productivity associated with those colonies; and
- No razorbill have been observed carrying fish in the area in which Hornsea Three is located (Figure 1.26).

1.3.6 Guillemot

1.3.6.1 In the absence of site specific tracking data for guillemot from FFC pSPA, Thaxter *et al.* (2012) has been used in the Hornsea Three Habitat Regulations Assessment Screening Report (DONG Energy, 2016) as a criterion for establishing whether there is likely to be connectivity (and hence risk of an impact) between FFC pSPA breeding colony and Hornsea Three (DONG Energy, 2016). The mean-maximum foraging range estimate for guillemot is 84.2 km (Thaxter *et al.* 2012) with a maximum foraging range of 135 km. The foraging ranges derived by Thaxter *et al.* (2012) were considered to have a high level of associated confidence due to being supported by a large number of studies and a large quantity of data. Hornsea Three is located approximately 149 km from FFC pSPA, the closest guillemot breeding colony. The distance of Hornsea Three beyond maximum foraging range of this species from FFC pSPA suggests that the potential for connectivity of breeding individuals from this colony to be present during the breeding season at Hornsea Three is extremely unlikely. This is consistent with reported observations of few birds bringing back fish from beyond 30 km of the colony (Brown and Grice, 2005) indicating that few birds may be foraging out to the maximum foraging range as presented in Thaxter *et al.* (2012).

1.3.6.2 It has been suggested as part of the Evidence Plan process that further sources of information, namely tracking data obtained for guillemot from a number of UK breeding colonies and Wakefield *et al.* (2017) be used to identify whether there is evidence to suggest connectivity between FFC pSPA and Hornsea Three.

1.3.6.3 Wakefield *et al*. (2017) GPS-tracked a sample of four seabird species that included 178 guillemots from 12 colonies in the UK. The sample of colonies were drawn from throughout the geographical, environmental and colony size range of the study species in Britain and Ireland. The sample of colonies did not include FFC pSPA. The GPS tracking was carried out during May-July, 2010 – 2014, when the study species were either approaching the end of the incubation period or raising small chicks.

1.3.6.4 The pertinent observation from Wakefield *et al*. (2017) is that Hornsea Three lies at least twice the distance beyond FFC pSPA than the intervening boundary delineating 95% at-sea UD of breeding guillemots during late incubation/early chick-rearing estimated as functions of colony distance, coast geometry, intra-specific competition and habitat (Figure 1.24). Furthermore, space use by guillemot declined with distance from the colony, in accordance with the hypothesis that such central-place foragers minimize distance-dependent travel costs. On the basis of these findings alone, it is considered a robust assumption that Hornsea Three does not lie within the maximum foraging range of breeding guillemots from FFC pSPA when successfully breeding i.e. a distance compatible with a two parent family able to bring enough food back to keep a chick alive.

1.3.6.5 A summary of a subset of the GPS-tracking data used from the FAME and STAR programmes by Wakefield *et al.* (2017), has been made available by the RSPB in order for Ørsted to review whether Thaxter *et al*. (2012) is the best available evidence to identify the potential for connectivity of breeding guillemot from FFC pSPA with Hornsea Three during the breeding season. The subset of data comprises of maximum foraging distances recorded at 10 of the 12 guillemot colonies sampled (Table 1.3). The GPS tracking was carried out during May-July, 2010 – 2014, when the study species were either approaching the end of the incubation period or raising small chicks.

Table 1.3: Maximum foraging ranges of guillemot derived from tracking data from a range of breeding colonies in the UK.

County	Colony	Maximum foraging range (km)	Number of birds sampled
Shetland	Fair Isle	338.38	18
Orkney	Copinsay	26.61	9
Aberdeenshire	Buller of Buchan	21.39	2
Aberdeenshire	Winnyfold	17.08	5
Aberdeenshire	Fowlsheugh	44.17	10
Scottish Borders	St Abbs	40.24	1

County	Colony	Maximum foraging range (km)	Number of birds sampled
Co. Dublin	Lambay Island	43.90	4
Argyll and Bute	Colonsay	80.39	77
Argyll and Bute	Lunga	28.67	3
Outer Hebrides	Shiants	7.03	1

1.3.6.6 A greater maximum foraging distance than that presented by Thaxter *et al.* (2012) was recorded from only one study site with this located in Shetland. The GPS-tracking studies occurred at a time when seabird breeding productivity in Scotland was improving following declines that primarily affected colonies in the north and east (e.g. Shetland, Isle of May; JNCC 2016). However, some regions still continued to record very low levels of breeding success during the period 2011 to 2013, namely Shetland (JNCC 2016). During those three years, the mean breeding success of guillemot in Shetland was 0.14, compared to 0.62 in north-west Scotland and 0.72 in south-east Scotland. This coincided with shortages in sandeels, the main prey for guillemots breeding in this area.

1.3.6.7 Hughes (2013), which reported on the tracking data collected at Fair Isle, stated that guillemots tracked in 2012 did not travel '*anywhere near as far'* as those birds tracked in 2011. The average breeding success at Fair Isle in 2012 was 0.15 chicks/pair compared to 0 chicks/pair in 2011 (JNCC, 2017). This increased breeding productivity, although still being very poor, was believed to be related to slightly better feeding conditions near to Fair Isle in 2012. In relation to the large foraging ranges recorded in 2011 Bolton and Owen (2012) state that '*it is difficult to avoid the conclusion that such long trips are indicative of low food availability closer to the colony'*.

1.3.6.8 In recent decades breeding success has been good at colonies between Humberside and south-east Scotland. This is in contrast to colonies further north where breeding success has been comparatively low (Heubeck and Parnaby, 2012; MacArthur Green, 2014). Across the five years during which tagging was carried out (2010 – 2014) the average productivity at the Fair Isle colony was 0.27 (JNCC, 2016). However, at FFC pSPA the average breeding productivity across the same period was 0.77, considerably higher than the productivity recorded at colonies in Shetland and Orkney. High breeding success at colonies between Humberside and south-east Scotland implies that food supply, and as such foraging opportunities, are good. This would result in foraging breeding adults having to travel shorter distances than those cited in the literature in order to acquire food. This information indicates that foraging trips of guillemot from the FFC pSPA are more likely to occur closer to the colony with less than 5% of foraging trips interacting with Hornsea Three.

1.3.6.9 The maximum foraging range presented for guillemot from Fair Isle is associated with one bird and occurred in a year when the sandeel stock in Shetland was significantly reduced (2011) and the breeding success of most seabirds was close to zero (JNCC, 2016; Hughes, 2013; Heubeck and Parnaby, 2012). It is also known that the chick of the bird that undertook this foraging trip subsequently died (MacArthur Green, 2014). A guillemot flies at approximately 19 m/s (Pennycuick, 1997) and would therefore take 9.8 hours to complete a foraging trip of this length (return trip = 680 km) assuming minimal time spent foraging for food. A guillemot chick needs five feeds a day and therefore as only one adult of the breeding pair will be foraging at a time (the other attending the chick) (Uttley *et al.*,1994), foraging at such a distance would not result in a successful breeding attempt.

1.3.6.10 In years where breeding success has been higher at colonies in Shetland, the distance travelled by birds to find food has been shorter. Burke and Montevecchi (2009) compared breeding guillemot in two consecutive years that had differing food availability. In the first year the mean-maximum foraging range of guillemot was 60 km whereas in the second year this increased to 81 km due to changes in food availability. In this second year Burke and Montevecchi (2009) suggested that birds were close to an energetic limit meaning that foraging effort could not be increased further without a decrease in the survival rates of chicks.

1.3.6.11 It is therefore considered that the foraging ranges recorded for birds from colonies in Shetland and Orkney are not applicable to birds at FFC pSPA and therefore the use of the mean-maximum foraging range from Thaxter *et al.* (2012) (84.2 km), which is higher than the majority of other maximum foraging ranges recorded at other UK colonies in Table 1.2, in the Hornsea Three Habitat Regulations Assessment Screening Report (DONG Energy, 2016) is appropriate to inform the conclusion of no connectivity between breeding birds from FFC pSPA and Hornsea Three.

1.3.6.12 BirdLife's Seabird Foraging Range Database (Birdlife International, 2014) provided cumulative frequency and proportion of birds found foraging at different distances from a colony for guillemot (Figure 1.27). These data indicates that 95% of foraging trips occur within 70 km of a colony (Figure 1.27) thus supporting the assertions made in relation to the tracking data presented above.

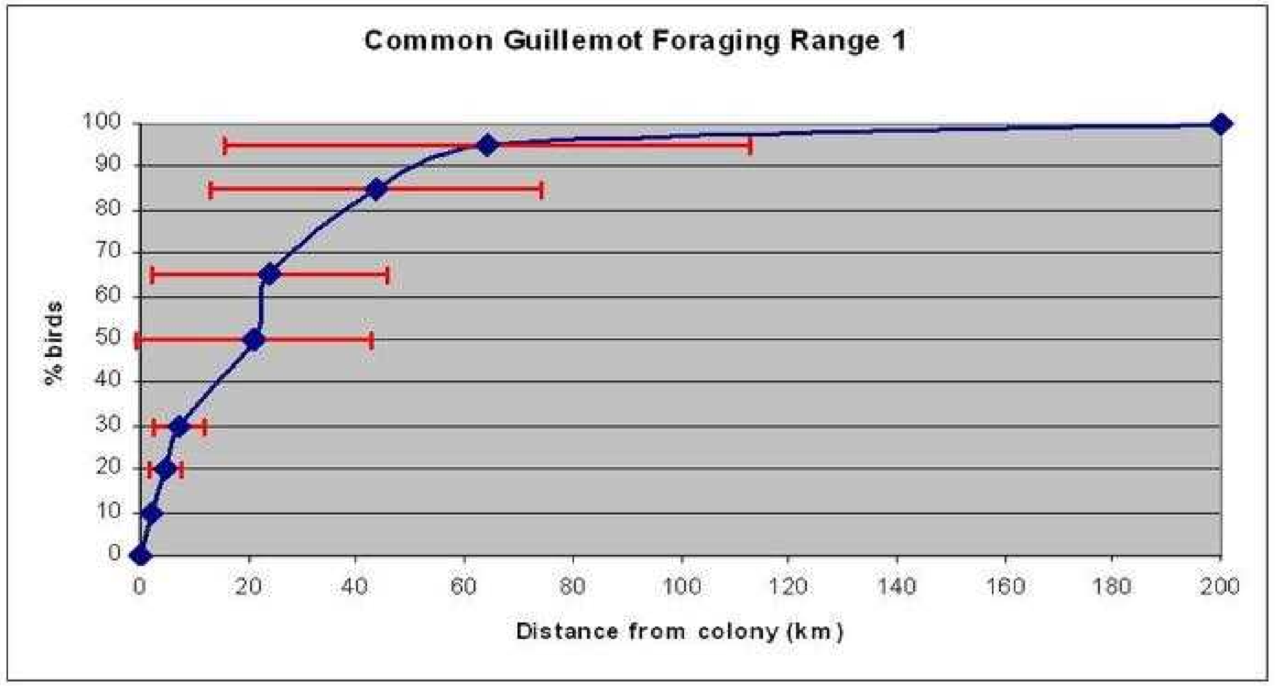

Figure 1.27: Cumulative frequency and proportion of birds found foraging at different distances from colony (Birdlife International, 2014).

1.3.6.13 Behavioural data associated with bird records collected during boat-based surveys undertaken for the Hornsea Project One and Hornsea Project Two developments have also been analysed to identify if guillemot observed at Hornsea Three may be associated with FFC pSPA. Figure 1.28 shows the percentage of guillemot observed carrying fish as recorded across Hornsea Zone transects during the breeding season. Transects are presented running from west to east. The data show a higher percentage of birds were recorded carrying fish on transects located closer to FFC pSPA. Transects HZT17 to HZT22 overlap with Hornsea Three plus a 4 km buffer. Of the 4,141 birds recorded during surveys of the six transects covering Hornsea Three only two birds were observed carrying fish (0.05%). When considering the six transects closer inshore (HZT29 to HZT24) this percentage increases to an average of 1.1% and when considering those transects overlapping with Hornsea Project One and Hornsea Project Two (HZT05 to HZT14) is also higher at 0.1%. These data support the assertions already made in this section, indicating that birds from FFC pSPA make very few foraging trips out to Hornsea Three, consistent with the cumulative foraging range data presented in Figure 1.27.

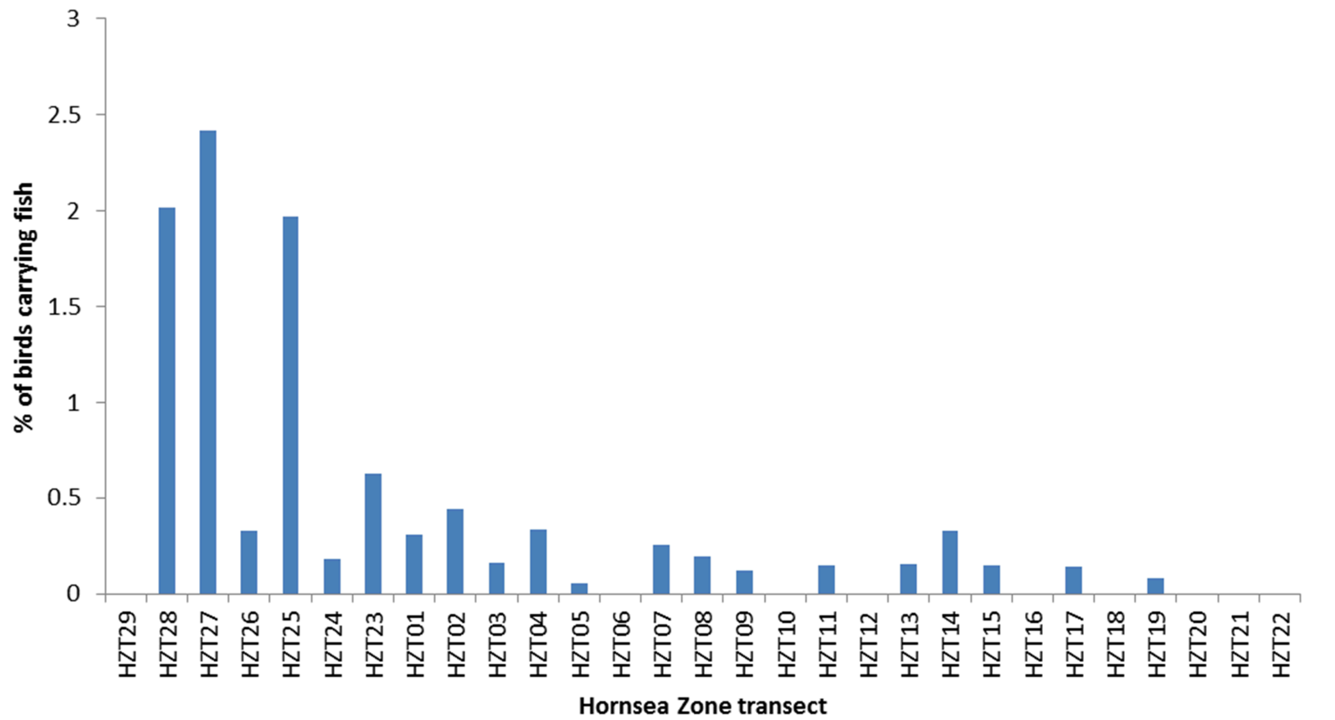

Figure 1.28: Number of guillemot recorded carrying fish during boat-based surveys undertaken for Hornsea Projects One and Two. Transects are ordered from west to east.

Conclusion

1.3.6.14 Based on the evidence presented in this section it is considered extremely unlikely that breeding guillemot from the colony at FFC pSPA will utilise Hornsea Three as a foraging area in the breeding season and therefore impacts on the species in the breeding season are screened out for FFC pSPA. This conclusion is consistent with the conclusion reached in the HRA Screening Report for Hornsea Three (DONG Energy, 2016) and is based on the following information:

- Thaxter *et al.* (2012) reports a maximum foraging range of 135 km (Hornsea Three is located 149 km from the colony at FFC pSPA);
- Cumulative foraging range data indicates that 95% of guillemot foraging trips will occur within 70 km of a colony (Figure 1.27);
- Wakefield *et al.* (2017) showed that Hornsea Three lies at least twice the distance beyond FFC pSPA than the intervening boundary delineating 95% at-sea UD of breeding guillemot (Figure 1.24);
- Wakefield *et al.* (2017) showed that space use by guillemot declined with distance from the colony, in accordance with the hypothesis that such central-place foragers minimize distance-dependent travel costs;
- Increased breeding productivity is associated with shorter foraging ranges with high breeding productivity at FFC pSPA suggesting shorter foraging ranges at FFC pSPA;

- Large maximum foraging ranges recorded at some colonies in the UK are not considered applicable to FFC pSPA due to the low levels of breeding productivity associated with those colonies; and
- A negligible proportion (0.05%) of guillemot recorded in the area in which Hornsea Three is located have been observed carrying fish (Figure 1.28).

1.4 Apportioning of impacts to the Flamborough and Filey Coast pSPA

1.4.1 Overview

1.4.1.1 The following species-specific sections outline the calculated apportioning values to be used to apportion impacts from Hornsea Three to breeding adult populations of relevant species at FFC pSPA. For features of the FFC pSPA for which connectivity has been identified in the breeding season, age class data from surveys undertaken across the Hornsea Zone have been used to identify the proportion of adult and immature birds present at Hornsea Three. In the non-breeding season, population data from Furness (2015) has been used to determine the proportion of adult birds from FFC pSPA present in the relevant BDMPS population.

1.4.1.2 Where necessary, based on the information presented in Section 1.3 consideration is also given to apportioning impacts to the immature component of the populations associated with FFC pSPA. This is relevant to puffin, razorbill and guillemot only as it is considered that there is either no connectivity or limited connectivity between breeding adult birds from FFC pSPA and Hornsea Three. As any impact on breeding adult birds would be negligible the usual approach to capturing impacts on immature birds (i.e. through population modelling by applying additional mortality(based on the total breeding adult impact) to immature age classes in proportion to their presence (i.e. based on the PVA stable age structure)) would not adequately capture the level of impact on immature birds.

1.4.1.3 Apportioning values for immature gannet and kittiwake are not specified here, and any impacts on immature birds calculated as part of population modelling (if this is considered necessary as part of the assessments presented) will be based on the level of impact apportioned to the breeding adult population. This is the approach previously applied in population modelling (Hornsea Project Two) and is considered appropriate for these species at Hornsea Three.

1.4.1.4 Following advice provided by Natural England through the Evidence Plan process, no updates have been made to the population data presented in Furness (2015).

Breeding season

1.4.1.5 Connectivity between Hornsea Three and three species from FFC pSPA (gannet, kittiwake and puffin) is considered possible and therefore apportioning of impacts associated with Hornsea Three to the relevant populations at FFC pSPA is required.

1.4.1.6 To calculate apportioning values for these three species, site-specific data collected as part of aerial surveys covering Hornsea Three plus a 4 km buffer[2] and boat-based data covering the former Hornsea Zone plus a 10 km buffer have been analysed. These surveys used different criteria to record the age class of a bird. In the Hornsea Three aerial surveys birds were identified as either adult, immature, juvenile or unknown. In boat-based surveys, birds were classified as either adult, not adult, immature, juvenile or aged using a number representing the year of life (i.e. 2 = second year). In addition, gannets were assigned a plumage score between 1 and 6 with scores of 1-5 corresponding to juvenile and immature birds in increasing years of life and a score of 6 corresponding to adult birds. For the analyses presented below only those birds identified as adults, non-adults, immatures and those aged using a number are included. Very few juvenile birds were recorded in surveys during the breeding season as defined for each species and, on a precautionary basis these were excluded from the calculations presented in the following species-specific sections.

1.4.1.7 The aging of birds in both aerial and boat-based surveys can prove challenging for certain species. Immature kittiwake and puffin beyond their first year are essentially indistinguishable from adult birds during surveys. This means that using the age proportions from site-specific data would represent a considerable over-estimate of the proportion of adult birds present at Hornsea Three. In order to address this limitation, an approach was developed during the examination for Hornsea Project Two. This approach utilises age-specific survival rates (Horswill and Robinson, 2015) to calculate the proportion of different age classes likely to be present at Hornsea Three. The survival rates used, although not specific to FFC pSPA, are those used for Population Viability Analysis (PVA) undertaken for Hornsea Project Two (SmartWind, 2015) and used in the assessments for Hornsea Three.

1.4.1.8 The approach used in the following sections is considered to be precautionary. The main area of precaution is the affinity exhibited by different immature age classes to natal waters during the breeding season. First year birds show considerably less affinity for natal waters than do older immatures with the majority of birds remaining in wintering areas. Applying the approach used at Hornsea Project Two assumes that the proportion of older immatures in natal waters is consistent with the proportion of first year immatures. This under-estimates the proportion of older immature age classes present at Hornsea Three, as these birds show a much greater affinity for natal waters with much higher proportions of these age classes present in natal waters. This and other sources of uncertainty and precaution related to the calculated apportioning values are discussed in the species-specific sections below.

[2] The buffer areas represent the largest areas across which survey data were collected. These buffer areas are defined based on JNCC *et al.* (2017) guidance in relation to the largest spatial extent across which displacement impacts may occur (for the most sensitive species). The 10 km buffer around the former Hornsea Zone was agreed with JNCC as part fo the application process for the Hornsea Project One offshore wind farm

1.4.1.9 The following species-specific sections also provide further discussion in relation to the accuracy of the apportioning values calculated including how these values may under-estimate or over-estimate the proportion of adult breeding birds present at Hornsea Three.

Non-breeding seasons

1.4.1.10 The calculation of apportioning values for non-breeding seasons (post-breeding, non-breeding and pre-breeding) follows the approach used previously in the application and examination documentation for multiple offshore wind farms including Hornsea Project One and Hornsea Project Two. The contribution of adult birds from FFC pSPA, as estimated by Furness (2015), to the relevant BDMPS population for each species/season combination is divided by the total BDMPS population to calculate the proportion of the BDMPS population represented by adult birds from FFC pSPA.

1.4.2 Gannet

Breeding season

1.4.2.1 In the breeding season it is likely that breeding birds from the FFC pSPA, immature birds from colonies throughout the North Sea and potentially further afield and non-breeding birds may occur at Hornsea Three. It is therefore necessary to apportion potential impacts from Hornsea Three to these 'populations' in order to identify the potential effect on the FFC pSPA.

1.4.2.2 As indicated in Section 1.3.2, results from Langston *et al.* (2013) indicate that breeding gannets from FFC pSPA occur at Hornsea Three (Figure 1.18). However, it can be suggested that Hornsea Three does not represent an important area for birds from FFC pSPA with such areas located closer to the coast.

1.4.2.3 There is no recent or firm evidence that specifies a more accurate proportion of how many immature birds may be present in the North Sea during the breeding season. Historical evidence suggests that the proportion of immature gannet in the population may be quite high (Tasker *et al*., 1985). Tasker *et al.* (1985) recorded observations of gannet from non-fishing vessels in the North Sea and observations were analysed to provide the proportion of immatures present within five sea areas in the North Sea on a monthly basis. In the south-east North Sea the percentage of immatures in the population ranged from 50% in May to 61% in August. In the region described as 'Offshore Bass Rock' by Tasker *et al.* (1985) which is to the north of Hornsea Three, the percentage of immature birds ranged from 28% in June to 61% in July.

1.4.2.4 Immature birds are not as restricted in terms of foraging range during the breeding season, when compared to breeding adults which are provisioning young. Nelson (2002) states that in the breeding season immature birds "pursue extensive and probably haphazard summer foraging which can take them anywhere in their total range…" while birds in all stages of plumage development are seen in all parts of their range throughout the year (Wernham *et al*., 2002). These observations were confirmed by GPS tracking of immature gannets at Grassholm, Wales which showed immatures have the ability to disperse widely during the breeding season with some individual potentially prospecting at other colonies (Votier *et al.,* 2010). Taking account of the movements of immature birds recorded by Votier *et al.* (2010) and described in Nelson (2002) and Wernham *et al*. (2002) it is considered likely that in addition to immatures originating from the FFC pSPA, there will also be immature birds associated with other breeding colonies in the North Sea and beyond, present at Hornsea Three during the breeding season. These birds, described as 'floaters' in Nelson (2002), are present throughout the North Sea in the breeding season. Immature and non-breeding birds may be present at colonies in gatherings called 'clubs'. These clubs are attended by immature/non-breeding birds throughout the breeding season although the composition of the clubs, in terms of age classes and origin of birds may change throughout this period (Nelson, 2002). Therefore consideration needs to be given to the presence of these birds at Hornsea Three.

1.4.2.5 The Hornsea Three aerial surveys and former Hornsea Zone boat-based surveys both covered Hornsea Three and collected age class data. The following analyses present data from both datasets with a discussion then provided as to which provides a better reflection of the age structure of the population present at Hornsea Three.

1.4.2.6 Boat-based surveys for the Hornsea Project One and Hornsea Project Two developments were conducted using two spatial scales one covering the central area of the former Hornsea Zone that incorporated the Hornsea Project One and Hornsea Project Two areas plus respective 4 km buffer areas and another covering the entirety of the former Hornsea Zone plus a 10 km buffer (Figure 1.29). Transects covering the Hornsea Project One and Two project areas had a spacing of 2 km (Subzone transects) whilst those covering the former Hornsea Zone had a spacing of 6 km (Hornsea Zone transects). Table 1.4 presents the proportion of adult and immature gannet recorded during boat-based surveys using differing subsets of the dataset.

Table 1.4: The proportion of adult and immature gannets calculated using Hornsea Three aerial survey data and different subsets of the boat-based survey data collected for the Hornsea Project One and Hornsea Project Two developments during the breeding season (April to August).

Data subset	Transects	Sample size	Adult proportion (%)	Immature proportion (%)
Aerial survey data				
All data	All	169	72.8	27.2

Data subset	Transects	Sample size	Adult proportion (%)	Immature proportion (%)
Boat-based survey data				
All data	Subzone and Hornsea Zone transects	8,829	70.3	29.7
All Subzone transect data	Subzone transects	2,970	74.8	25.2
1	All Hornsea Zone transects	2,810	56.1	43.9
2	Subzone transects inshore of P1 and P2 (1-14)	1,461	83.7	16.3
3	Subzone transects covering P1 and P2 (15-40)	1,467	60.3	39.7
4	Subzone transects covering the western region of P1 and P2 (15-26)	795	66.0	34.0
5	Subzone transects covering the eastern region of P1 and P2 (27-40)	672	53.6	46.4
6	Hornsea Zone transects inshore of P1 and P2 (1-4 and 23-29)	2,239	78.5	21.5
7	Hornsea Zone transects covering P1 and P2 (5-14)	1,023	57.2	42.8
8	Hornsea Zone transects offshore of P1 and P2 (15-22)	527	40.4	59.6

1.4.2.7 The proportions presented in Table 1.4 suggest that as distance from the FFC pSPA colony increases the proportion of adult birds present also decreases. This is illustrated by both the data associated with the Hornsea Zone transects (data subsets 6, 7 and 8), where the adult proportion decreases from 78.5% to 40.4% and across the Hornsea Project One and Hornsea Project Two project areas where the adult proportion is 66.0% in the western side and 53.6% in the eastern side (data subsets 4 and 5). As the Hornsea Zone transect data offshore of Hornsea Project One and Hornsea Project Two (data subset 8) covers Hornsea Three it is considered that this proportion is the most applicable to the apportioning of birds to FFC pSPA in the breeding season.

1.4.2.8 Boat-based surveys conducted across the former Hornsea Zone provide information on over 31,000 gannets of which 58% were aged. These birds were identified and aged based on direct observation by experienced seabird observers. The Hornsea Three aerial surveys recorded 1,221 gannets of which 33% were aged. The proportion of birds for which an age could be assigned is therefore higher in the boat-based dataset, in addition, the boat-based survey dataset is much larger and covers a much wider spatial scale.

1.4.2.9 One of the main limitations of aging birds from aerial survey data is the inability to age birds recorded on the sea surface. For gannet, over 67% of the birds recorded were on the sea surface and therefore could not be aged. The ability to age of birds also differs between the two survey platforms. It can be argued that during boat-based surveys, surveyors are able to observe the bird for a longer period of time, allowing for better consideration of the behaviour (e.g. flight characteristics, interactions with other birds), size and shape of the bird all of which can provide an indication as to the age of a bird. Aerial surveys allow for some consideration of these factors with aging, the protocols for which are repeatable between reviewers, conducted from videos which provide a permanent record.

1.4.2.10 Assigning age classes to gannet during at sea surveys can prove problematic, with immature feathers on four and five year old birds deemed difficult to observe meaning that these age classes may be wrongly assigned. Immature and non-breeding adult birds are present at breeding colonies throughout the breeding season in gatherings called 'clubs' (Nelson, 2002) and therefore it is considered likely that fourth and fifth-year birds may also be present at Hornsea Three. Further to this, it is not known what proportion of birds recorded as adults are breeding birds associated with the FFC pSPA, with some of these adult birds possibly non-breeding birds. It is therefore considered that the use of a 40.4% apportioning value is precautionary.

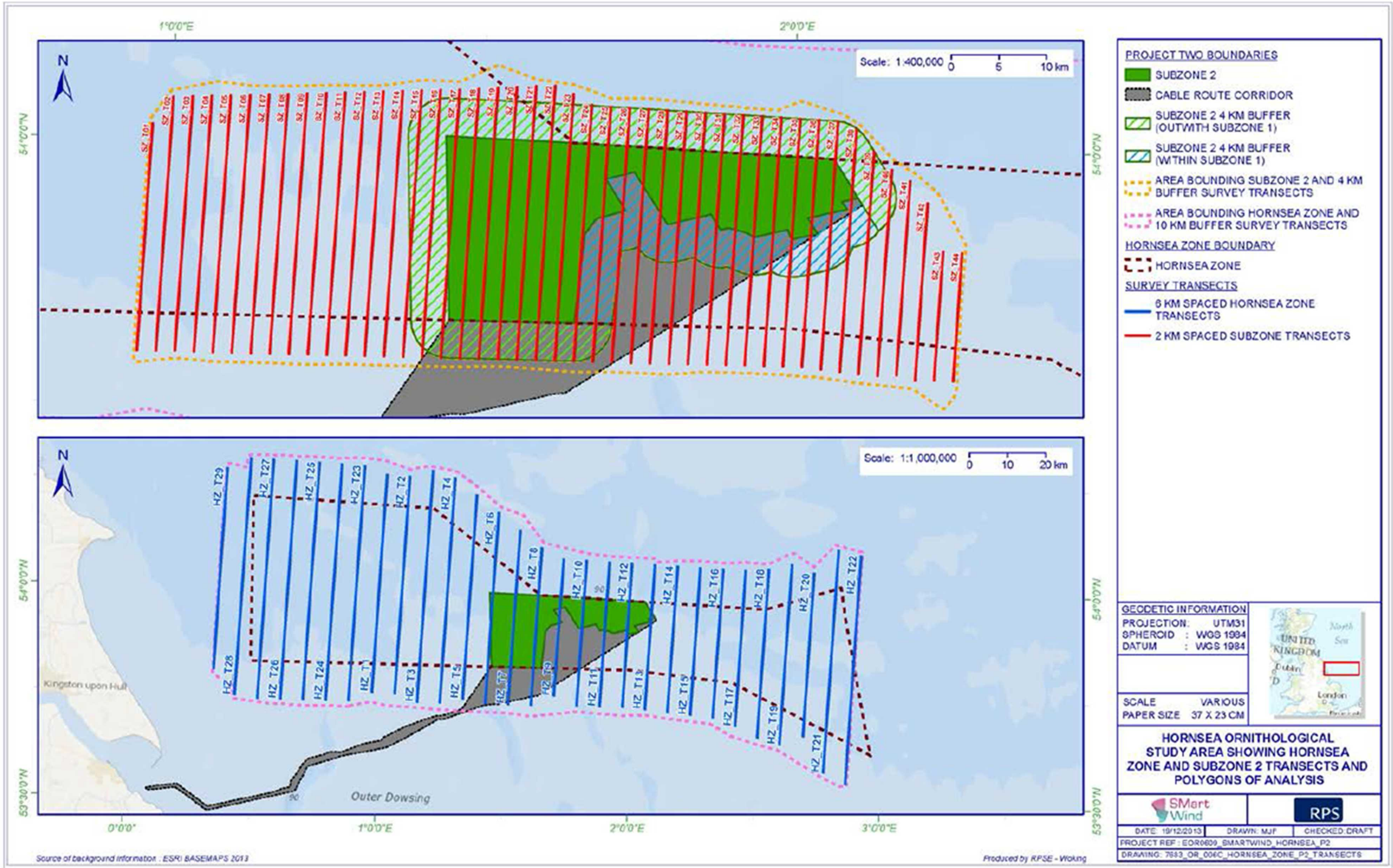

Figure 1.29: Survey extents for the Hornsea Project Two development (it should be noted that in the first year of surveys (2010-11) the extents were slightly reduced covering only the Project One Subzone plus a 4 km buffer and only the central area of the Hornsea Zone).

Non-breeding seasons

1.4.2.11 For apportioning in non-breeding seasons (post- and pre-breeding seasons), population data from Furness (2015) were used to calculate the contribution of birds from FFC pSPA to a wider population present within the North Sea. This approach is consistent with the approach applied at Hornsea Project Two and East Anglia Three by both the relevant Applicant and Natural England.

1.4.2.12 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the post-breeding season as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of gannet was calculated as 456,298 individuals. The contribution of breeding birds from FFC pSPA to this population is 4.8%.

1.4.2.13 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the pre-breeding season as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of gannet was calculated as 248,386 individuals. The contribution of breeding birds from FFC pSPA to this population is 6.2%.

Summary

1.4.2.14 Based on the calculations presented in the previous sections the following apportioning values will be applied in assessments for gannet at Hornsea Three:

- Breeding season = 40.4%
- Post-breeding season = 4.8%
- Pre-breeding season = 6.2%

1.4.2.15 It is important to note that the approaches used to calculate these apportioning values (boat-based data and data from Furness (2015) are consistent with the approaches used in the assessments for consented offshore wind farm developments (e.g. Hornsea Project Two). These approaches were recommended by and used to inform the final positions of Natural England for the assessments conducted at Hornsea Project Two (see Natural England's Written Representation and Appendix 3 of Natural England's submission at Deadline 3) with those in the non-breeding season identical to those applied by Natural England for that project.

1.4.3 Kittiwake

Breeding season

1.4.3.1 In the breeding season it is possible that breeding birds from the FFC pSPA, immature birds from colonies throughout the North Sea and potentially further afield and non-breeding birds may occur at Hornsea Three. It is therefore necessary to apportion potential impacts from Hornsea Three to these 'populations' in order to identify the potential effect on the FFC pSPA.

1.4.3.2 As indicated in Section 1.3.3, tracking data provided by the RSPB indicate that breeding kittiwake from FFC pSPA occur at Hornsea Three (Figure 1.22). However, Wakefield *et al.* (2017) indicates that the area in which Hornsea Three is located is utilised for only a small proportion of foraging activity (less than 5%) (Figure 1.21).

1.4.3.3 The identification of kittiwake age classes at sea is difficult and in most cases impossible (with the exception of first summer of younger birds). Whilst one year old kittiwakes can be easily identified due to differences in plumage, second and third year old birds, which have not yet reached the age of first breeding, cannot (Coulson, 2011; Olsen and Larsson, 2003). Therefore data on age class collected during surveys will potentially represent a considerable overestimate of the proportion of breeding adults present at Hornsea Three.

1.4.3.4 It is certain that an unknown proportion of the cohort of unaged 'adult type' kittiwakes at Hornsea Three will include two and three year old birds. Coulson (2011) provides evidence that shows that immature kittiwake visit natal waters with increasing numbers of older immatures visiting breeding colonies. This therefore supports the conclusion that the approach proposed to calculate an apportioning value for the breeding season will under-estimate the proportion of second and third year immatures which will show a much greater affinity for natal waters than first year birds.

1.4.3.5 Further to this, it is not possible to separate non-breeding adult birds from those that are breeding at FFC pSPA. A minimum of 4% of adult male birds miss a breeding season at North Shields, Tyneside, whereas females do so about half again as frequently with a recorded maximum of approximately 13% (Coulson, 2011). There is though no evidence to suggest that non-breeding adults, irrespective of where they last bred or attempted to do so, are not represented at Hornsea Three.

1.4.3.6 Whilst maintaining the proportion represented of each year class of immatures at Hornsea Three, mortality reduces the absolute number of birds present from each successive year class of kittiwake. In calculating the number of two and three year old kittiwakes at Hornsea Three, the analysis uses survival rates of each immature age class of kittiwake that follows the Model KI1 in SmartWind (2015) (i.e. 0.79 for juveniles, 0.85 for one year olds and 0.87 for two year olds).

1.4.3.7 The Hornsea Three aerial surveys and former Hornsea Zone boat-based surveys both covered Hornsea Three and collected age class data. The following analyses present data from both datasets with a discussion then provided as to which provides a better reflection of the age structure of the population present at Hornsea Three.

1.4.3.8 Boat-based surveys for the Hornsea Project One and Hornsea Project Two developments were conducted using two spatial scales one covering the central area of the former Hornsea Zone that incorporated the Hornsea Project One and Hornsea Project Two areas plus respective 4 km buffer areas and another covering the entirety of the former Hornsea Zone plus a 10 km buffer (Figure 1.12). Transects covering the Hornsea Project One and Two project areas had a spacing of 2 km (Subzone transects) whilst those covering the former Hornsea Zone had a spacing of 6 km (Hornsea Zone transects). Table 1.3 presents the proportion of adult and immature kittiwake recorded during boat-based surveys of Hornsea Project One and Hornsea Project Two using differing subsets of the dataset as described in paragraph 1.4.2.6.

Table 1.5: The proportion of adult and immature kittiwake calculated using the Hornsea Three aerial survey data and different subsets of the boat-based survey data collected for the Hornsea Project One and Hornsea Project Two developments in the breeding season (April to July).

Data subset	Transects	Sample size	Adult proportion (%)	Immature proportion (%)
Aerial survey data				
All data	All	897	95.3	4.7
Boat-based survey data				
All data	Subzone and Hornsea Zone transects	29,187	91.9	8.1
All Subzone transect data	Subzone transects	11,331	91.3	8.7
1	All Hornsea Zone transects	6,561	88.0	12.0
2	Subzone transects inshore of P1 and P2 (1-14)	4,254	95.7	4.3
3	Subzone transects covering P1 and P2 (15-40)	6,506	88.9	11.1
4	Subzone transects covering the western region of P1 and P2 (15-26)	3,496	92.4	7.6
5	Subzone transects covering the eastern region of P1 and P2 (27-40)	3,010	84.9	15.1
6	Hornsea Zone transects inshore of P1 and P2 (1-4 and 23-29)	6,374	96.6	3.4
7	Hornsea Zone transects covering P1 and P2 (5-14)	3,645	91.1	8.9
8	Hornsea Zone transects offshore of P1 and P2 (15-22)	1,075	77.5	22.5

1.4.3.9 The proportions presented in Table 1.5 from boat-based survey data suggest that as distance from the FFC pSPA colony increases the proportion of adult birds present also decreases. This is illustrated by both the data associated with the Hornsea Zone transects (data subsets 6, 7 and 8), where the adult proportion decreases from 96.6% to 77.5% and across the Hornsea Project One and Hornsea Project Two project areas where the adult proportion is 92.4% in the western side and 84.9% in the eastern side (data subsets 4 and 5). As the Hornsea Zone transect data offshore of Hornsea Project One and Hornsea Project Two (data subset 8) covers Hornsea Three it is considered that this proportion is the most applicable subset of the boat-based survey data to use in order to calculate the likely proportion of adult birds at Hornsea Three taking into account the presence of older immatures which are indistinguishable from adult birds (Table 1.6). In addition, the same analysis process has been applied to the data collected by aerial surveys at Hornsea Three (Table 1.7).

Table 1.6: Estimated breeding season contribution of FFC pSPA birds to total predicted to be present at Hornsea Three using immature proportions as calculated from survival rates and numbers of one year old birds recorded on boat-based survey transects covering Hornsea Three.

Analysis step	Formula (using the parameters identified as part of each analysis step	Value
(a) Survival rate of juvenile birds		0.79
(b) Survival rate of one year old birds		0.85
(c) Survival rate of two year old birds		0.87
(d) % of kittiwake at Hornsea Three assigned to one year old birds		22.5%
% of kittiwake at Hornsea Three assigned to other immature age classes (e) two years old (f) three years old	e = [{(a) x b} / a] x d f = ([{(a) x b} x c] / a) x d	19.1% 16.6%
(g) % of kittiwakes at Hornsea Three assigned to adults	g = 100% - (d + e + f)	41.7%

Table 1.7: Estimated breeding season contribution of FFC pSPA birds to total predicted to be present at Hornsea Three using immature proportions as calculated from survival rates and numbers of one year old birds recorded during aerial surveys of Hornsea Three.

Analysis step	Formula (using the parameters identified as part of each analysis step	Value
(a) Survival rate of juvenile birds		0.79
(b) Survival rate of one year old birds		0.85
(c) Survival rate of two year old birds		0.87
(d) % of kittiwake at Hornsea Three assigned to one year old birds		4.7%
% of kittiwake at Hornsea Three assigned to other immature age classes (e) two years old (f) three years old	e = [{(a) x b} / a] x d f = ([{(a) x b} x c] / a) x d	4.0% 3.5%
(g) % of kittiwakes at Hornsea Three assigned to adults	g = 100% - (d + e + f)	87.9%

1.4.3.10 Boat-based surveys conducted across the former Hornsea Zone provide information on over 122,000 kittiwake of which 37% were aged. These birds were identified and aged based on direct observation by experienced seabird observers. The Hornsea Three aerial surveys recorded 4,803 kittiwakes of which 39% were aged. The proportion of birds for which an age could be assigned are therefore comparable between the two datasets, however, the boat-based survey dataset is much larger and covers a much wider spatial scale. One of the main limitations of aging birds from aerial survey data is the inability to age birds recorded on the sea surface. For kittiwake, nearly 60% of the birds recorded were on the sea surface and therefore could not be aged. The ability to age birds also differs between survey platforms. It can be argued that during boat-based surveys surveyors are able to observe the bird for a longer period of time, allowing for better consideration of the behaviour (e.g. flight characteristics, interactions with other birds), size and shape of the bird all of which can provide an indication as to the age of a bird. Aerial surveys allow for some consideration of these factors with aging, the protocols for which are repeatable between reviewers, conducted from videos which provide a permanent record.

1.4.3.11 Based on the proportion of first year birds observed from boat based surveys, and the likely age structure of the kittiwake population it is considered that adults will comprise 41.7-87.9% of the individuals observed at Hornsea Three. However, this range, especially the uppermost value, is considered to be precautionary due to the following:

- Neither value accounts for adults in the population not breeding in a given year – this could account for a further reduction of c5-10% (Coulson, 2011; Marine Scotland Licensing Operations Team, 2017);
- A smaller proportion of one year old birds are likely to be present in natal waters with a much greater proportion of older age classes of immature birds showing affinity with natal waters;
- FAME data indicates that the majority of foraging flights are close to the colony and data given by BirdLife (see Section 1.3.3) suggests that only up to 5% of birds are likely to travel as far as Hornsea Three; and
- Immature birds are not likely to be evenly distributed within the North Sea and will show aggregations near to foraging resources. If the area within which Hornsea Three lies is seen to be notable for kittiwake foraging; immatures may be present in large numbers.

1.4.3.12 In addition, information presented in Section 1.3.3 indicates that very few breeding kittiwake from the FFC pSPA are likely to use Hornsea Three as a foraging area for the following reasons:

- Cumulative foraging range data (Figure 1.14) indicates that very few foraging trips (if any) would occur at a distance beyond 120 km (the maximum foraging distance reported by Thaxter *et al.* (2012) (Hornsea Three is 149 km from FFC pSPA);
- When breeding productivity is high, foraging ranges are short (Hamer *et al.,* 1993; Lewis *et al.,* 2006; Riou *et al.,* 2006; Thaxter *et al.,* 2012). Breeding productivity at FFC pSPA is comparatively high suggesting that foraging ranges will be short;
- Based on the relationship between time constraints and breeding productivity, a number of studies have shown that the foraging ranges of kittiwake are unlikely to exceed 73 km (Daunt *et al.,* 2002; Coulson, 2011; Pearson (1968)););
- At sea utilisation maps presented in Wakefield *et al.* (2017) derived utilising the tracking data used to inform the basis for connectivity between FFC pSPA and Hornsea Three suggest that the area in which Hornsea Three is located is beyond the 95% utilisation contour; and
- Site-specific flight direction data does not indicate movements of birds to and from the colony at FFC pSPA into Hornsea Three.

1.4.3.13 The evidence reviewed here, therefore suggests the proportion of adult kittiwake at Hornsea Three will be lower than the 87.9% value obtained through aerial survey. In addition, the use of survival rates in the apportioning approach presented in Table 1.9 is considered to be appropriately precautionary. Older immature age classes are known to show a greater affinity for natal waters with the proportion of older immature age classes returning to natal waters during the breeding season therefore higher than the proportion of one year old birds returning to natal waters. The approach applied in Table 1.9 assumes that a consistent proportion of each age group will be present at Hornsea Three and therefore likely under-estimates the proportions of older immature age classes present at Hornsea Three. The apportioning value calculated using boat-based survey data is therefore considered to be appropriately precautionary for use in further analyses.

Non-breeding seasons

1.4.3.14 For apportioning in non-breeding seasons (post- and pre-breeding seasons), population data from Furness (2015) were used to calculate the contribution of birds from FFC pSPA to a wider population present within the North Sea. This approach is consistent with the approach applied at Hornsea Project Two and East Anglia Three by both the relevant Applicant and Natural England.

1.4.3.15 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the post-breeding season as presented in Furness (2015), the UK North Sea Waters BDMPS population of kittiwake was calculated as 829,937 individuals. The contribution of breeding birds from FFC pSPA to this population is 5.4%.

1.4.3.16 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the pre-breeding season as presented in Furness (2015), the UK North Sea Waters BDMPS population of kittiwake was calculated as 627,816 individuals. The contribution of breeding birds from FFC pSPA to this population is 7.2%.

Summary

1.4.3.17 The information presented throughout this Annex indicates that the few breeding kittiwake from the FFC pSPA are likely to use Hornsea Three. Therefore based on the calculations presented in the previous sections the following apportioning values will be applied in assessments for kittiwake at Hornsea Three:

- Breeding season = 41.7%
- Post-breeding season = 5.4%
- Pre-breeding season = 7.2%

1.4.3.18 It is important to note that the approaches used to calculate these apportioning values (boat-based data and data from Furness (2015)) are consistent with the approaches used in the assessments for consented offshore wind farm developments (e.g. Hornsea Project Two and East Anglia Three). These approaches were used to inform the final positions of Natural England for the assessments conducted at Hornsea Project Two (see Appendix Q of the Applicant's submission at Deadline 7 and Natural England's submission at Deadline 5) with those in the non-breeding season identical to those applied by Natural England for that project.

1.4.4 Puffin

Breeding season

1.4.4.1 In the breeding season it is possible that breeding birds from the FFC pSPA, immature birds from colonies throughout the North Sea and potentially further afield and non-breeding birds may occur at Hornsea Three. It is therefore necessary to apportion potential impacts from Hornsea Three to these components of the population in order to identify the potential effect on the FFC pSPA.

1.4.4.2 Harris (1983) indicates that immature birds are frequently observed at colonies with many birds visiting colonies other than that at which they fledged. Immature birds arrive progressively earlier at breeding colonies as they age with all age classes remaining at a colony until the end of the breeding season (Harris, 1983; Sandvik *et al.*, 2008). Although it is suggested that younger immatures may be distributed in areas away from colonies in the breeding season, first year birds are thought to represent 15% of birds present in rafts beneath colonies (Harris, 1983).

1.4.4.3 It is not until egg laying is well underway that immature birds begin appearing at breeding colonies (Harris and Wanless, 2011). As the season progresses, increasing numbers of immature birds return to colonies initially represented by four-year–old birds with the youngest age classes being the last to appear. On the Isle of May, birds in their first year of life seldom come ashore in the colony before July and then few individuals with others flying over the colony and adjacent sea area with the arrival of older immatures becoming progressively earlier (2^{nd} year = approximately mid-May to early July, 3^{rd} year = mid-April to mid-May, 4^{th} year = late March to mid-April, 5^{th} year = late March to early April) (Harris and Wanless, 2011).

1.4.4.4 In their first year of life approximately 50% of birds lose their black face patches during spring moult whereas by late March/early April the proportion of breeding birds retaining traces of black winter feathers on the face is generally low i.e. less than <1% of birds at the Isle of May during 2006 – 2010 (Harris and Wanless, 2011). Most adult birds soon thereafter complete their facial moult. It is reasonable to assume therefore that the immatures identified at Hornsea Three during the period April to July from their black face patches, is an underestimate of the proportion of bird's in their first year of life. Moreover as over 50% of birds aged in the Hornsea Zone from April to June were recognisable as being in their first year of life (Table 1.8), it may be argued that the majority of the remainder of birds comprise of other immatures including those from older age classes. This is inferred from the observation that with increasing age prior to first-time breeding immatures show a greater affinity for visiting the colony (Harris and Wanless, 2011). This can be expected to be accompanied by an increasing proportion of each successive age class of immature birds returning to the adjacent sea to the colony with the centre of distribution for an age class progressively moving closer to the colony. However with an increased number of birds of each successive age class of immature returning to the vicinity of the colony, most of the birds not recognisable as being in their first year of life at Hornsea Three during April to June may comprise of immatures. Support for this is inferred from observations that adult birds at sea around Flamborough Head carrying fish to the colonies came from distances of up to 40 km (Webb *et al.*, 1985), and not regularly from the distance of Hornsea Three.

1.4.4.5 No puffins were aged during aerial surveys of Hornsea Three as the defining features immature birds (black faces and smaller bills) are not captured by imagery. Therefore boat-based data from the former Hornsea Zone has been used to calculate the proportion of adult and immature birds present at Hornsea Three. Boat-based surveys for the Hornsea Project One and Hornsea Project Two developments were conducted using two spatial scales one covering the central area of the former Hornsea Zone that incorporated the Hornsea Project One and Hornsea Project Two areas plus respective 4 km buffer areas and another covering the entirety of the former Hornsea Zone plus a 10 km buffer (Figure 1.12). Transects covering the Hornsea Project One and Two project areas had a spacing of 2 km (Subzone transects) whilst those covering the former Hornsea Zone had a spacing of 6 km (Hornsea Zone transects). Table 1.3 presents the proportion of adult and immature (i.e. those one year of age or above) puffin recorded during boat-based surveys of Hornsea Project One and Hornsea Project Two using differing subsets of the dataset as described in paragraph 1.4.2.6.

1.4.4.6 The proportions presented in Table 1.8 for data suggest that as distance from the FFC pSPA colony increases the proportion of adult birds present decreases. This is illustrated by both the data associated with the Hornsea Zone transects (data subsets 6, 7 and 8), where the adult proportion decreases from 74.1% to 30.0% and across the Hornsea Project One and Hornsea Project Two areas where the adult proportion is 55.3% in the western side and 13.0% in the eastern side (data subsets 4 and 5). However, it is important to note that by subdividing the data the sample size for the majority of the subdivisions falls below the threshold considered to provide a representative sample (i.e. 100 records). Datasets 1 and 6, which are both associated with Hornsea Zone transects both contain over 100 records. On Hornsea Zone transects closer to FFC pSPA a higher percentage of adults are recorded when compared to all transects covering the entire former Hornsea Zone. In order for the adult percentage to decrease across the entire Hornsea Zone fewer adults must be present on transects further away from FFC pSPA therefore supporting the assumption that fewer adult birds occur as distance from FFC pSPA increases.

1.4.4.7 The conclusion that more immatures occur further offshore is supported by observations from boat-based surveys in the north-west North Sea presented in Camphuysen (2005). Within 20 km of land, 99% of all puffins observed were adults in breeding plumage. However, with increasing distance from the coast more immatures were identified (25-40% immatures over 100 km from the coast).

1.4.4.8 As the sample size of the subdivision offshore of Hornsea Projects One and Two (dataset 8) falls below 100 records, on a precautionary basis the proportion of immatures calculated using data associated with all Subzone and Hornsea Zone transects is used to enable further analysis. This dataset contains the largest number of records and therefore provides the most robust representation of the age structure at Hornsea Three of the four datasets for which there are over 100 records. However, it is important to note that this dataset contains a higher survey effort in inshore areas and therefore resulting analyses will over-estimate the proportion of adults present at Hornsea Three.

Table 1.8: The proportion of adult and immature puffin calculated using different subsets of the boat-based survey data collected for the Hornsea Project One and Hornsea Project Two developments in the breeding season (May to July).

Data subset	Transects	Sample size	Adult proportion (%)	Immature proportion (%)
All data	Subzone and Hornsea Zone transects	379	52.8	47.2
All Subzone transect data	Subzone transects	119	45.4	54.6
1	All Hornsea Zone transects	155	62.6	37.4
2	Subzone transects inshore of P1 and P2 (1-14)	46	50.0	50.0
3	Subzone transects covering P1 and P2 (15-40)	70	41.4	58.6
4	Subzone transects covering the western region of P1 and P2 (15-26)	47	55.3	44.7
5	Subzone transects covering the eastern region of P1 and P2 (27-40)	23	13.0	87.0
6	Hornsea Zone transects inshore of P1 and P2 (1-4 and 23-29)	116	74.1	25.9
7	Hornsea Zone transects covering P1 and P2 (5-14)	35	40.0	60.0
8	Hornsea Zone transects offshore of P1 and P2 (15-22)	10	30.0	70.0

1.4.4.9 Table 1.9 presents the calculations underpinning the analysis which concludes with the proportion of breeding adults present at Hornsea Three. It should be noted that this analysis does not account for the greater affinity for visiting the colony prior to first-time breeding that immatures show with increasing age and therefore likewise adjacent sea area, which can be expected to result in more birds at Hornsea Three with each successive age class of immature birds. The analysis suggests that even when using highly precautionary assumptions that it is unlikely breeding adult birds will be present at Hornsea Three. The analysis is considered to be precautionary for the following reasons:

- A likelihood of a greater proportion of older age classes of immature birds showing affinity with the colony
- The majority of foraging flights are close to the colony and data given by BirdLife (see Section 1.3.4) suggests that less than 5% of birds are likely to travel as far as Hornsea Three
- Immature birds are not likely to be evenly distributed within the North Sea and will show aggregations near to foraging resources. If the area within which Hornsea Three lies is seen to be notable for puffin foraging; immatures may be present in large numbers.

1.4.4.10 It should be noted that even when conducting the analysis presented in Table 1.9 using the dataset lowest immature proportion presented in Table 1.8 that has over 100 records (dataset 6), the resulting proportion of adult birds is 33.9%. However, the use of this dataset is not considered appropriate as the transects with which data are associated are located much closer to the puffin breeding colony at FFC pSPA than the area in which Hornsea Three is located with the likelihood of a bird from FFC pSPA occurring in this area considered to be higher based on the information presented in Section 1.3.4.

Table 1.9: Estimated breeding season contribution of FFC pSPA birds to total predicted to be present at Hornsea Three using immature proportions as calculated from survival rates and numbers of one year old birds recorded on boat-based survey transects covering Hornsea Three.

Analysis step	Formula (using the parameters identified as part of each analysis step	Value
(a) Survival rate of juvenile birds		0.709
(b) Survival rate of one year old birds		0.709
(c) Survival rate of two year old birds		0.76
(d) Survival rate of three year old birds		0.805
(e) % of puffin at Hornsea Three assigned to one year old birds		47.2%
% of puffin at Hornsea Three assigned to other immature age classes (f) two years old (g) three years old (h) four years old	f = [{a x b} / a] x e g = ([{a x b} x c] / a) x e h = {([{a x b} x c]x d} / a) x e	33.5% 25.4% 14.5%
(i) % of puffins at Hornsea Three assigned to adults	i = 100% - (e + f + g + h)	0%

1.4.4.11 The use of survival rates in the apportioning approach presented in Table 1.9 is considered to be appropriately precautionary. Older immature age classes are known to show a greater affinity for natal waters (Harris and Wanless, 2011) with the proportion of older immature age classes returning to natal waters during the breeding season therefore higher than the proportion of first year birds returning to natal waters. The approach applied in Table 1.9 assumes that a consistent proportion of each age group will be present at Hornsea Three and therefore likely under-estimates the proportions of older immature age classes present at Hornsea Three.

1.4.4.12 As a result of the analysis presented here and the information presented in Section 1.3.4 it is considered highly unlikely that breeding adult puffin from FFC pSPA will be present at Hornsea Three with birds identified as adults during surveys most likely either older immature age classes or non-breeding birds.

1.4.4.13 It is considered that no adult breeding puffin will be present at Hornsea Three during the breeding season, and so it is assumed that the population observed there will, therefore, be composed of immature and non-breeding adult birds. Hornsea Three is located a considerable distance from any breeding colony, including the FFC pSPA, and so the immature population that may occur there is likely to comprise birds from colonies around the UK. It is also known that birds are likely to visit multiple colonies before age at first breeding (Harris and Wanless, 2011). It is considered likely though that the majority of birds will still originate from those breeding colonies that are closest to Hornsea Three including FFC pSPA, the Farne Islands (39,962 occupied burrows in 2013), Coquet Island (12,344 occupied burrows in 2013) and the Firth of Forth (51,991 equivalent pairs in 2013). These breeding colonies are much larger than FFC pSPA (980 pairs) and as such would have larger associated populations of immature birds. Therefore any apportioning of impacts from Hornsea Three to the total population of immatures present at Hornsea Three would result in a negligible proportion being apportioned to FFC pSPA.

1.4.4.14 In addition to immature birds, non-breeding adult birds are likely to be present at Hornsea Three. However, it is not known how large this population is, with estimates suggesting that between 1 and 20% of birds may miss a breeding season (Harris and Wanless, 2011). Although it has not been possible to quantify how many non-breeding birds may be present, it can be assumed that their presence will further dilute the impact that can be attributed to FFC pSPA.

1.4.4.15 Due to the complexities in defining a breeding season BDMPS immature population, any impacts that may affect the immature population associated with FFC pSPA will be considered on a qualitative basis.

Non-breeding season

1.4.4.16 In the non-breeding season, population data from Furness (2015) were used to calculate the contribution of birds from FFC pSPA to a wider non-breeding population present within the North Sea. This approach is consistent with the approach applied at Hornsea Project Two and East Anglia Three by both the relevant Applicant and Natural England.

1.4.4.17 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the non-breeding season as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of puffin was calculated as 231,958 individuals. The contribution of breeding adult birds from FFC pSPA to this population is 0.4%. The contribution of immature birds associated with FFC pSPA to this population is 0.02%

Summary

1.4.4.18 Based on the calculations presented in the previous sections the following apportioning values will be applied in assessments for breeding adult puffin at Hornsea Three:

- Breeding season = 0%
- Non-breeding season = 0.4%

1.4.4.19 For immature birds an apportioning value of 0.02% is considered appropriate in the non-breeding season. Due to the complexities associated with defining a total immature population that may interact with Hornsea Three, the level of impact attributable to the immature population associated with FFC pSPA will be considered in a qualitative manner in the RIAA.

1.4.4.20 It is important to note that the approaches used to calculate these apportioning values (boat-based data and data from Furness (2015)) are consistent with the approaches used in the assessments for consented offshore wind farm developments (e.g. Hornsea Project Two). The apportioning values presented above for breeding adult birds in the non-breeding season are identical to those used to inform the final positions of Natural England for the assessments conducted at Hornsea Project Two (see Appendix 6 of Natural England's submission at Deadline 3).

1.4.5 Razorbill

Breeding season

1.4.5.1 As discussed in Section 1.3.5, there is not considered to be connectivity between the breeding population of razorbill present at FFC pSPA and Hornsea Three with the population at Hornsea Three believed to be composed of immature and non-breeding birds. Therefore impacts associated with Hornsea Three are not attributable to the breeding razorbill population at FFC pSPA and no apportioning is required for breeding adult birds.

1.4.5.2 It is considered that no adult breeding razorbill will be present at Hornsea Three during the breeding season and so it is assumed that the population observed there will be composed of immature and non-breeding adult birds. Immature birds are known to visit colonies before age at first breeding (Furness, 2015), but the population observed there could comprise birds from colonies around the UK, with birds likely to visit multiple colonies before age at first breeding.

1.4.5.3 It is considered likely that a large proportion of the immature population present at Hornsea Three will originate from those breeding colonies that are closest to it including FFC pSPA (10,570 pairs), the Farne Islands (491 occupied sites in 2016), St Abb's to Fast Castle SPA (1,385 pairs in 2016) and the Firth of Forth (3,597 equivalent pairs in 2015). Only a proportion of the mortality of immature birds predicted will, therefore, be attributable to the FFC pSPA.

1.4.5.4 In addition to immature birds, non-breeding adult birds are likely to be present at Hornsea Three. However, it is not known how large any such population would be. It is not known what proportion of the adult razorbill population does not breed in any given breeding season, however, in guillemot there is evidence that approximately 7% of the adult population does not breed (Reed *et al.* 2015). Although it is not possible to quantify how many non-breeding birds may be present, the presence of these birds will further reduce the impact that should be attributed to FFC pSPA.

Non-breeding seasons

1.4.5.5 For apportioning in non-breeding seasons (post-, non- and pre-breeding seasons), population data from Furness (2015) were used to calculate the contribution of birds from FFC pSPA to a wider population present within the North Sea. This approach is consistent with the approach applied at Hornsea Project Two and East Anglia Three by both the relevant Applicant and Natural England.

1.4.5.6 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the post-breeding and pre-breeding (migration) seasons as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of razorbill was calculated as 592,641 individuals. The contribution of breeding birds from FFC pSPA to this population is 3.4%. The contribution of immature birds associated with FFC pSPA to this population is 2.3%

1.4.5.7 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the non-breeding season as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of razorbill was calculated as 218,708 individuals. The contribution of breeding birds from FFC pSPA to this population is 2.7%. The contribution of immature birds associated with FFC pSPA to this population is 0.53%

Summary

1.4.5.8 Based on the calculations presented in the previous sections the following apportioning values will be applied in assessments for breeding adult razorbill at Hornsea Three:

- Breeding season = N/A
- Post-breeding season = 3.4%
- Non-breeding season = 2.7%
- Pre-breeding season = 3.4%

1.4.5.9 For immature razorbill associated with the FFC pSPA the following apportioning values will be applied:

- Post-breeding season = 2.3%
- Non-breeding season = 0.53%
- Pre-breeding season = 2.3%

1.4.5.10 Due to the complexities associated with defining a total immature population that may interact with Hornsea Three, the level of impact attributable to the immature population associated with FFC pSPA will be considered in a qualitative manner in the RIAA.

1.4.5.11 It is important to note that the approaches used to calculate these apportioning values (boat-based data and data from Furness (2015)) are consistent with the approaches used in the assessments for consented offshore wind farm developments (e.g. Hornsea Project Two). The apportioning values presented above for breeding adult birds in the post-, non- and pre-breeding seasons are identical to those used to inform the final positions of Natural England for the assessments conducted at Hornsea Project Two (see Appendix 5 of Natural England's submission at Deadline 3).

1.4.6 Guillemot

Breeding season

1.4.6.1 As discussed in Section 1.3.6, there is not considered to be connectivity between the breeding population of guillemot present at FFC pSPA and Hornsea Three with the population at Hornsea Three believed to be composed of immature and non-breeding birds. Therefore impacts associated with Hornsea Three are not attributable to the breeding guillemot population at FFC pSPA and no apportioning is required.

1.4.6.2 It is considered that no adult breeding guillemot will be present at Hornsea Three during the breeding season, and so it is assumed that the population observed there will be composed of immature and non-breeding birds. Immature birds are known to visit colonies before age at first breeding (Furness, 2015), but the population observed there could comprise birds from colonies around the UK, with birds likely to visit multiple colonies before age at first breeding.

1.4.6.3 It is considered likely that a large proportion of the immature population present at Hornsea Three will originate from those breeding colonies that are closest to Hornsea Three including FFC pSPA, the Farne Islands (32,855 pairs in 2016), St Abb's to Fast Castle SPA (24,258 pairs in 2016) and the Firth of Forth (21,181 pairs in 2015). Only a proportion of the mortality of immature birds predicted will, therefore, be attributable to the FFC pSPA.

1.4.6.4 In addition to immature birds, non-breeding birds are likely to be present at Hornsea Three. Reed *et al.* (2015) indicate that at the Isle of May approximately 7% of the breeding population skip a breeding season.

Non-breeding season

1.4.6.5 In the non-breeding season, population data from Furness (2015) were used to calculate the contribution of birds from FFC pSPA to a wider non-breeding population present within the North Sea. This approach is consistent with the approach applied at Hornsea Project Two and East Anglia Three by both the relevant Applicant and Natural England.

1.4.6.6 Based on the proportion of birds from UK and foreign colonies considered to be present in the North Sea during the non-breeding season as presented in Furness (2015), the UK North Sea and Channel Waters BDMPS population of guillemot was calculated as 1,617,306 individuals. The contribution of breeding birds from FFC pSPA to this population is 4.4%. The contribution of immature birds associated with FFC pSPA to this population is 2.9%

Summary

1.4.6.7 Based on the calculations presented in the previous sections the following apportioning values will be applied in assessments for guillemot at Hornsea Three:

- Breeding season = N/A
- Non-breeding season = 4.4%

1.4.6.8 For immature birds, an apportioning value of 2.9% is considered appropriate in the non-breeding season. Due to the complexities associated with defining a total immature population that may interact with Hornsea Three, the level of impact attributable to the immature population associated with FFC pSPA will be considered in a qualitative manner in the RIAA.

1.4.6.9 It is important to note that the approaches used to calculate these apportioning values (boat-based data and data from Furness (2015)) are consistent with the approaches used in the assessments for consented offshore wind farm developments (e.g. Hornsea Project Two). The apportioning values presented above for breeding adult birds in the non-breeding season are identical to those used to inform the final positions of Natural England for the assessments conducted at Hornsea Project Two (see Appendix 4 of Natural England's submission at Deadline 3).

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