BEATRICE OFFSHORE WIND FARM
ORNITHOLOGICAL TECHNICAL REPORT

FINAL VERSION

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EXECUTIVE SUMMARY

This Technical Report provides a detailed assessment of the ornithological interests for the proposed Beatrice Offshore Wind Farm in support of the Environmental Impact Assessment.

This assessment is based on data collected during twenty two boat surveys of the Wind Farm Site and buffer zone, aerial surveys of the Beatrice Offshore Wind Farm and the Round Three zone to the east, vantage point observations made from the coast and the Beatrice Alpha Platform, satellite tracking data of breeding birds from colonies along the East Caithness coast and previous boat based surveys conducted across the Moray Firth.

Fourteen seabird species and three wildfowl species were identified for detailed assessment, on the basis of their recorded occurrence in the surveys and the species known to be present within the region. Detailed baseline descriptions for these species are provided. These describe the temporal and spatial patterns of site use by these species, drawing on a wide range of data sources.

The potential impacts of the Beatrice Offshore Wind Farm on the ornithological interests are discussed in relation to construction and decommissioning and operation. Impacts considered include those due to increased vessel traffic, construction activities, disturbance and displacement, collision with rotors and indirect effects. A summary is provided below:

- Impacts due to boat traffic were determined to be of minor or negligible magnitude and therefore *not significant* for all species.
- Impacts due to construction activities were determined to be of minor or negligible magnitude and therefore *not significant* for all species.
- Impacts due to displacement of breeding birds were determined to be of negligible magnitude and therefore *not significant* for all species.
- Impacts due to barrier effects were determined to be of minor or negligible magnitude and therefore *not significant* for all species.
- Impacts due to collisions with rotors were determined to be of minor or negligible magnitude and therefore *not significant* for all species.
- Impacts due to indirect effects were determined to be of negligible magnitude and therefore *not significant* for all species.

The potential for cumulative impacts, in particular in combination with the proposed Moray Firth Round 3 Zone, Eastern Development Area Offshore Wind Farm (Moray Firth Round 3 Zone EDA), located to the east of the Beatrice Offshore Wind Farm, were considered within the same categories described above.

- Cumulative impacts due to displacement of birds were determined to be of minor or negligible magnitude and therefore *not significant* for all species.
- Cumulative impacts due to barrier effects were determined to be of minor or negligible magnitude and therefore *not significant* for all species.
- Cumulative impacts due to collisions with rotors were predicted to be of minor magnitude and therefore *not significant* for all species.
- Cumulative impacts in combination with other offshore wind farm developments in eastern Scotland and wave and tidal renewable developments in Orkney and the Pentland Firth were predicted to be of minor or negligible magnitude and therefore *not significant* for all species.

1 INTRODUCTION

Background

1.1 The proposed Beatrice Offshore Wind Farm is being developed by Beatrice Offshore Wind Farm Limited (BOWL), a joint venture partnership between Scottish and Southern Energy Renewables (SSER) and Repsol Nuevas Energias UK (Repsol) formerly SeaEnergy Renewables Limited (SERL).

1.2 RPS has been commissioned by BOWL to provide ornithological advice and the ornithological impact assessment chapter for the Environmental Statement and the accompanying Technical Report.

1.3 This ornithological Technical Report presents and interprets the results of site specific studies:

- boat-based and aerial seabird surveys,
- results of wildfowl migration surveys,
- a seabird tracking study,

and also draws on older contextual bird data available for the region and desk-based research and reviews as appropriate for informing the Environmental Impact Assessment (EIA) for the wind farm.

The potential impacts of each phase of the development on the ornithological assemblage have been assessed, with a particular emphasis on priority species of conservation concern.

Site Description

1.4 At its closest point to the coast the Beatrice Offshore Wind Farm Site is located approximately 13.5 km off the Caithness coastline and centred approximately 18 km south south-east of Wick (Figure 2.1). The wind farm polygon is approximately 19 km long (north-east to south-west) and 9 km wide (north-west to south-east), with a total area of approximately 131.5 km^2. The wind farm lies entirely within Scottish Territorial Waters in water depths of 35-50 m of lowest astronomical tide, with a 2.8-3.2 m tidal range and maximum marine current of ca. 0.5 knots. The Wind Farm Site lies at the northern edge of the Smith Bank, on predominantly sandy substrates. For the purposes of this assessment a range of possible turbine specifications, layouts and installation options (as provided by the developer) will be considered, in line with the concept of the 'Rochdale Envelope' approach to Environmental Impact Assessment.

Purpose and Scope of the Assessment

1.5 The overriding purpose of this Technical Report is to provide a quantitative and qualitative assessment for the Ornithology chapter of the Beatrice Offshore Wind Farm ES. The Report will therefore:

- Collate all ornithological data gathered to date for the Beatrice Offshore Wind Farm application and provide a baseline description of the ornithological interests within the wind farm application site itself and the wider Moray Firth;

- Establish the ornithological significance of the proposed Beatrice Offshore Wind Farm Site throughout the year, both alone and in-combination with other offshore wind farms, through analysis of data from boat-based surveys, aerial surveys, migration surveys and tracking studies;

- Predict potential ornithological impacts of construction, operation and decommissioning of the Beatrice Offshore Wind Farm, and the overall significance of these impacts; and

- Provide suggestions for mitigation (where required) and future monitoring.

1.6 There are three key potential impacts identified on the seabird assemblage during the construction, operation and decommissioning of Beatrice Offshore Wind Farm, based on reviews of offshore wind farms and birds, e.g. Drewitt and Langston (2006); Dierschke *et al.* (2006); Langston (2010):

- The potential for the Beatrice Offshore Wind Farm to adversely affect seabirds of highest conservation concern, listed on Annex 1 of the EU Birds Directive and/or Schedule 1 of the Wildlife & Countryside Act 1981 (as amended). Direct adverse impacts may arise through loss of foraging habitat, disturbance, displacement, collision with turbines or barrier effects; and indirect impacts may occur through changes in the distribution and abundance of prey species.

- The potential for the Beatrice Offshore Wind Farm to adversely affect qualifying ornithological features of nearby designated sites (Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSIs) and Ramsar sites); and

- The potential for the Beatrice Offshore Wind Farm to adversely affect other seabirds in internationally-, nationally- or regionally-important numbers present over winter, during migration, or whilst commuting locally between foraging and breeding grounds.

1.7 The format of the remainder of this report is as follows:

1.8 **Section 2** provides an overview of the methodologies used to gather baseline data for the Beatrice Offshore Wind Farm, analytical methods used to interpret the data and the procedure followed for the impact assessments, including definition of the concept of 'significance' in relation to impact identification. Where applicable, the methods used to generate population estimates (e.g. statistical approaches such as Distance analysis, Buckland *et al*. 2001) and collision risk estimates (e.g. Collision Risk Modelling) will also be discussed.

1.9 **Section 3** presents the baseline conditions determined from the boat and aerial surveys in combination with migration surveys, a tracking study, and desk-based analysis and reviews of older data which provides a contextual picture of the bird interests within the region.

1.10 Within this section, information on the cited interests and current condition of nearby designated sites is provided, as well as for those located further away but included due to the presence of far-ranging species. The section then presents information on the rationale behind the species selected for inclusion in the impact assessment, based on criteria such as conservation status, sensitivity and relative numbers compared to international, national and regional populations.

1.11 The following subsections then provide individual species accounts for each key species identified. These present the results of surveys and the interpretation of any trends in spatial, seasonal or inter-annual variation, as well as providing a determination of the relative importance of the Beatrice Offshore Wind Farm Site to the species in a wider spatial context.

1.12 **Section 4** constitutes the impact assessment of the potential effects on each species of principal concern. This is described in relation to the three phases of the project: construction, operation and decommissioning.

1.13 The distributions of foraging species during the breeding season will be explored and the potential effects of avoidance of the wind farm site on the populations of these species will be discussed.

1.14 Collision Risk Modelling (CRM) results are presented, investigating the potential for collision during the operational phase of the development for sensitive species under a variety of scenarios including a range of avoidance rates.

1.15 **Section 5** forms the Cumulative Impact Assessment (CIA) of effects in-combination with other offshore wind farms, both within the Moray Firth and also more widely within north-east Scotland. This will be undertaken in relation to the types of effect identified in the impact assessment section (e.g. displacement and collision risk). Other regulated activities in the Moray Firth region will also be included where significant cumulative effects are considered possible, and consideration will also be made for combined effects with underwater renewables (e.g. wave and tidal projects) within the Pentland Firth and Orkney area

1.16 In addition, **Appendix 1** presents full boat survey observation data, the analyses of which are summarised in the assessment.

Available Ornithological Data

1.17 Monthly bird surveys of the Beatrice Offshore Wind Farm Site and buffer zone were undertaken between October 2009 and September 2011 using standard boat based methods (Camphuysen *et al.* 2004). In March 2011 a replacement aerial survey was flown due to unsuitable weather preventing the boat survey in that month. As detailed below there is also a considerable amount of additional bird data available for this region of the Moray Firth.

1.18 Additional bird studies have been conducted to complement the boat and aerial surveys:

- The passage of migrating wildfowl across the Moray Firth was studied using vantage point methods during Autumn 2010 and Spring 2011.
- During the 2011 breeding season, individuals from four seabird species which breed in the East Caithness Cliffs Special Protection Area (SPA), were fitted with satellite tags to track their foraging movements.

These studies have provided more focussed data in order to highlight any species specific impacts.

1.19 The data obtained from these surveys forms the core of the ornithological site assessment. However, there are a range of other ornithological data sources available for this area, collected during the previous 30 years. These data provide a very high level of information on the bird interests in the region. These additional data sources are summarised below.

- Aerial surveys of the Moray Firth Round 3 Eastern Development Zone, commissioned by The Crown estate, were undertaken during the summer of 2009 (May, July, August, Digital video, HiDef 2009) and the winter of 2009-10 (November, December, February, Wildfowl and Wetland Trust Consulting (WWTC) 2010). These surveys covered between half and all of the Beatrice Offshore Wind Farm Site.

- Platform based monthly surveys for the Beatrice Demonstrator wind farm were conducted between 2005 and 2008. These provide a continuous dataset, covering the before, during construction and post-construction periods of the earlier Beatrice Demonstrator development, which lies approximately 11 km to the south west of the current proposed development.

- The RSPB undertook comprehensive seabird surveys of the entire Moray Firth (out to an approximate line connecting Duncansby Head in Caithness to Peterhead in Aberdeenshire) on a monthly basis for two years (1982 and 1983). These surveys provide a valuable overview of past bird distributions and seasonal changes across a wide area.

Definitions of site and assessment scenarios

1.20 In the following sections the term 'application site' refers to the area within the final site boundary, while the term 'boat based study area' refers to the entire area covered by the boat surveys conducted between October 2009 and September 2011 on which this assessment is based, which includes a buffer zone of 4 km around the Wind Farm Site boundary (Figure 2.1).

1.21 Beatrice Offshore Wind Limited supplied three alternative turbine options and associated spacing configurations, as well as four combinations of sub-structures and foundations for the purposes of this assessment. The worst case option may vary, depending on the nature of the impact under consideration. Thus, no single combination of turbines, sub-structures and foundations necessarily represents the worst case scenario for all potential impacts. For each potential impact under consideration, the worst case option is defined at the beginning of the section.

2 METHODOLOGY

Data sources

2.1 Boat-based and aerial surveys conducted for the Beatrice Offshore Wind Farm during a two year period between October 2009 and September 2011 were the primary source of data used to inform this technical report. All survey and impact assessment methodologies followed standard guidance for data gathering and assessment of offshore wind farms. The purpose of the surveys was to establish the nature of present bird use of the survey area, in order to establish a clear baseline against which any future potential changes can be assessed. Two additional studies, one focussed on foraging seabirds from colonies within the East Caithness SPA and another on wildfowl migration, were conducted to provide additional information on particular aspects of bird presence within the region.

2.2 In addition, past surveys of the region have been used to provide a contextual picture of the ornithological interests within the wider area, both spatially and temporally. These include:

(1) Aerial surveys of the adjoining Round Three wind farm area (zone one), undertaken during Summer 2009 (by HiDef Aerial Surveying) and Winter 2009-2010 (by the WWTC). A total of seven surveys were conducted, four of which included approximately half of the Beatrice Offshore Wind Farm Site and the remaining three covering the entire application site.

(2) Thirty eight vantage point surveys undertaken on a monthly basis from the Beatrice Offshore Wind Farm Alpha oil platform (58° 6.06 N 3° 4.837 W), between January 2005 and June 2008. This work was undertaken in relation to the Beatrice Demonstrator turbines.

(3) Two years of monthly boat surveys of the Moray Firth conducted between January 1982 and December 1983 by the RSPB. These surveys covered an area demarcated by the coastline to the west and south and extending to an approximate line connecting Duncansby Head in Caithness to Peterhead in Aberdeenshire (see Figure 3.1.3 for an example of coverage).

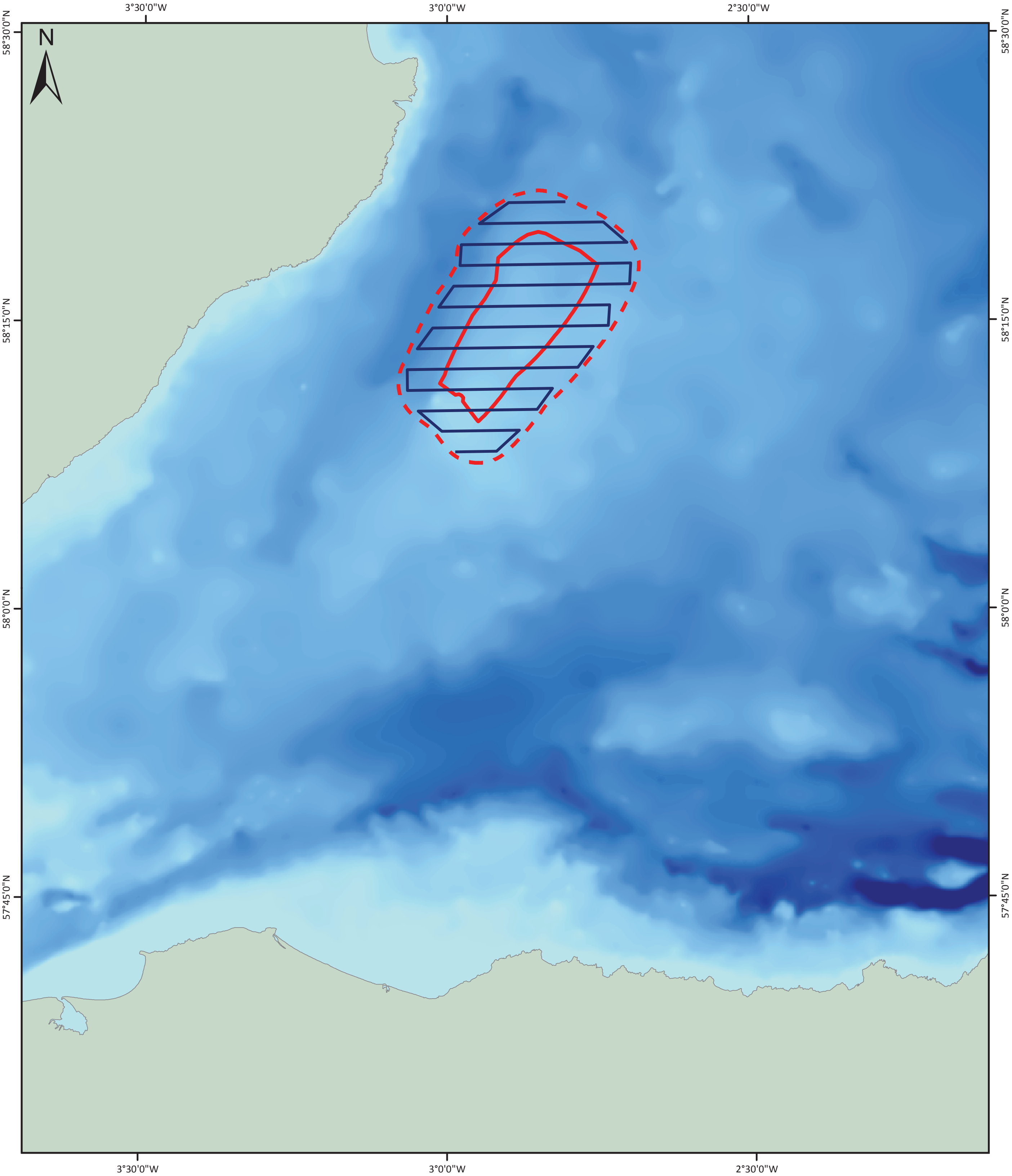
Survey methods

Boat based Surveys

2.3 Monthly boat-based surveys of the Beatrice Offshore Wind Farm site and 4 km buffer were conducted between October 2009 and September 2011, following standard seabird survey methods (Camphuysen *et al.* 2004, Maclean *et al*. 2009, Table 2.1). This comprised a transect route of 204 km which crossed the site in an east-west orientation at 2 km intervals (Figure 2.1). The boat based study area, included a buffer zone with a width of 4 km around the Wind Farm Site boundary and was approximately 383 km^2. The surveys were undertaken by the Institute of Estuarine and Coastal Studies (IECS) at Hull University.

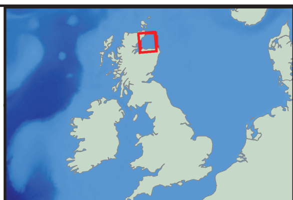
Table 2.1. Dates of boat surveys of the Beatrice Offshore Wind Farm and buffer conducted by IECS between October 2009 – September 2011.

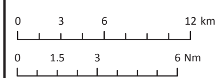
Survey number	Year	Month	Day 1	Day 2
1	2009	October	14	15
2	2009	December	3	10
3	2010	February	12	13
4	2010	March	3	4
5	2010	April	8	9
6	2010	April	27	28
7	2010	May	15	16
8	2010	June	22	23
9	2010	July	19	20
10	2010	August	15	16
11	2010	September	19	30
12	2010	October	12	13
13	2010	December	13	14
14	2011	January	19	20
15	2011	January	27	28
16	2011	February	27	28
17	2011	April	10	11
18	2011	May	31	n/a
19	2011	June	16	17
20	2011	July	1	2
21	2011	August	1	2
22	2011	September	(Aug 31st)	1



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Boat-based transect route





This map contains TCarta and UKCS Bathymetry, 2009.

NOT TO BE USED FOR NAVIGATION

Beatrice Offshore Wind Farm

Figure 2.1

Boat-based transect layout used in ornithological surveys

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Date: 10/10/2011	Scale: 1:500,000	
Drawing Number: sgp6355_Beatrice_2_01_boatSurveyTransects		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

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2.4 A minimum of two trained observers undertook bird observations on each survey, positioned on the observation platform of the vessel. A third observer was used during the peak wildfowl migration months in April and October 2010 and April 2011. For the first four surveys (October 2009 to March 2010) a single marine mammal observer was deployed. For the remaining surveys two marine mammal surveyors were used. Regular rotation of roles between the surveyors was undertaken to prevent fatigue.

2.5 For seabirds, only data collected in sea states less than five (significant wave height of 1.25-2.5 m) have been used for analysis, in accordance with Camphuysen *et al.* (2004) and Maclean *et al*. (2009). A breakdown of sea state for each survey is provided in Appendix 1.

2.6 The location of the vessel was recorded at set intervals using a GPS receiver. Using the time of day the details of each observation were linked to the GPS position data, in order to provide an accurate location. During surveys the vessel travelled at a constant speed of approximately 10 knots.

2.7 In each survey month (weather permitting), the survey was split over two days, with half of the site surveyed each day (with one exception in May 2011 when the survey was completed in a single day due to a deteriorating weather forecast). Each survey day comprised approximately six hours of observations, including a break of approximately 20 minutes.

2.8 Birds on the sea were recorded in four distance bands extending to a maximum of 300 m from one side of the vessel only as follows; 0 – 50 m, 50 – 100 m, 100 – 200 m and 200 – 300 m. All bird observations comprise details of observation time, species, number of individuals, age and sex (where possible).

2.9 Birds in flight were recorded during snapshots at intervals of 500 m (this equates to approximately once every minute) along the transects, using the following methodology. All birds within a box 300 m to a side and extending in front and to the side of the vessel were recorded. No adjustment for distance was performed, as this has been shown to lead to over-estimation of abundance (Maclean *et al*. 2009). Recorded details included species, number, precise time and flight height within the following height bands; <20 m, 20 - 150 m, 150 – 200 m, >200 m.

2.10 During 2011 a contingency plan was put in place for months where the weather prevented the boat survey from being conducted. This allowed for a visual aerial survey to be conducted by the WWTC. The area surveyed was the same as that for the boat surveys. However in this case, the transects were aligned north-south rather than east-west, to reduce problems caused by glare from the sea surface. Only one replacement aerial survey was required, in March 2011. The aerial survey methods (visual and high definition video) are described below.

Aerial Surveys

2.11 Aerial surveys have been conducted using two different methods: visual surveys, conducted by trained observers (WWTC) and high definition digital video surveys (HiDef Aerial Surveying).

Aerial Survey - Visual Survey Methods

2.12 WWTC uses a methodology based on that developed by the National Environment Research Institute (NERI) in Denmark (Kahlert *et al.* 2000; see also Camphuysen *et al.* 2004). The method constitutes a line transect survey, with birds (individuals or flocks) assigned to distance bands aligned in parallel to the direction of travel.

2.13 The aircraft holds straight and level flight at an altitude of 76 m (250 ft) and a speed of approximately 185 kmh (100 knots) though the airspeed may vary in conditions presenting tailwinds and headwinds. The location of the aircraft is recorded every 5 seconds using a Garmin 12XL GPS which is connected to a laptop using the GPSU software.

2.14 Ideal survey design is for transects to be orientated perpendicular to major environmental gradients, such as sea depth. In this manner any systematic variation in seabird density is captured by each transect, rather than within a subset, improving the precision of the density estimates obtained. However, it is sometimes necessary to adjust transect orientation to minimise the effect of glare from the sun.

2.15 Using a clinometer, birds are located in one of four distance bands covering an area from 44 m to 1,000 m either side of the aircraft (Figure 2. 2); any birds beyond 1,000 m are not recorded. Reliable density estimation is dependent on 100 % detection of birds in distance band ‘A’, therefore effort is concentrated on this band.

2.16 For each bird or flock of birds, the species, number, behaviour, distance band (A-D) and the time at which it was perpendicular to the aircraft’s flight path, are recorded using a dictaphone. Occasionally, where conditions allow it is also possible to record age and sex of birds of some species.

2.17 Surveys are generally made during a four-hour period centred on midday GMT to minimise the effects of glare, and are undertaken in good weather conditions, generally with wind speeds of 15 knots or less.

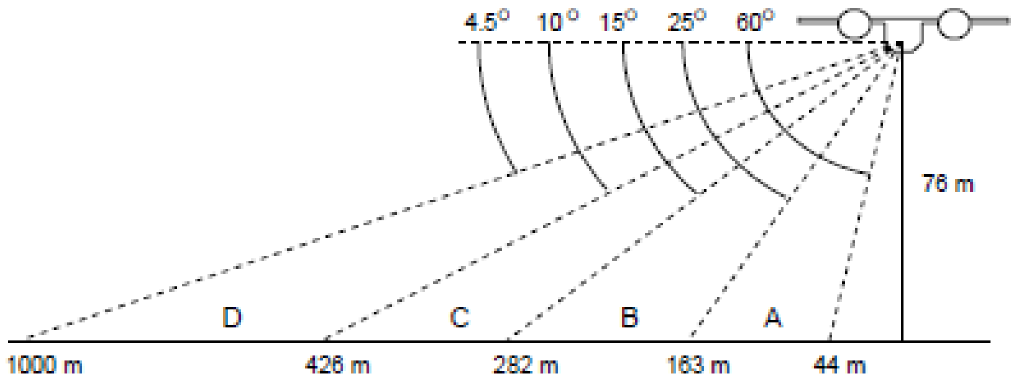


Figure 2.2. Representation of visual aerial survey line transect (not to scale) illustrating distance bands A to D and associated viewing angles from the survey plane. (Image taken from WWTC Method Statement).

Aerial Survey – Digital Video Survey Methods

2.18 The strip transect surveys undertaken by HiDef Aerial Surveying during their surveys made use of four high definition digital video cameras set alongside one another to provide a strip width of

400 m from a flying height of 610 m (2000 ft.). At this height, image resolution of 2 cm was obtained.

2.19 Transects were spaced at 2 km, aligned north-south. Flight speed was set at 180 kmh.

2.20 Bird identification was achieved by a multi-stage process. Initially, the video images were reviewed and frames containing only sea removed. Subsequently, trained aerial ornithologists reviewed the images and identified seabirds to species if possible or species group otherwise. A sub-sample of data, typically 20 %, was also reviewed independently to ensure a high standard of bird identification.

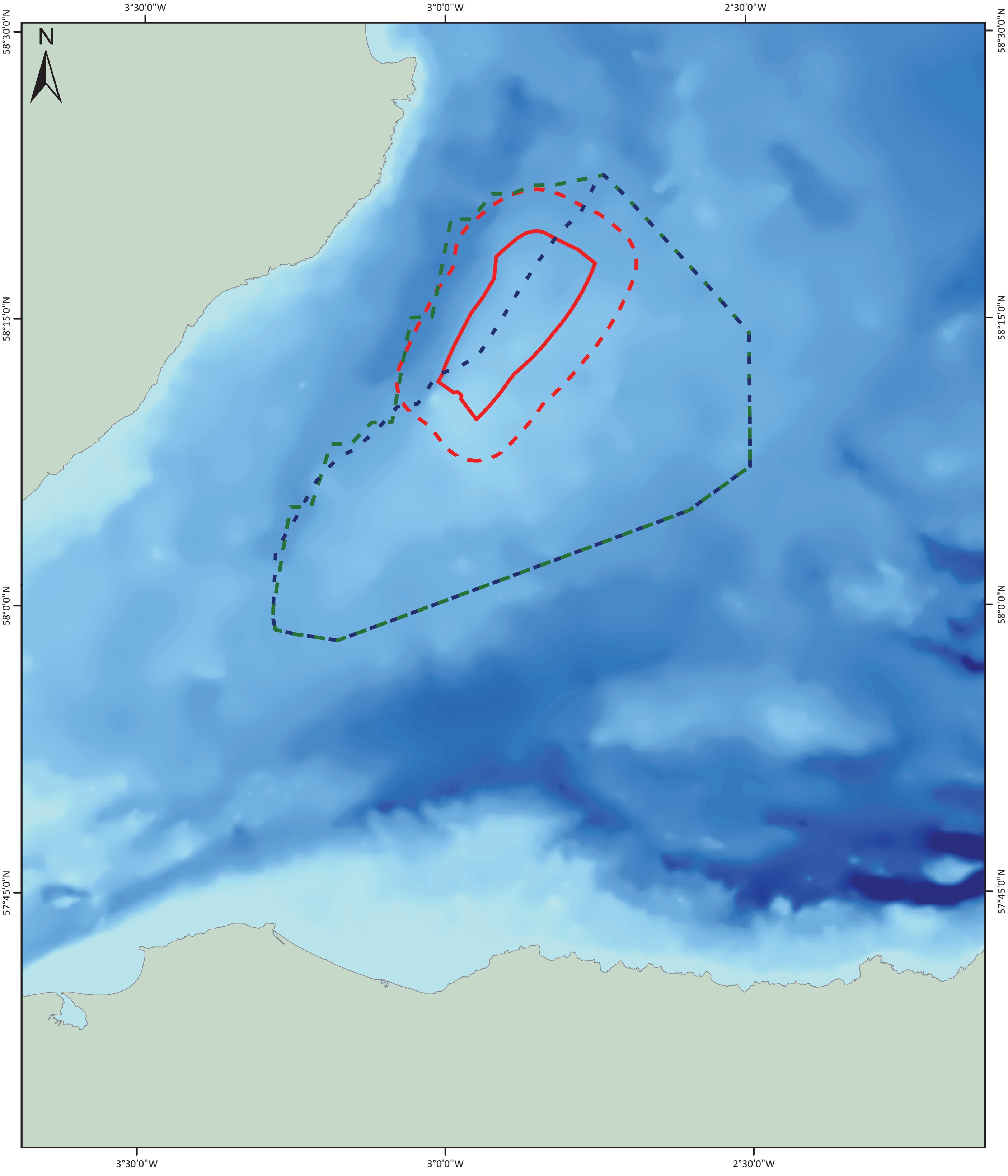
2.21 Each video frame had location data linked to it from the onboard GPS. This was further analysed to estimate individual bird locations within the images.

2.22 During Summer 2009 HiDef Aerial Surveying undertook three aerial surveys of the Moray Firth Round 3 Eastern Development Zone wind farm site using high definition digital video methods. These 'enabling action' surveys, commissioned by the Crown Estate, also provided partial coverage of the Beatrice Offshore Wind Farm site (89 km^2; Figure 2.3, Table 2.2). A further four aerial surveys (using observers) of the two wind farm areas were conducted during Winter 2009-2010 by WWTC (Table 2.2). Three of these latter surveys were extended to provide complete coverage of the Beatrice Offshore Wind Farm site.

Table 2.2. Dates of aerial surveys of the Moray Firth Round Three Eastern Development Zone wind farm area and Beatrice Offshore Wind Farm conducted by HiDef Consulting and WWTC between May 2009 and March 2011.

Survey number	Surveyor	Year	Month	Days	Coverage of Beatrice Application site
1	HiDef	2009	5	29	Partial
2	HiDef	2009	6	9, 10, 29	Partial
3	HiDef	2009	8	5, 6	Partial
4	WWTC	2009	11	7	Complete
5	WWTC	2009	12	10	Partial
6	WWTC	2010	2	8	Complete
7	WWTC	2010	2	19	Complete
8 *	WWTC	2011	3	28	Complete

* This survey (8) was a replacement for a missed boat survey as a result of a prolonged period unsuitable weather during the month.

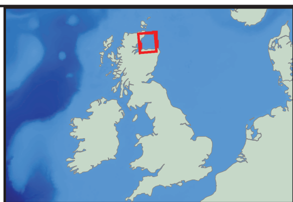


Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km

Aerial survey areas

- HiDef
- WWT



This map contains TCarta and UKCS Bathymetry, 2009.

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Beatrice Offshore Wind Farm

Figure 2.3

Aerial survey area used in ornithological surveys

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Date: 10/10/2011	Scale: 1:500,000	
Drawing Number: sgp6355_Beatrice_2_03 aerialSurveyAreas		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

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Migration Surveys

2.23 Migration vantage point (VP) surveys were undertaken during the Autumn (20th September to 12th November) 2010 and Spring (14th March to 11th May) 2011 goose and swan migration periods. These surveys were designed to estimate the extent of wildfowl migration across the Moray Firth, with a particular emphasis on goose and swan species known to visit sites such as the Loch of Strathbeg SPA in north east Aberdeenshire. These surveys were undertaken in collaboration with the ornithological consultants for the Moray Firth Round 3 Eastern Development Zone wind farm area.

2.24 Four locations on the Moray coast were selected in order to provide suitable vantage points for observing birds potentially crossing the Moray Firth in the vicinity of the wind farm application sites (see Figure 3.17.8). Two were on the east Caithness coast at Duncansby Head (ND 406 733) and Sarclet Head (ND 350 433) and two were on the north Aberdeenshire coast at Whitehills (NJ 658 655) and Rosehearty (two adjacent sites used, NJ 931 678 or NJ 928 677, depending on wind direction and strength).

2.25 The vantage point locations were selected to facilitate the best observation of wildfowl as they headed out across the Moray Firth and also as they came ashore. The sites on the Aberdeenshire coast were also selected to provide information on birds heading towards (Autumn) and away from (Spring) a known migration destination at the Loch of Strathbeg.

2.26 Surveying was undertaken from each site on two days each week over an eight week period. Survey days were selected on the basis of wind conditions, in order to maximise the probability of observing migrating birds. Thus, days during Autumn with north and north-westerly winds were favoured over southerly ones and vice versa in Spring (i.e. tail winds).

2.27 During the Autumn study period observations were undertaken simultaneously at all four locations on most occasions. This was intended to allow any repeat sightings of the same flocks travelling across the Moray Firth between the pairs of vantage points to be recorded. While this was generally possible between the close pairs of sites, analysis of the data failed to identify any flocks for which such a connection could be reliably established across the Moray Firth (i.e. between Aberdeenshire and Caithness). Thus, during the Spring survey, observations continued to be undertaken simultaneously at each pair of vantage points, but the requirement to synchronise across all four sites was relaxed. Consequently, a greater overall temporal spread of observations was achieved, increasing survey coverage without impacting on the quality of data obtained.

2.28 Each survey comprised of two, three hour observation periods separated by a break. During the survey periods systematic scans were conducted and birds in flight were identified to species where possible. The primary target species were geese, swans and raptors, with lower priority given to other species which traverse the offshore region in much lower numbers (e.g. seaduck, waders and passerines). All apparent migration movements of these species were recorded. Flights were identified as constituting migration based on characteristics such as height, direction and flock size. Target species were recorded to maps of the area with flight lines indicating the route taken between first and last observations. The size of flock and any other relevant information was also recorded.

Tracking Study

2.29 During the 2011 breeding season, researchers from the University of Plymouth undertook a tagging study on breeding seabirds from colonies within the East Caithness SPA (Bicknell *et al.* 2011). Using tags with GPS receivers to record bird movements, this work permitted the foraging areas used by breeding seabirds to be identified. Thus, potential links between the East Caithness SPA and the Wind Farm Site could be established.

2.30 Four species were selected for the study; Northern fulmar *Fulmarus glacialis*, common guillemot *Uria aalge*, black-legged kittiwake *Rissa tridactyla* and razorbill *Alca torda*. Since the tags required retrieval in order to download the data, only breeding individuals were selected, as this increased the likelihood of successful tag retrieval at their nest sites. Tagging commenced in late May 2011 and continued until mid July.

2.31 A total of 75 tags with foraging data were retrieved across 74 individuals of the four species (17 fulmars, 20 guillemots, 19 kittiwakes and 18 razorbills).

Beatrice Demonstrator

2.32 In 2006 Talisman Energy (UK) Ltd and Scottish and Southern Energy installed two wind turbines adjacent to the Beatrice Alpha Oil Platform. This project was designed to operate as a demonstrator, providing valuable information about the technical, environmental and economic issues associated with creating a commercial deepwater wind farm in an offshore location. An Environmental Statement was produced for this development. A year long survey of the Demonstrator site was completed using the nearby Beatrice AP platform for vantage point watches. These surveys obtained site-specific information on bird activity within the area, which lies approximately 11 km to the south west of the Beatrice Offshore Wind Farm Site boundary.

2.33 Monitoring continued after the submission of the impact assessment for a further 2½ years, covering pre-construction, construction and post-construction periods. The data therefore covers the period from January 2005 to June 2008. These data have been used here to provide further information on seasonal variations in bird activity within the vicinity of the Wind Farm Site.

2.34 Data were collected from two primary viewing locations, one of which was directed at the turbine locations, the other a control area giving a view oriented at 90° to that overlooking the turbines. During the initial survey months, a different 'control' viewpoint was used to that used for the majority of the study. Tests on the data obtained from the two alternative control viewpoints revealed no detectable differences in seabird observations from the two locations. Therefore these data were combined and used as a single control dataset.

2.35 Analysis of these data (RPS 2010) revealed very little difference in the seasonal patterns of species presence as observed from the two alternative view points. Therefore, for the purposes of contributing to the baseline contextual picture presented here, the data from the different viewing locations were pooled to provide a more robust dataset.

RSPB surveys

2.36 The RPSB surveys of the Moray Firth conducted by boat each month between January 1982 and December 1983 were used to provide a regional context for spatial and temporal bird distributions. The total area covered and the grid used to divide it up are presented in Figure 2.4. The dataset provided counts of each species by month and grid cell. These were converted to density estimates using transect length per grid cell. The densities were then averaged over the two years by season (pre-breeding: February to March, breeding: April to July, post-breeding: August to October and winter: November to January).

Desk Studies

2.37 Background information on seabird distributions within the North Sea was taken from Stone *et al.* (1995) and Mitchell *et al.* (2004) and other sources as appropriate. Colony counts were derived from SPA citations documents or the colony counts submitted to the JNCC's Seabird Monitoring Programme, where the latter provided more up to date information. These were used to determine regional breeding numbers and distributions for each species. Much of the information on bird behaviour and ecology has been taken from *Birds of the Western Palaearctic* (Snow and Perrins 1998), which provides a comprehensive text on each species. The Birdlife International hosted website, seabird.wikispaces.com, was also consulted for species specific foraging range data and ecological accounts.

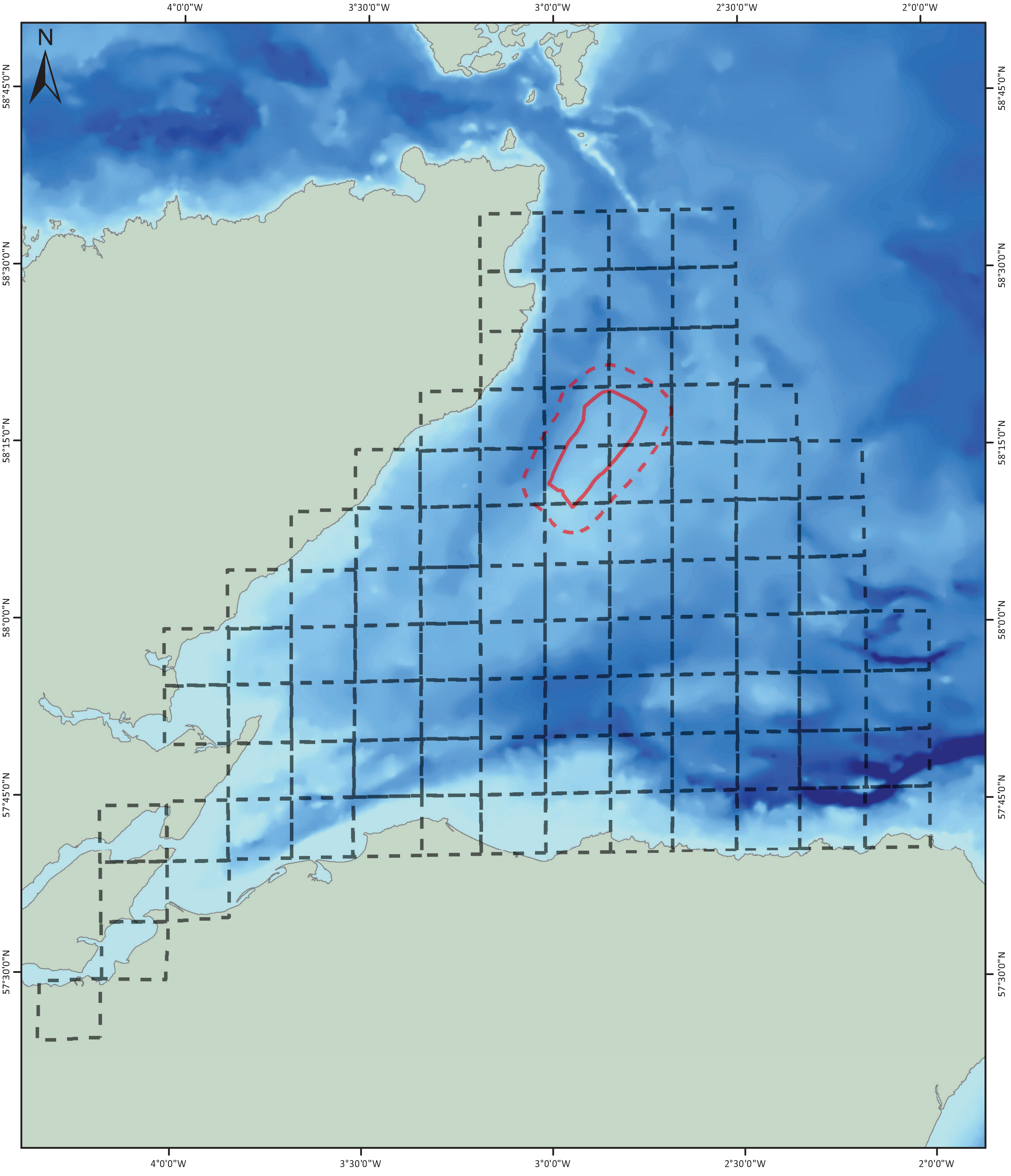
2.38 For a few offshore wind farms there are publicly available studies which provide information on how birds have responded to the construction of a wind farm (e.g. Horns Rev and Nysted, Denmark, Petersen *et al*. 2006; Southern Kalmar Sound, Sweden, Pettersen 2005; Egmond ann Zee, Netherlands, Lindeboom *et al*. 2011). For these wind farms a range of studies have been conducted, looking at changes in bird distributions and migration routes. Where appropriate these studies have been used in the current assessment.

Data Analyses

Boat surveys

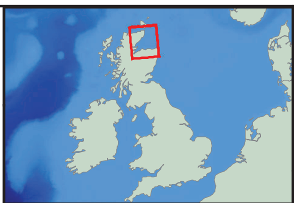
2.39 The boat surveys corresponded to a line transect survey of birds on the water and a strip transect of birds in flight. Analysis of birds on the water was conducted using Distance methods (Buckland *et al*. 2001), thereby accounting for the decline in detectability with increasing distance from the survey vessel. To maximise the robustness of the density and abundance estimates, the shape of the decline in detection probability (the detection function) was estimated for each species using observations pooled across all the surveys, while encounter rate and flock size were estimated for each survey independently. Variance estimates were obtained using the analytical method implemented in Distance. Only data collected along the east – west oriented transects was analysed, although all observations are presented in the distribution figures.

2.40 Observations of flying seabirds collected during snapshots were used to calculate collision risk mortality. Collision risk modelling was conducted using both the current standard method, initially developed in relation to onshore wind farms (Band 2007) and the recently developed offshore modification of this (Band 2011).



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Survey grid boundaries



0 5 10 20 km

0 3 6 12 Nm

Beatrice Offshore Wind Farm

Figure 2.4

RSPB Boat Survey Grid Cell Areas

Drawn: CH	Checked: MT	Approved: MT
Date: 20/02/2012	Scale: 1:810,000	
Drawing Number: sgp6355_Beatrice_surveygrid		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

Aerial surveys

2.41 The aerial surveys were conducted using two different approaches (visual and digital video) which require different analysis methods. Visual surveys generate line transect data, for which Distance analysis (Buckland *et al.* 2001), conducted in a similar manner to that for boats is appropriate. Data derived from digital video corresponds to a strip transect, thus there is no requirement to account for imperfect detection.

2.42 Only observations collected within the 4 km buffer around the Wind Farm Site were analysed.

Migration surveys

2.43 Each of the flight lines recorded during the surveys was given a score indicating the estimated likelihood that the birds were either heading in, or had arrived from, a direction which crossed the Wind Farm Site. Flights were thus assigned to one of three exclusive categories as defined in Table 2.3.

Table 2.3. Migration surveys for the Beatrice Offshore Wind Farm, definition of risk categories for flights in relation to passage across the Wind Farm Site.

Risk score	Risk description	Risk definition
0	Unlikely	Flight estimated as unlikely to have passed, or be going to pass, within 2 km of application site boundary
1	Possible	Flight estimated to have passed, or be going to pass, within 2 km of the Wind Farm Site boundary
2	Probable	Flight estimated to have passed, or be going to pass, through the Wind Farm Site. (NB: this did not include the flights identified as 'Possible')

2.44 The number of individuals of each species observed within the three categories was calculated. This figure was then multiplied by an inflation factor, to account for the proportion of the study period during which no surveys were conducted (including the proportion of activity expected at night) to generate estimates of the total number of each species expected to have passed through the survey area. Survey days were selected on the basis of winds favourable for migration (i.e. tail winds). Therefore, this extrapolation was considered to be precautionary, providing an upper estimate of the possible total.

2.45 Estimated collision mortality for each key species observed were calculated as the product of:

- the extrapolated number of probable and possible flights through the Wind Farm Site,
- the proportion of flights made at rotor height (derived from boat observations),
- the proportion of the risk window (maximum wind farm width presented to the birds on south-east / north-west migration * rotor diameter) swept by rotor blades (area of each rotor * number of turbines),
- the most recent SNH wind farm avoidance rates (SNH 2010),
- the probability of collision and,
- the proportion of time the wind farm would be operational.

2.46 Estimates for each of these parameters are provided in Table 2.4. Estimates of rotor swept area and probability of collision for each species and turbine combination revealed that for all species the worst case scenario was the 3.6 MW turbine (this reflects the greater proportion of rotor swept space, Table 2.4). Therefore only collision mortality results for this turbine option are provided.

Table 2.4. Wildfowl migration collision risk modelling parameter calculations.

Calculation step		Method		
Turbine capacity		3.6 MW	6 MW	7 MW
Number of birds through application site		VP survey data		
Proportion of flights at risk height		Boat survey data		
Proportion of risk window swept by rotor blades (rotor swept area × no. turbines) / (wind farm width × rotor diameter)		1.274	1.068	1.005
Avoidance rates	Pink-footed goose, greylag goose, barnacle goose, unidentified goose	0.99		
	Whooper swan	0.98		
Probability of collision (from Band Model)	Pink-footed goose, unidentified goose	0.061	0.05	0.048
	Greylag goose	0.066	0.055	0.053
	Barnacle goose	0.058	0.048	0.046
	Whooper swan	0.092	0.082	0.079
Proportion of time wind farm operational		0.85		

Beatrice Demonstrator

2.47 Bird observations collected during the monthly vantage point surveys for the Beatrice Demonstrator site between January 2005 and June 2008 were standardised to the number of observations per hour, since survey effort varied between months. For each species, the monthly average and variance in numbers seen per hour were calculated, to generate temporal distributions.

Determination of impacts

Defining species sensitivity

2.48 The sensitivity of each bird species observed in the Wind Farm Site plus buffer was defined according to a range of criteria. These included measures of the importance of both the numbers of birds on the site and/or the conservation status of the species as a whole, and whether the species is protected under certain legislation, or is cited as an interest feature of a designated site of national or international importance. Sensitivity ranges from very high to low according to different criteria (see Table 2.5).

2.49 Red and amber-listed species identified in the Birds of Conservation Concern (Eaton *et al.* 2009) were given Medium Sensitivity in recognition of the fact that Amber-listed species may become red-listed species in future (Table 2.5).

2.50 Eaton *et al.* (2009) place species that have stable populations on the Green or Amber-lists, the choice of which reflects factors such as the number of sites at which any given species is present. JNCC have interpreted that Article 1 of the Birds Directive applies to all species of naturally occurring birds in the wild state in the European territory of the Member States to which the Treaty applies implying that all species will be of some conservation concern apart from vagrants/rarities whose main populations lie outside the UK. For this reason Green-listed species are accorded Low sensitivity.

2.51 The significance of the number of birds of any species estimated to be present in the boat based study area was defined in relation to estimated international, national and regional populations through the use of the 1 % criterion (Eaton *et al.* 2009). For example, the population of the site area would be internationally important if it exceeded 1 % of the European flyway population. Species occurring in internationally important numbers are accorded very high sensitivity, with nationally important populations given high sensitivity and regionally important populations given medium sensitivity (Table 2.5).

2.52 Threshold values for international and national populations were derived from figures provided by BirdLife International (2004), which represents the most up to date synthesis of international and national population data. The 1 % criterion, whilst not necessarily of biological relevance, has been previously used as a standard for designating areas of conservation interest (Skov *et al*. 2007). Appropriate numbers for both breeding and wintering populations were determined for each species, taking into account seasonal patterns of movement.

2.53 Species which typically occur on passage (e.g. shearwaters) may be drawn from breeding populations located considerable distances from the Wind Farm Site, including ones from other countries. This makes determination of appropriate population sizes very difficult. In these cases, passage populations were estimated from knowledge of the species' ecology and movements and consideration of the breeding sites which could contribute to those birds observed on the Wind Farm Site.

Table 2.5: Definition of terms relating to the sensitivity of the ornithological receptors (species) of the Beatrice Offshore Wind Farm Site.	
Sensitivity	**Definition**
High	▪ Species present in internationally important numbers i.e. greater than 1% of European flyway population ▪ Cited interest of SPAs. Cited means mentioned in the citation text for the site as a species for which the site is designated. ▪ Other species which contribute to the integrity of an SPA (i.e. within assemblage criteria).
Medium	• Regionally important population of a species, either because of population size or distributional context. • EU Birds Directive Annex 1, EU Habitats Directive priority habitat / species and / or Wildlife and Countryside Act Schedule 1 species (if not covered above). • UK BAP priority species (if not covered above). • Red and Amber-listed of the Birds of Conservation Concern in the UK. • Species present in nationally important numbers i.e. greater than 1% of the Great Britain population
Low	• Any other species of conservation interest under Article 1 of the Birds Directive (e.g. Green-listed species of the Birds of Conservation Concern).

2.54 Classification of the regional importance of populations observed on site (i.e. if the population exceeded 1 % of the population in the entire Moray Firth area) was straightforward for breeding species such as auks or some gulls where the size of the breeding population is known. However, for non-breeding species present in winter, or on passage, classification was more problematic. For passage species, regional population sizes were estimated as the sum of individuals from all the breeding colonies considered likely to contribute to the potential flux of birds through the region. This was done using knowledge of movements made in Spring and Autumn, to and from breeding colonies (e.g. Tasker *et al*. 2004). A similar process was conducted for species present in the winter, based primarily on species accounts which provide details of seasonal patterns of movement (e.g. Snow and Perrins 1998).

Defining the magnitude of an impact

2.55 The magnitudes of impact used in this assessment ranged from *large* to *negligible* according to the proportion of the ‘population’ or ‘habitat’ lost (see Table 2.6).

2.56 It is important to note that these definitions are not taken literally and serve as generic guidelines that can be adapted to suit the different types of impact. For example, in relation to disturbance and displacement the proportion of the ‘population’ lost is interpreted as that which could be disturbed and subsequently displaced from the site. Similarly for collision, it is not the proportion of the entire population that is killed as a result of the wind farm, but a comparison of mortality resulting from collision with the background level of mortality through natural causes (e.g. predation or disease and anthropogenic effects such as pollution in the case of seabirds) as an impact ‘over and above’ background mortality levels.

Table 2.6: Definition of terms relating to the magnitude of an impact upon the ornithological receptors (species) of the Beatrice Offshore Wind Farm.	
Magnitude	**Definition**
Large	Major effects on the feature / population, which would have a sufficient effect to irreversibly alter the nature of the feature in the short-to-long term and affect its long-term viability (i.e. > 20 % population loss).
Medium	Effects that are detectable in short and long-term, but which should not alter the long-term viability of the feature / population (i.e. 5-20 % population loss).
Small	Minor effects, either of sufficiently small-scale or of short duration to cause no long-term harm to the feature / population, (i.e. 1-5 % population loss).
Negligible	A potential effect that is not expected to affect the feature / population in any way; therefore no effects are predicted (i.e. <1 % population loss).

Defining the significance of an impact

2.57 The significance of any impact upon each species receptor was determined by combining the sensitivity of the species with the magnitude of the impact (see Table 2.7). The significance ratings used in this assessment ranged from *Negligible* to *Major*.

Table 2.7: Significance of an effect resulting from each combination of receptor sensitivity and the magnitude of the impact upon it.

		Magnitude of Impact			
		Negligible	Small	Medium	Large
Sensitivity	Low	*Negligible*	*Negligible*	*Minor*	*Minor*
	Medium	*Negligible*	*Minor*	*Minor*	*Moderate*
	High	*Negligible*	*Minor*	*Moderate*	*Major*

2.58 It should be noted that although the shading in Table 2.7 suggests that each combination of impact magnitude and receptor sensitivity has a single possible outcome (e.g. the combination of a medium magnitude impact and a high sensitivity receptor results in an impact of moderate significance), the interpretation of impact magnitude used in this assessment has included a finer scale of variation. Therefore, in the example given above, if the impact magnitude was considered to lie at the lower end of medium this would give rise to an impact of minor significance. Minor or negligible Impacts were defined as not significant, if the impact magnitude was considered to be of a sufficiently small size that even a small impact was unlikely.

2.59 The four point measures of negligible, minor, moderate and major significance resulting from the different combinations of sensitivity and magnitude are interpreted as defined in Table 2.8. An impact of major significance, whilst considered unacceptable, need not necessarily lead to the development being abandoned or even radically overhauled, if the impact can be demonstrated not to be irreversible or of sufficient duration to be damaging in the longer term, especially where effective mitigation is supplied. Where mitigation is undertaken, it is the nature of the resulting residual impact that needs to be carefully considered. Similarly, impacts of moderate significance may be judged as tolerable even without mitigation if the effects are of limited scope and duration.

Table 2.8 Interpretation of significance categories.

Effect	Definition
Major	The impact on birds gives rise to serious concern and should be considered unacceptable.
Moderate	The impact on birds gives rise to some concern but it is likely to be tolerable (depending upon its scale and duration)
Minor	The impact on birds is undesirable, but of limited concern. Not significant.
Negligible	Not significant.

Indirect impacts

2.60 Indirect impacts may occur through changes in habitat or in abundance and distribution of prey. The likely magnitude of indirect impacts was assessed by considering the factors listed below, particularly in relation to other wind farms. Examples of impacts considered were:

- Construction and operational noise on the known prey species of sensitive receptors;
- Changes in prey distribution on sensitive receptors as interpreted in terms of the species' flexibility in habitat use (Garthe and Hüppop 2004). Scores ranged from one (very flexible in habitat use) to five (reliant on specific habitat features). This scale was used to infer a magnitude of impact in terms of a species' dependence on a specific food supply, should that be affected; and
- Potential change in geomorphological conditions during and after construction that may affect the distribution of prey species and therefore foraging opportunities for sensitive receptors.

2.61 Areas of sea bed habitat within the Wind Farm Site may be changed either temporarily or permanently. Permanent changes would result from both buried or surface laid cables with protection (although to differing spatial extents) and through the installation of turbine foundation structures. Foundation structures offer considerable potential for alternative micro-habitats to develop which would favour localised increases in some invertebrates or fish. These in turn could be exploited by particular bird species. However, the substructures may be coated with anti-fouling agents which would reduce the likelihood of such habitat creation. Changes in seabed habitat in this case are therefore most appropriately considered as an indirect effect, of variable but unknown magnitude. In theory, positive effects upon habitat conditions and/or prey populations could compensate any small losses of habitat resulting from turbine foundations. However, this will be dependent on the final choice of turbine substructures and foundations.

2.62 The potential for cumulative indirect impacts was also considered. This included consideration of the potential for simultaneous construction of the Wind Farm and the adjoining proposed Round Three wind farm.

Impact assessment methods

Displacement effects

2.63 Assessment of the potential extent to which species will be displaced from the Wind Farm Site due to avoidance of turbines, and the consequent impacts on their populations, is very difficult to predict. While comparative studies of offshore wind farms pre- and post-construction have been undertaken (e.g. Horns Rev and Nysted Denmark, Petersen *et al*. 2006; Southern Kalmar Sound Sweden, Pettersen 2005; Egmond ann Zee Netherlands, Lindeboom *et al*. 2011), the wind farms studied have all been located in shallower depths and nearer to shore than the proposed Wind Farm Site. Consequently, a different suite of species, notably comprising wintering populations of seaduck, have been the primary targets for research on displacement effects. In some of these studies evidence for avoidance of the Wind Farm Site by some species has been found, whilst other species have not found any apparent effect.

2.64 The Wind Farm Site lies in considerably deeper water, with a different range of species present. Thus, while previous research can guide displacement predictions, these studies are not directly comparable to the assessment of potential effects on foraging seabirds during the breeding season.

2.65 In order to generate predictions of how the presence of the wind farm may impact on foraging seabirds, a simple mechanistic model was developed. This model uses predictions of radial turbine avoidance distances to estimate the total area within the Wind Farm Site from which seabirds could be displaced. Whilst there are no empirical estimates of avoidance distance from wind turbines for most seabird species, this approach provides a framework within which the topic can be explored. In addition, because this method is based on a simple mechanism, the approach can be used in reverse to estimate avoidance distances from published displacement percentages. The method assumes that displacement of birds from a wind farm occurs due to the presence of the turbines directly, rather than due to indirect impacts on their prey.

2.66 The focus for the displacement assessment was on species which use the Wind Farm Site for foraging during the breeding season as this represents a period during which the size of the populations at potential risk can be estimated and the species in question are expected to be at their least flexible in terms of site use. Outside the breeding season, many fewer birds were seen and those that were are likely to have been drawn from much larger regional or national populations (e.g. representing birds on passage). Therefore the magnitude of any impacts outside the breeding season were assumed to be small in size and spread across large populations.

2.67 The impacts on displaced breeding birds were explored through reductions in their reproductive output using population models. This was based on the conservative assumption that foraging birds displaced from the areas around the turbines cannot be accommodated within equivalent quality neighbouring areas. Instead they are forced to use sub-optimal foraging locations which prevent successful reproduction. Table 2.9 provides examples of avoidance distances and associated displacement percentages for the three turbine options under consideration. In a review of terrestrial bird species' avoidance distances from onshore wind farms (Hotker *et al.* 2006), the median minimal avoidance distances were all less than 300 m, and in many cases were considerably less. This review also found evidence to suggest a positive relationship between turbine size and avoidance distance. However, this aspect was not considered in further detail here with respect to the alternative turbines under consideration since the effect would be counteracted by the increased separation distance between larger turbines.

Table 2.9. Seabird avoidance distances and associated predicted displacement percentages for each wind farm scenario based on turbines with 3.6 MW, 6 MW and 7 MW outputs and their predicted minimum spacing.

Radial avoidance distance	Displacement percentage		
	3.6 MW (min. spacing: 642 m)	**6 MW (min. spacing 900 m)**	**7 MW (min. spacing 900 m)**
50	2	1	1
100	7.6	4	4
200	30.5	15.5	15.5
300	68.6	35	35
400	100	62	62

2.68 It is not anticipated that this method will permit precise predictions of displacement to be estimated for this impact assessment, since avoidance distances are not known for the species involved. However, the likelihood of significant population level impacts can be explored for a range of plausible avoidance distances. The approach also permits the generation of testable predictions of how a relatively easily measured quantity (in this case avoidance distance) can be used to estimate a much less easily measured one (displacement percentage), or vice versa. Furthermore, this method also explicitly provides a means by which observed changes in behaviour over time could lead to changes in the scale of consequent impact. Thus, habituation by birds to the wind farm could result in reductions in avoidance distance and consequently reductions in the area from which the birds are effectively excluded. While habituation to the presence of turbines has not been reported in relation to offshore wind farms, this effect has been reported in relation to onshore wind farms (e.g. Madsen and Boertmann 2008). It is plausible that birds will also habituate to offshore wind farms, although this will be more difficult to assess compared with terrestrial locations. In addition the shorter period over which offshore wind farms have been installed reduces the likelihood of detecting such changes.

2.69 Age or stage based matrix population models were developed for each species considered at risk of displacement, using published demographic rates. Outputs from the simulations were reported as changes in the long term population growth rate. Consequently, the models developed were density independent and deterministic, as these provide an appropriate level of information without the need for additional and (in this case) unnecessary complexity.

2.70 For each species the model was run six times, across the range of breeding bird displacement estimates listed in Table 2.9, plus a baseline simulation for zero displacement. For each run the peak number of individuals estimated to make use of the site, derived from the boat surveys, was multiplied by the range of worst case displacement percentages in Table 2.9 (for the 3.6 MW turbines). The resulting number of individuals were prevented from breeding in each year of a 25 year population simulation. The long term growth rate of the population was then calculated from the projected population sizes. Because the models were developed at the level of the individual this formulation is conservative with respect to breeding, since it assumes that only one bird from any given pair is using the site, and that this is sufficient to cause a failed breeding attempt.

Collision risk modelling

2.71 To quantify the potential risk of additional mortality above the current baseline for each species caused by collisions with operational turbines, collision risk modelling (CRM) was undertaken. Two methods were employed; the first used the method described in the guidance by MacLean *et al.* (2009). In this, the authors recommend that the Band *et al.* (2007) model (directional approach) is used, which has been the standard method for most onshore and offshore wind farms to date. The second used the recently developed revision to this method (Band 2011), developed as part of the Crown Estate's Strategic Ornithological Support Services (SOSS) work output. The main revision is the incorporation of seabird density estimates in the calculations. Further details on the two methods are provided in the following sections.

2.72 A precautionary approach was adopted for the CRM process, therefore the worst case turbine scenario was used to generate collision risk estimates. To identify which of the three turbine options represented the greatest collision risk some preliminary calculations were made (Table 2.10). In terms of potential for collisions, the most important variable is the rotor frontal area (the area of the rotor disc) divided by the rotor diameter (this provides a proxy for the number of potential rotor transits). The scenario which represented the greatest potential risk of collisions was the smallest turbine under consideration (3.6 MW), with a proposed total number installed of 277. Since this turbine option represents the greatest risk, only collision mortality estimated for this turbine option were provided here. If one of the other turbine options (6 MW and 7.6 MW) is subsequently used for the Wind Farm, lower estimated collision mortality rates would be predicted. In all cases birds are assumed to be moving through the site continuously and each species' densities are maintained, irrespective of any collisions that might deplete the population.

Table 2.10. Rotor swept volumes and generic rotor transit values for each turbine option.

Scenario	Power output (MW)	Planned number	Rotor radius (m)	Rotor frontal area (m^2)		Total rotor frontal area / diameter
				Per turbine	Total	
1	**3.6**	277	53.6	9025.7	2500119	23322
2	**6**	166	75	17671.5	2933469	19556
3	**7**	142	82.5	21382.5	3036310	18402

Datasets Used

2.73 Data used to estimate mean densities of birds within the Wind Farm Site were taken from boat-based surveys conducted on the proposed Wind Farm Site between October 2009 and September 2011 inclusive. Typically, CRM outputs are presented as annual estimates, with individual months discussed where appropriate (e.g. periods of peak collisions). To generate monthly estimates the collision mortality was calculated for each survey and the average across replicate months used as the final estimate for that month. In both 2009 and 2010 poor weather in November prevented the boat survey from being undertaken. Collision estimates for November were therefore calculated as the average of the October and December estimates. Collision estimates are presented as annual and breeding season totals using species specific data to determine breeding months (Snow and Perrins 1998).

2.74 All snapshot flights recorded within survey height band B (20 - 150 m) were included in the CRM. This is slightly precautionary as the minimum blade clearance for all of the turbine options under consideration is defined as 25.5 m. However, since the lower blade clearance height was not known at the beginning of the boat survey period (Autumn 2009), a conservative lower height for the potential collision band was defined at the outset and used throughout. The estimated proportion of flights at rotor height therefore includes a proportion of birds which flew between 20 m and 25.5 m (i.e. below actual rotor height), thereby inflating the subsequent collision estimates. The number of additional birds counted in snapshots which flew between 20 m and 25.5 m can only be estimated by making assumptions about the height distribution of bird within the rotor height band. The most precautionary assumption is that birds are evenly distributed throughout the height band. Since the proportion of the 20 – 150 m height band which is not rotor swept beneath the rotor blades is 4.2 % (calculated as 5.5 divided by [150 – 20]), the number of flights used to calculate collision mortality was reduced by this amount. This correction was applied to the estimated total number of birds used in the calculations (i.e. the extrapolated value derives as the number of birds in snapshots multiplied up to the whole Wind Farm Site). This minimised the potential impact of rounding errors which could occur for birds present in small numbers.

2.75 The key difference between the two collision risk models (Band 2007, Band 2011) is how the number of rotor transits is estimated. In the Band (2007) model, the overall flux of birds through the wind farm during a particular period of interest (in this case one month) is calculated. The flux estimates are then used to predict the number of birds that would collide with the turbines within the proposed wind farm in each period. In the Band (2011) model, there is no estimation of bird flux, but rather the density of each species in the snapshots is used in conjunction with the total rotor swept area to generate predicted rates of collision.

2.76 Further details on the two rotor transit methods are provided below.

<u>Stage 1 – Estimation of rotor transits</u>

Band (2007) Model

2.77 Collision risk was considered across an area in relation to the vertical span of the turbine array in front of a bird as it flies towards the wind farm with the intention of continuing on in the same direction. This "Risk Window" can be thought of as a two-dimensional area facing a bird approaching the turbine areas from any given direction. The size of the Risk Window is defined here as the width of the application area multiplied by the diameter of the proposed turbine rotors.

2.78 For each species estimates of the mean number of birds in flight within the wind farm (inside the Wind Farm Site boundary) during a particular month were calculated. From the density the overall flux of that species flying through the wind farm in a particular month was calculated, using published flight speed figures.

Step 1 – Birds Flying Through the Survey Risk Window

2.79 The monthly total number of flying birds recorded during snapshots, and total number of snapshots per month were used to calculate the mean number of birds per snapshot. Unidentified birds (e.g. large gull *sp.*) have been assigned as positively identified species, in the same proportions as the positively identified component species. Proportions were estimated across all surveys to increase robustness.

2.80 Multiplication of the mean number of birds in flight by the proportion seen at potential collision height (PCH) provided an estimate of the mean number at risk height. The proportion observed at PCH was estimated from boat-based survey data over all surveys (i.e. from October 2009 to September 2011), and included birds seen both on the Wind Farm Site and in the buffer, in order to draw from a large sample size. All the species analysed here were considered to have sufficient observations (> 80) for robust estimation of flight height proportions. Nevertheless, the site specific results were also compared against the estimated average proportion of birds at PCH reported in a review of wind farm assessments (Cook *et al*. 2011).

2.81 The expected number of birds flying at PCH within the entire application site boundary at any instant was calculated for each period of interest by extrapolating from the snapshot area to the total application site area.

Step 2 – Passage Rates

2.82 The maximum and minimum flight length across the Wind Farm Site were determined and the median of these two values calculated. The maximum flight length was taken as the longest straight line dimension across the Wind Farm Site, while the minimum flight length was estimated as a bird passing through a single turbine at the extremity of a turbine array, which equates to the rotor diameter. Using the median of these two values was considered to be more precautionary than the guidelines in Maclean *et al.* (2009), which recommend that the maximum flight distance is used. However, the maximum distance does not represent a worst-case scenario, since it results in the fewest number of transits per month required to maintain the mean snapshot number estimated from the surveys. Passage rates were determined by calculating the duration of a flight across the site. Average flight speeds for each species were taken from Alerstam *et al.* (2007), Pennycuick (1987), and Pennycuick (1997).

2.83 The passage rate was then converted to the number of transits per hour, and from this the monthly passage rate was calculated as the hourly rate multiplied by the number of hours during each month which each species is potentially active. Nocturnal activity rates were incorporated using a species specific index of nocturnal activity (Garthe and Hüppop 2004), expressed as a percentage. The total monthly hours of daylight and darkness were calculated from the Wind Farm Site's latitude and day of year using the method of Forsythe *et al.* (1995).

2.84 For each month, transit rates were thus calculated as the hourly transit rate multiplied by the number of daylight hours and the percentage of night time hours each species was expected to be active in that month.

Step 3 – Flight Risk Window

2.85 The Risk Window for birds passing through the wind farm was taken to be the length of the longest diagonal across the Wind Farm Site (19,210 m) multiplied by the diameter of the rotors.

Step 4 – Area Swept by Wind Farm Rotors

2.86 The Rotor Swept Area was calculated as frontal area of one rotor multiplied by the total number of turbines.

Step 5 – Number of Rotor Transits

2.87 The monthly number of birds in the rotor swept area was calculated as the flux of birds at PCH through the wind farm (from step 2) multiplied by the ratio of rotor swept area (step 4) to risk area (step 3).

Band (2011) Model

2.88 For each month, bird density was calculated as the number of individuals seen in snapshots divided by the number of snapshots, multiplied by the ratio of total application site area to total snapshot area. This value was then multiplied by the proportion at rotor height to give bird density at PCH.

2.89 Total potential rotor transits was calculated as the product of bird density at rotor height, total rotor frontal area (number of turbines multiplied by rotor area) and flight speed, all divided by the product of rotor diameter, seconds in an hour, daylight hours and potentially active night-time hours. As with the other method, this was done for each month.

2.90 The remaining steps are common to both modelling approaches.

Stage 2 – Probability of Collision

2.91 Band's (2011) probability of collision (*p*) spreadsheet produced for the Strategic Ornithological Support Services work package 1 was used to estimate the probability that a bird will collide with turbines, assuming no avoidance action.

2.92 The probability of collision is calculated using bird and turbine specific metrics. For birds these include body length, wingspan and flight speed. These were taken from published sources (Snow and Perrins 1998, Alerstam *et al*. 2007, Patterson 2006, Pennycuick 1987). Where a range was available the median value was used (Table 2.11).

Table 2.11 Morphological and behavioural characters used for the collision risk modelling.

Species	Bird length (m)	Wing span (m)	Flight speed (ms^{-1})	Proportion activity at night
Fulmar	0.475	1.07	13	0.75
Gannet	0.935	1.73	14.9	0.25
Arctic skua	0.435	1.18	13.8	0
Great skua	0.585	1.5	14.9	0
Kittiwake	0.39	1.07	13.1	0.5
Great black-backed gull	0.71	1.57	13.7	0.5
Herring gull	0.61	1.44	12.8	0.5
Arctic tern	0.34	0.8	10.9	0
Pink-footed goose	0.675	1.525	18.0	0.25
Greylag goose	0.825	1.635	18.0	0.25
Whooper swan	1.525	2.305	17.3	0.25

2.93 The collision probability increases with turbine rotation speed. According to Siemen's 3.6 MW turbine specifications, the cut-in wind speed is 3 m/s and the cut-out wind speed is 35 m/s, with a maximum rotation speed of 13 rpm. Accounting for variability in wind speed, offshore wind turbines are typically operational for 85 % of the time (this also includes time lost to breakdowns and maintenance; DTI's Capital Grant Scheme for Offshore Wind Annual Reports (BERR, 2007b), showed that both North Hoyle and Kentish Flats OWF were operational for 87 % of the time in 2006-07, with Scroby Sands available for 84 % of the time in 2005 (E.ON UK, 2005). In contrast, Barrow Offshore Wind Farm was only operational for 67 % of the time in 2006/07 (due to some maintenance problems). The monthly collision probability estimates were therefore multiplied by 0.85 to account for the proportion of time when the turbines are predicted to be stationary.

Stage 3 – Predicted Mortality

Step 1 – Predicted Mortality With No Avoidance

2.94 The number of wind farm transits per month (Stage 1) was multiplied by the probability of collision (Stage 2), and corrected for the predicted proportion of time when the turbines will not be rotating. This gives the predicted number of collisions per month, assuming no avoidance actions.

Step 2 – Predicted Mortality With Avoidance

2.95 Birds take avoiding action to avoid collisions with turbines. This can be both 'far-field' or 'macro' through avoidance of the wind farm area, and 'near-field' or 'micro' avoidance through the selection of routes between or above turbines, or last minute evasion of approaching blades.

2.96 Several attempts to estimate avoidance rates empirically have been made (for a review see Cook *et al*. 2011). These have either estimated macro avoidance or micro avoidance. For collision risk modelling these need to be combined (as: 1 – (macro * micro)) to generate overall avoidance rates. However, inconsistencies in the distance over which these terms have been applied makes combination of macro and micro avoidance rates potentially unreliable. Consequently, Cook *et al*. (2011) recommend that a lower avoidance rate of 99 % is appropriate, although the inclusion of 98 % is seen as useful to permit comparisons with previous assessments.

2.97 Maclean *et al.* (2009) recommend the use of avoidance rates between 99 % and 99.9 % for the seabird species under consideration here (Table 2.12). As a precautionary approach the lower avoidance rates used for all species in this analysis was 99 %. This is the lowest value recommended for seabirds by both Maclean *et al.* (2009) and Cook *et al.* (2011).

Table 2.12. Recommended avoidance rates for species groups, from Maclean *et al*. (2009).

Avoidance Rate	Species
99.0%	Terns, divers, cormorant, ducks, geese, grebes, puffin
99.5%	Auks, gulls, gannet
99.9%	Fulmar, shearwaters

2.98 The monthly mortality estimates were combined, to give annual and breeding season mortality figures. These were then assessed in relation to regional, national and international populations, taking into account the months when each species was observed.

2.99 Published information on adult survival rates were compiled in order to predict the potential sensitivity of each species to the estimated collision mortality. The scoring system in Garthe and Hüppop (2004) forms the basis of categorisation (Table 2.13).

Table 2.13. Recommended avoidance rates for species groups, from Maclean *et al*. (2009).

Sensitivity due to population recovery time	Definition based on annual survival rate	Species
Very high	> 0.90	Large gulls, gannet, razorbill, fulmar
High	0.85 - 0.90	Terns, eider, great skua, common guillemot
Medium	0.80 - 0.85	Divers, cormorant, Arctic skua, kittiwake, black-headed gull
Low	0.75 - 0.80	Scoters, little gull, common gull
Very low	< 0.75	Grebes

3 BASELINE CONDITIONS

Seabirds in Shetland, Orkney and Moray Firth

3.1 The Moray Firth's coastal and offshore waters are internationally important for populations of seabird, seaduck, wader and wildfowl. Because of this, a number of areas bordering the Firth have been designated as Special Protection Areas (SPAs) under the EU Birds Directive (Kalejta-Summers 2004). In addition to resident birds, the area is used for breeding, over-wintering or as a temporary feeding ground during the spring and autumn migrations of species breeding in Scandinavia and the Arctic. While a number of studies have reported recent changes in either the relative abundance of some species, or in areas of use, the Moray Firth as a whole has remained an important area for seabirds and waterbirds for the last decade (Kalejta-Summers 2004).

3.2 Numerous sites along the coast of the Moray Firth from Duncansby Head in north east Caithness to Rattray Head in north east Aberdeenshire, support internationally and nationally important breeding populations of kittiwake, guillemot, razorbill, fulmar and cormorant (Table 3.1). The nearest designated site to the Wind Farm Site is the East Caithness Cliffs SPA, which at its closet point lies approximately 10.7 km to the north-west of the Wind Farm Site.

3.3 During the breeding season large numbers of seabirds congregate at breeding sites and in the coastal waters of the Moray Firth. At the end of the breeding season, many of these seabirds, notably the auks, disperse to foraging areas farther offshore. Seaducks, including eider, goldeneye, long tailed duck, common scoter and velvet scoter over winter in the Inner Moray Firth in large flocks, and combined populations in excess of 20,000 birds have been reported (Lloyd *et al.* 1991). Red-throated divers, great crested grebes, long-tailed duck and significant numbers of unidentified scoter species are present in large numbers during winter (Dean *et al.* 2003)

The Smith Bank

3.4 The Wind Farm Site lies at the northern edge of the Smith Bank, an area with predominantly sandy substrates at relatively shallow depths. A survey of the seabed was carried out for the Beatrice Demonstrator Project in October 2005 to confirm the nature of the benthic environment (Demonstrator ES). A more recent survey has further confirmed the range of substrates present in the area (Brown and May 2011). Survey data suggests that much of the substrate present within the Wind Farm Site is suitable for sandeels, which are a common prey item for many seabirds (e.g. auks, fulmar and kittiwake).

Designated sites

3.5 There are no current or proposed designated sites within the boundary of the Wind Farm Site.

3.6 The coast between Peterhead in Aberdeenshire and Duncansby Head in Caithness contains eight SPAs, five of which are also designated as Ramsar sites (Table 3.1). A further five SPAs in Orkney have been considered, in acknowledgement of the wide range over which some seabird species forage (Table 3.2), and another six UK SPAs designated for gannets are listed, in recognition of the particularly long foraging distances this species undertakes (Table 3.3). Sites were included on the basis of the mean maximum foraging range (www.seabird.wikispaces.com) of their qualifying species, or if they included wintering species which could migrate through the Wind Farm Site. It is expected that for some of the species listed, significant impacts will be identified, leading to a requirement for a Habitats Regulations Assessment. Tables 3.1, 3.2 and 3.3 below provide population estimates for each of the SPA qualifying species, and also the shortest distances from the Wind Farm Site. These SPAs often comprise component SSSI and Ramsar sites which are coincidental in extent, and so these other sites do not require additional examination. A map of the Moray Firth and Orkney SPAs is provided in Figure 3.0.

Table 3.1. Special Protection Areas (SPAs) in the vicinity of the Beatrice Offshore Wind Farm Site, and their qualifying interests.

Site name (distance to the Beatrice Offshore Wind Farm)	Species listed on SPA citation	
	Species (season)	Population (year)
East Caithness Cliffs SPA (11 km)	Fulmar (breeding)	15,000 prs. (1985-1988)
	Great cormorant (breeding)	230 prs. (1985-1988)
	European shag (breeding)	2,300 prs. (1985-1988)
	Peregrine falcon (breeding)	6 prs. (1985-1988)
	Herring gull (breeding)	9,400 prs. (1985-1988)
	Great black-backed gull (breeding)	800 prs. (1985-1988)
	Kittiwake (breeding)	32,500 prs. (1985-1988)
	Common guillemot (breeding)	106,700 ind. (1985-1988)
	Razorbill (breeding)	15,800 ind. (1985-1988)
	Atlantic puffin (breeding)	1,750 prs. (1985-1988)
North Caithness Cliffs SPA (29 km)	Fulmar (breeding)	14,700 prs. (1985-1988)
	Peregrine falcon (breeding)	6 prs. (mid-1990s)
	Kittiwake (breeding)	13,100 prs. (1985-1988)
	Common guillemot (breeding)	38,300 ind. (1985-1988)
	Razorbill (breeding)	4,000 ind. (1985-1988)
	Atlantic puffin (breeding)	1,750 prs. (1985-1988)
Moray and Nairn Coast SPA, Ramsar (55 km)	Pink-footed goose (wintering)	139 ind. (1992-1996)
	Greylag goose (wintering)	2,679 ind. (1992-1996)
	Osprey (breeding)	7 prs (early 1990s)
	Redshank (wintering)	862 ind. (1992-1996)
Dornoch Firth and Loch Fleet SPA, Ramsar (58 km)	Greylag goose (wintering)	2,079 ind. (1992-1996)
	Wigeon (wintering)	15,022 ind. (1992-1996)
	Osprey (breeding)	20 ind.. (early 1990s)
	Bar-tailed godwit (wintering)	1,300 ind. (1992-1996)
Troup, Pennan and Lion 's Heads SPA (62 km)	Fulmar (breeding)	4,400 prs. (1995)
	Herring gull (breeding)	4,200 prs. (1995)
	Kittiwake (breeding)	31,600 prs. (1995)
	Common guillemot (breeding)	44,600 ind (1995)
	Razorbill (breeding)	4,800 ind. (1995)
Inner Moray Firth	Greylag goose (wintering)	2,651 ind. (1993-1997)

Table 3.1. Special Protection Areas (SPAs) in the vicinity of the Beatrice Offshore Wind Farm Site, and their qualifying interests.

Site name (distance to the Beatrice Offshore Wind Farm)	Species listed on SPA citation	
	Species (season)	Population (year)
	Red-breasted merganser (wintering)	1,184 ind. (1993-1997)
	Osprey (breeding)	2 ind. (early 1990s)
	Bar-tailed godwit (wintering)	1,090 ind. (1993-1997)
	Redshank (wintering)	1,621 ind. (1993-1997)
	Common tern (breeding)	310 prs. (1985-1988)
Loch of Strathbeg SPA, Ramsar (86 km)	Whooper swan (wintering)	183 ind. (1992-1996)
	Pink-footed goose (wintering)	39,924 ind. (1992-1996)
	Greylag goose (wintering)	3,325 ind. (1992-1996)
	Teal (wintering)	1,898 ind. (1992-1996)
	Goldeneye (wintering)	109 ind. (1992-1996)
	Sandwich tern (breeding)	530 prs. (1993-1997)
Cromarty Firth SPA, Ramsar (87 km)	Whooper swan (wintering)	64 ind. (1993-1997)
	Greylag goose (wintering)	1,782 ind. (1993-1997)
	Osprey (breeding)	2 prs. (early 1990s)
	Bar-tailed godwit (wintering)	1,355 ind. (1993-1997)
	Common tern (breeding)	294 prs. (1989-1993)

Source: http://jncc.defra.gov.uk/page-1409

Table 3.2 Special Protection Areas (SPAs) in Orkney and their qualifying interests (listed under Annex I and Annex II).

Site name (distance to the Beatrice Offshore Wind Farm)	Species listed on SPA citation	
	Species (season)	Population (year)
Hoy (57 km)	Red-throated diver (breeding)	58 breeding territories (1994).
	Fulmar (breeding)	35,000 prs. (1985-1988).
	Peregrine (breeding)	6 prs. (mid-1990s).
	Arctic skua (breeding)	59 prs. (1996).
	Great skua (breeding)	1,900 prs. (1996)
	Great black-backed gull (breeding)	570 prs. (1985-1988).
	Kittiwake (breeding)	3,000 prs. (1985-1988).
	Guillemot (breeding)	13,400 prs. (1985-1988).
	Puffin (breeding)	3,500 prs. (1985-1988).
Copinsay (63 km)	Fulmar (breeding)	1,615 prs. (1985-1988).
	Great black-backed gull (breeding)	490 prs. (1985-1988).
	Kittiwake (breeding)	9,550 prs. (1985-1988).
	Guillemot (breeding)	29,450 ind. (1985-1988).
Rousay (94 km)	Fulmar (breeding)	1,240 prs. (1986 + 1997).
	Arctic skua (breeding)	130 prs. (1992).
	Kittiwake (breeding)	4,900 prs. (1986 + 1997).
	Arctic tern (breeding)	790 prs. (1991-1995).
	Guillemot (breeding)	10,600 ind.(1986 + 1997).
Calf of Eday (97 km)	Fulmar (breeding)	1,955 prs. (1985-1988).
	Cormorant: (breeding)	223 prs. (1985-1988).
	Great black-backed gull (breeding)	938 prs. (1985-1988)
	Kittiwake (breeding)	1,717 prs. (1985-1988).
	Guillemot: (breeding)	12,645 ind. (1985-1988).
.	Fulmar (breeding)	1,400 prs. (1985-1988).
	Arctic skua (breeding)	78 prs. (1985-1988).
	Kittiwake (breeding)	23,900 prs. (1985-1988).
	Arctic tern (breeding)	1,140 prs. (1985-1988).
	Guillemot (breeding)	42,150 ind. (1985-1988).
	Razorbill (breeding)	1,946 ind. (1985-1988).

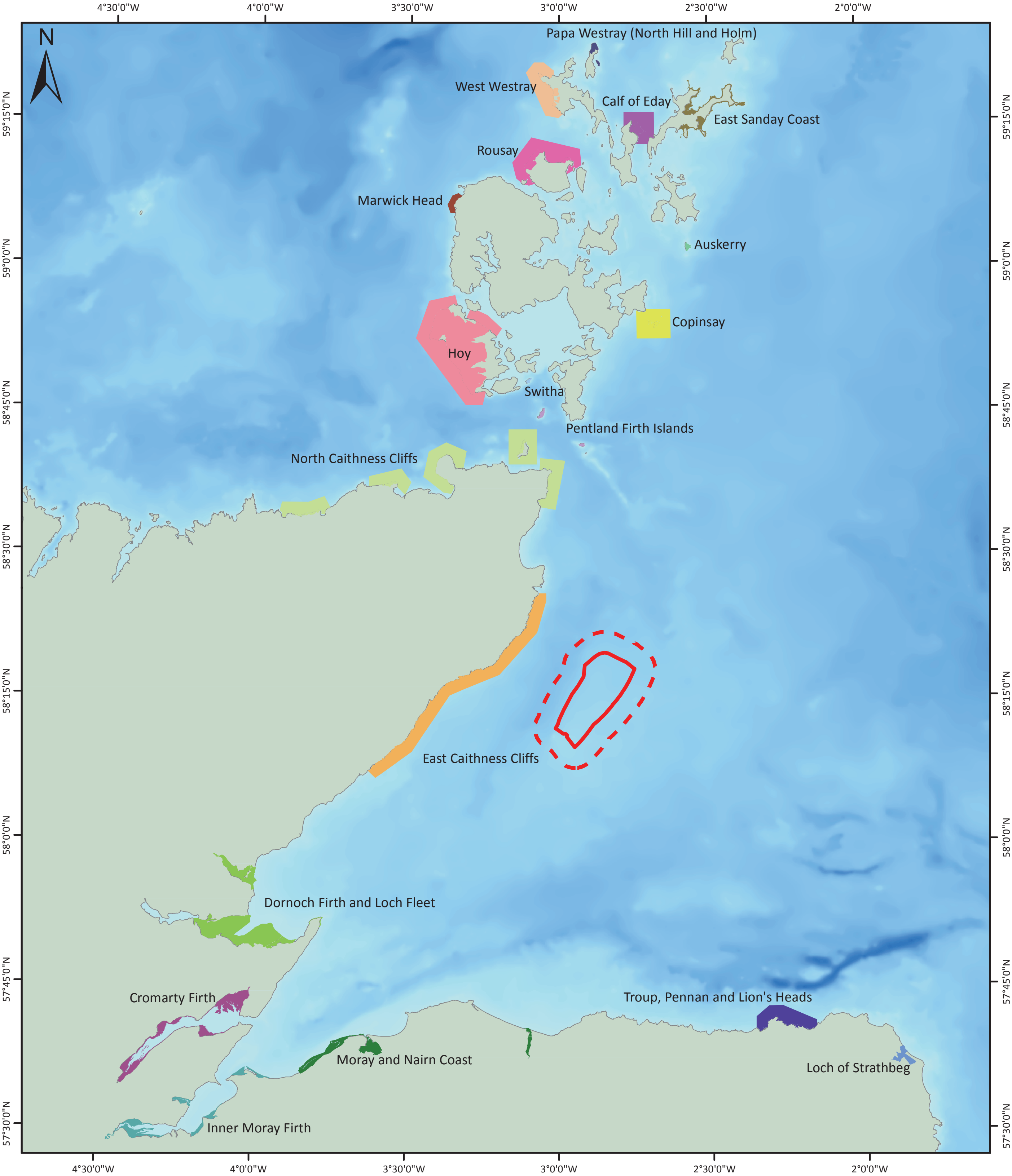
Source: http://jncc.defra.gov.uk/page-1409

Table 3.3. **UK SPAs designated for breeding fulmar and gannet within the mean maximum foraging range of these species (311 km and 308 km respectively).**

Site Name (distance to Beatrice Offshore Wind Farm)	**Number of prs.gannet (year)[1]**	**Number of prs.fulmar (year)[2]**
Fair Isle (150 km)	1,875 (2004)	35,210 (1985-1988).
Forth Islands (255 km)	48,065 (2004)	798 (1994)
Hermaness, Saxa Vord and Valla Field (296 km)	15,633 (2003)	19,539 (1999)
North Rona & Sula Sgeir (206 km)	9,225 (2004)	11,500 (1985-1986)
Noss (220 km)	8,652 (2003)	6,350 1987-1992)(
Sule Skerry & Sule Stack (130 km)	4,675 (2004)	NA

1wanless, S., Murra y, S. & Har ris, M.P. (2005) t he status of nor thern gannet in Britain and Irela nd in 2003/4, British Birds, 98, 208-294.

2 Source: http://jncc.defra.gov.uk/page-1409



Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

0 5 10 20 km

0 3.5 7 14 Nm

Beatrice Offshore Wind Farm

Figure 3.0

Special Protection Areas in the vicinity of Beatrice Offshore Wind Farm

Drawn: CH	Checked: MT	Approved: MT
Date: 02/09/2011	Scale: 1:1,000,000	
Drawing Number: SGP6355_Beatrice_3_0_spaLocations		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
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Overview of avifauna survey results

3.7 The survey protocol for the Beatrice Offshore Wind Farm was designed in line with the standard methods adopted for offshore boat surveying. These follow the accepted European Seabirds at Sea (ESAS) methods, as detailed in the relevant COWRIE (Collaborative Offshore Wind Research into the Environment) guidance (Camphuysen *et al.* 2004, Maclean *et al.* 2009).

3.8 The area surveyed, including a buffer width of 4 km, was approximately 383 km^2 (Figure 2.1)

3.9 A total of 21,419 individuals were recorded, either within the transect area on the sea (18,360, 18 species, 4 species groups) or in snapshots (3,059, 20 species, 3 species groups) across the entire boat based study area during the 22 boat surveys (Table 3.4). Density and abundance estimates are only presented for those species with sufficient observations to permit robust estimation (Buckland *et al.* 2001).

3.10 Among the 22 species listed in Table 3.4, there are a number which form part of the SPA citations in Tables 3.1, 3.2 and 3.3, either qualifying under (i) Article 4.1 of the Directive (2009/147/EC) by supporting populations of European importance listed on Annex I of the Directive, (ii) Article 4.2 of the Directive (2009/147/EC) by supporting populations of European importance of migratory species; or (iii) forming part of a seabird assemblage of international importance.

Table 3.4 Total number of birds recorded during boat surveys of the Beatrice Offshore Wind Farm boat based study area between October 2009 and September 2011, densities and abundances estimated using Distance analysis of birds observed in transects. Species for which there is no density or abundance estimates were seen too infrequently to permit reliable density estimation

Species	Numbers observed during boat surveys					Peak density from transects (boat based study area, birds / km^2 (CV))	Peak abundance from transects (boat based study area)
	In transect		In snapshot		Total		
	Wind Farm site	4 km buffer	Wind Farm site	4 km buffer			
Fulmar	398	1284	242	535	2459	7.82 (0.14)	2955.2
Manx shearwater*	-	2	-	7	9	-	-
Sooty shearwater	-	112	1	5	118	0.53 (0.99)	200.1
European storm petrel*	1	3	1	4	9	-	-
Gannet	84	307	32	105	528	1.63 (0.32)	614.4
Cormorant*	-	-	1	1	2	-	-
Shag	19	20	1	1	41	0.23 (0.51)	86.6
Arctic skua	5	7	4	3	19	0.23 (1.2)	88.6

Table 3.4 Total number of birds recorded during boat surveys of the Beatrice Offshore Wind Farm boat based study area between October 2009 and September 2011, densities and abundances estimated using Distance analysis of birds observed in transects . Species for which there is no density or abundance estimates were seen too infrequently to permit reliable density estimation

Species	Numbers observed during boat surveys					Peak density from transects (boat based study area, birds / km^2 (CV))	Peak abundance from transects (boat based study area)
	In transect		In snapshot		Total		
	Wind Farm site	4 km buffer	Wind Farm site	4 km buffer			
Great skua	23	50	9	9	91	0.43 0.35)	163.7
Kittiwake	1077	1185	55	202	2519	5.88 (0.43)	2222.6
Lesser black-backed gull*	-	5	2	1	8	-	-
Herring gull	61	163	77	114	415	1.55 (0.31)	586.1
Great black-backed gull	175	211	36	80	502	1.45 (0.29)	546.9
Unidentified large gull*	1	5	6	8	20	-	-
Common tern*	-	-	-	1	1	-	-
Arctic tern	-	18	5	6	29	0.46 (0.86)	174.2
Guillemot	3939	4569	267	364	9139	52.83 (0.09)	19960.6
Razorbill	470	1096	38	117	1721	8.62 (0.20)	3258.3
Black guillemot*	-	-	-	2	2	-	-
Unidentified auk	379	955	99	422	1855	4.10 (0.29)	1550.2
Puffin	459	914	5	11	1389	11.1 (0.13)	4192.5
Little auk*	2	7	-	-	9	-	-
Unidentified passerine*	-	-	-	1	1	-	-
Grey phalarope*	-	-	-	1	1	-	-
Whooper swan*	-	2	-	-	2	-	-

Species marked with * did not meet the minimum required level of observations to permit density estimation using Distance analysis, hence only raw counts are shown. All other density estimates were obtained using Distance analysis.

Non-seabird species

3.11 Birds recorded within the boat based study area, but not within the transect or in snapshots (i.e. incidental observations) are summarised in Table 3.5 (19 species and 3 species groups). The only species or group recorded in any numbers was pink-footed goose. Surveys conducted during daylight hours may have missed nocturnal movements of waders, wildfowl and passerines during migratory periods. However, the very small numbers of potential migrants (pink-footed goose excepted) are likely to reflect that these species usually migrate over the sea at high altitudes, particularly at night, and although for this reason may not be recorded during surveys in peak numbers, they will be at little risk of collision or barrier effects from the wind farm. A two year project to investigate the collision risk of migrating birds in the Danish offshore wind farms, Horns Rev and Nysted using data obtained from a combination of radar, visual and acoustic observations showed that during periods of mass migration, birds tended to be recorded at higher altitudes (Blew *et al*. 2008). Krijgsveld *et al*. (2005) found that during baseline studies of Dutch offshore wind farms, at night, flight altitudes were much higher, at altitudes of 150 m and more. Flight activities at night were mostly of migrating waders and larger passerines.

3.12 Wildfowl migration was the subject of a specific study, however no other potential migratory species (eg waders or passerines) were considered for impact assessment since the combination of low observed numbers and flight height observations clearly indicate these species are at little or no risk of impact.

Table 3.5 Total number of incidental birds recorded during boat surveys (i.e. not in transects or snapshots) of the Beatrice Offshore Wind Farm boat based study area between October 2009 and September 2011.

Species	**Incidental records of birds observed during boat surveys**	
	Application site	**4 km buffer**
Little tern		1
Black-headed gull		4
Black guillemot	1	3
Lesser black-backed gull	1	14
Common gull	1	8
Great northern diver		1
Red-throated diver	1	4
Unidentified diver	2	
Pink-footed goose	292	880
Eider		1

Table 3.5 Total number of incidental birds recorded during boat surveys (i.e. not in transects or snapshots) of the Beatrice Offshore Wind Farm boat based study area between October 2009 and September 2011.

Species	Incidental records of birds observed during boat surveys	
	Application site	4 km buffer
Wigeon		2
Curlew	1	1
Dunlin	2	5
Golden plover	8	
Unidentified wader	2	
Grey heron		1
Carrion crow	1	2
Goldcrest		1
Meadow pipit	2	1
Starling		1
Swallow	2	4
Unidentified passerine	2	7

Sensitivity of the avifauna

3.13 Species sensitivity was evaluated by examining the conservation status of the European and national population levels, combined with regional and local population size, and density and peak population estimates on the survey site. At this stage, ecology and behaviour which might affect avifauna response to wind farm construction were not evaluated.

3.14 Peak populations which exceed 1 % of the national threshold are classified as nationally important populations; peak populations which exceed 1 % of the regional population threshold are classified as regionally significant (Table 3.6)

Details of sensitive receptors

3.15 Target species were chosen from the list of potential species listed within local SPAs by evaluating boat survey data and determining species occurrence in the boat based study area. Individuals were assumed to originate from colonies in the region (including both SPA colonies and non-SPA colonies) defined as the seabird colonies in Orkney and bordering the Moray Firth.

Table 3.6 Number of birds recorded in Beatrice Offshore Wind Farm survey area compared to regional and national abundance thresholds.

Species	Estimated Peak Population (Boat survey)	GB1% Threshold (pairs)	Nationally Important Population?	Regional Population (Seabird 2000)	Regionally Important Population?
Fulmar	2955.2	5,390	No	256,590	Yes
Sooty shearwater	200.1	Passage sp.	n/a	n/a	Unknown
Shag	86.6	375	No	7,934	Yes
Gannet	614.4	4,371	No	12,444	Yes
Arctic Skua	88.6	32	Yes	1,582	Yes
Great skua	163.7	85	Yes	4,428	Yes
Kittiwake	2222.6	4,900	No	278,074	No
Great black-backed Gull	546.9	190	Yes	11,978	Yes
Herring gull	586.1	1,600	No	29,484	Yes
Arctic Tern	174.2	440	No	29,776	No
Guillemot	19960.6	7,035	Yes	483,194	Yes
Razorbill	3258.3	991	Yes	38,347	Yes
Puffin	4192.5	4,490	No	126,202	Yes

Species accounts

Explanation of species accounts

3.16 A list of species of principal concern was created by using Table 3.4 to determine all species of high conservation value found in the boat based study area. Table 3.6 was then used to find additional species which occur in regionally or nationally important numbers. For each of the species on this list population estimates are presented from the various surveys, together with distribution and behavioural observations from the survey area and wider region. The importance of the Wind Farm Site to each species through the year is discussed in relation to the wider region, which is defined here as the Orkney Isles and the seabird colonies adjacent to the Moray Firth. This sea area is defined as Region 3 by Stone *et al.* (1995), based on distinctive regional geographic, physical, and hydrogeologic differences from the surrounding area.

3.17 For each species, information is presented on:

- Relevant conservation designations;
- Breeding and wintering populations at international to regional level, with an emphasis on the nearest breeding colonies where appropriate;
- Graphical representations of the seasonal patterns of abundance for the whole survey area; and
- The maximum proportion of international, national, and percentage of regional populations achieved.

3.18 The peak population estimate refers to the estimated maximum abundance (derived from the boat surveys) occurring within the total boat based study area during the survey period.

Seabirds

<u>Fulmar</u>

3.19 Fulmars are one of the most common seabirds all year round in northern Britain. Adults show no pronounced pattern of migration, but rather disperse from the colonies at the end of the breeding season and return to nest the following year (Mitchell *et al.* 2004). The highest numbers of fulmar in the north and west of Scotland, including Shetland, occurs between March and April and continues into July with high numbers of birds around nest sites in at this time in these areas. Between August and November the distribution of fulmars extends southwards as birds disperse from their breeding colonies. Densities remain highest however, around Shetland and Orkney. In the months between December and February, the highest densities of fulmar remain in the vicinity of Shetland, Orkney and the Moray Firth (Stone *et al.* 1995).

3.20 Mitchell *et al.* (2004) recorded a total of 20,974 Apparently Occupied Sites (AOS) in East Caithness, Moray, and East Coast Sutherland during the Seabird 2000 survey programme, compared to a total of 485,852 AOS in the whole of Scotland (of which 279,390 were in Shetland and Orkney).

3.21 The European population of fulmar is between 2.8 and 4.4 million pairs, and is considered stable (BirdLife International 2004). Great Britain supports over 500,000 pairs, or between 11 % and 18 % of the European total population, most of which breed in Scotland. Although the overall population is stable and appears to be undergoing continued range expansion, fulmar are recognised as a species of conservation concern in Britain as over 50 % of the breeding population occurs within ten breeding sites (BirdLife International 2009). Mitchell *et al.* (2004) record slight variations in population throughout Caithness, Sutherland and Banff and Buchan, but no increase or decrease greater than 2 % of the regional total.

3.22 The most recent census estimates recorded 14,202 breeding pairs within the East Caithness Cliffs SPA (SNH 2008a), with another 14,621 pairs in the North Caithness Cliffs SPA (SNH 2008b).

3.23 The peak density of birds observed at the proposed Wind Farm Site was 7.82 per km^2. Boat surveys have recorded fulmar activity on the site year round (Figure 3.1.1), with generally high numbers occurring between May and August in 2010, coinciding with the period when adults are attending nests, and the lowest numbers occurring between November and January (Figure 3.1.2). A slightly different pattern was seen in 2011, with numbers remaining low during May to July but climbing during August and peaking in September.

3.24 The observed seasonal abundance from the boat surveys is closely matched by that obtained from the Beatrice Demonstrator observations (Figure 3.1.4).

3.25 The RSPB survey observations of the entire Moray Firth further reveal the widespread, year round distribution of fulmar (Figure 3.1.3), with even densities observed across most of the surveyed area throughout the year. The aerial surveys (Figures 3.1.5 and 3.1.6) also reveal even distributions across the areas surveyed. Individuals tracked during foraging trips during the 2011 breeding season travelled considerable distances (Figure 3.1.7, Figure A4.1), with several trips recorded out beyond the Moray Firth.

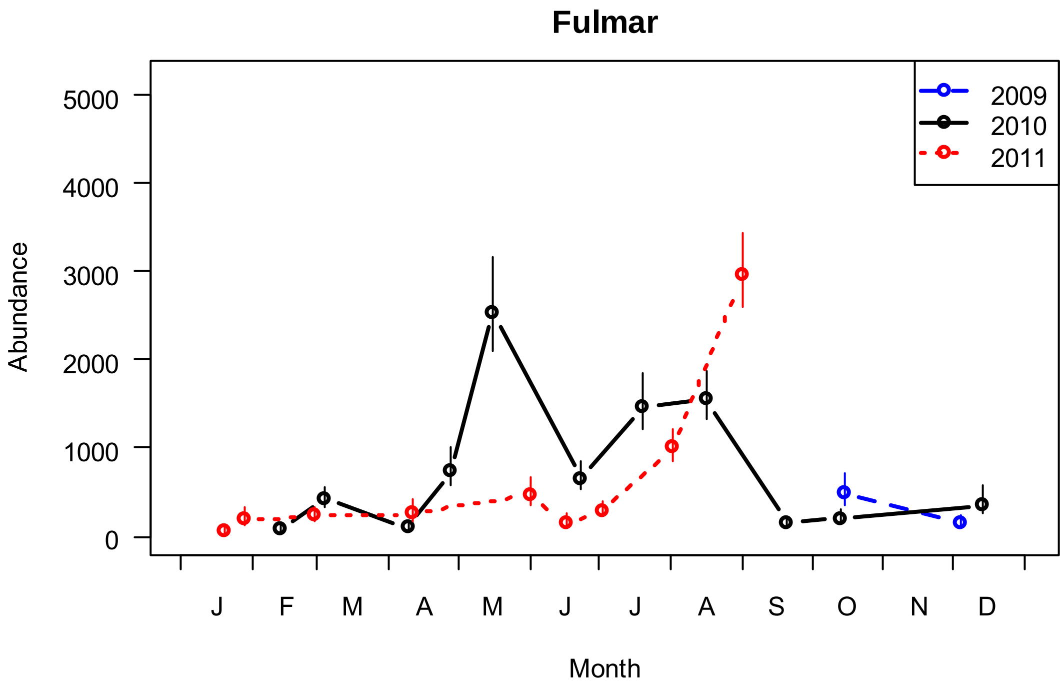


Figure 3.1.2 Northern fulmar seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).

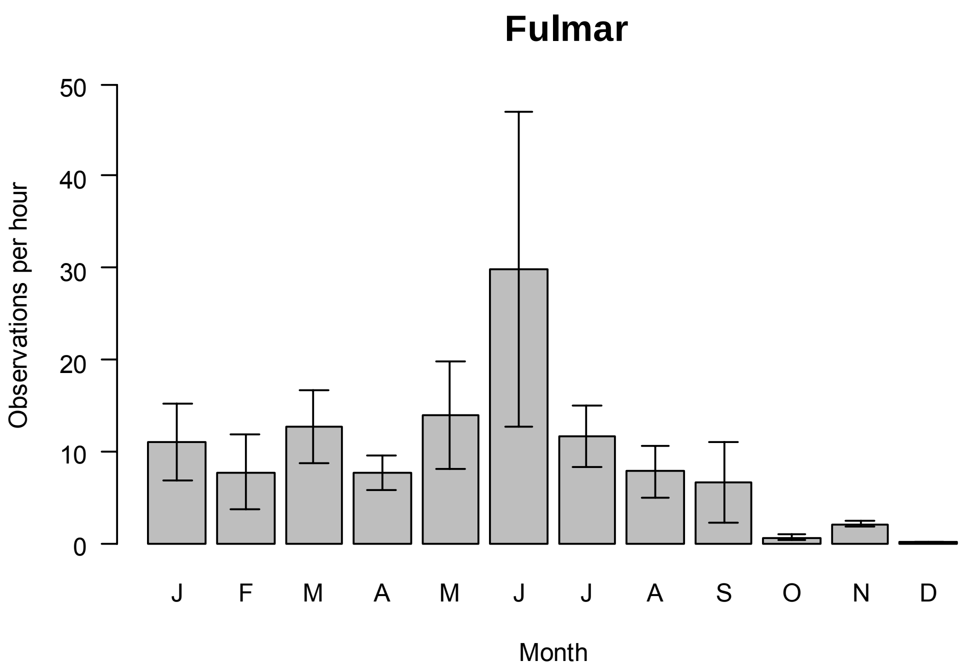
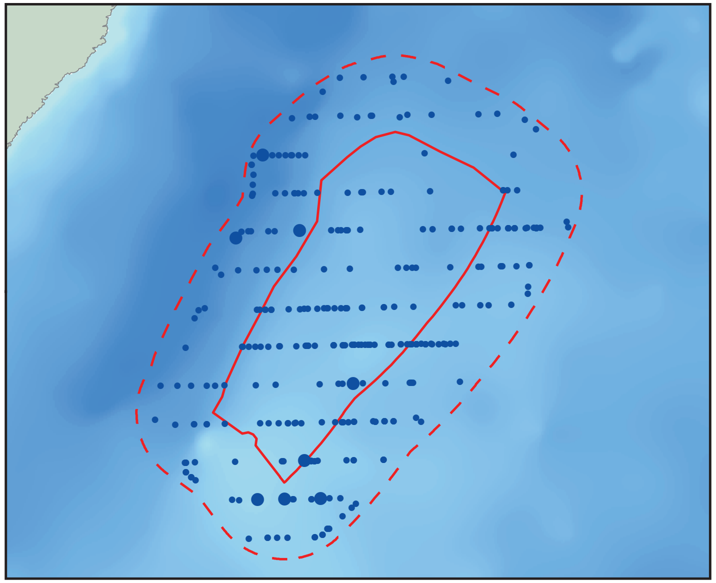
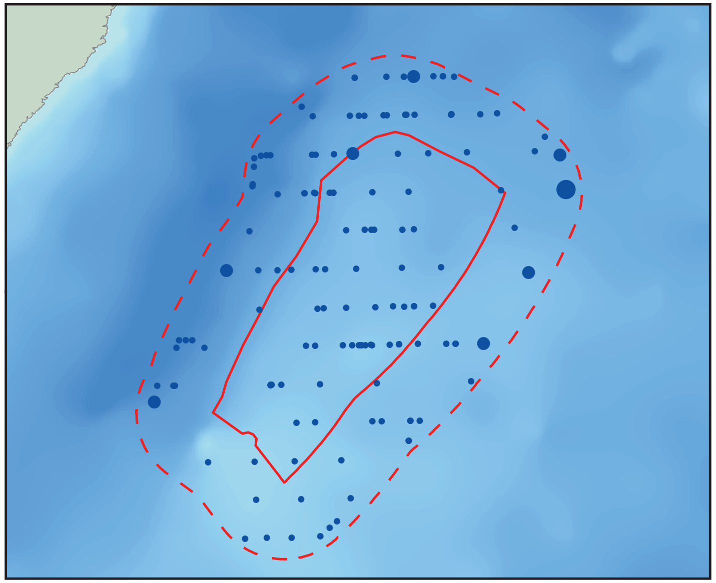


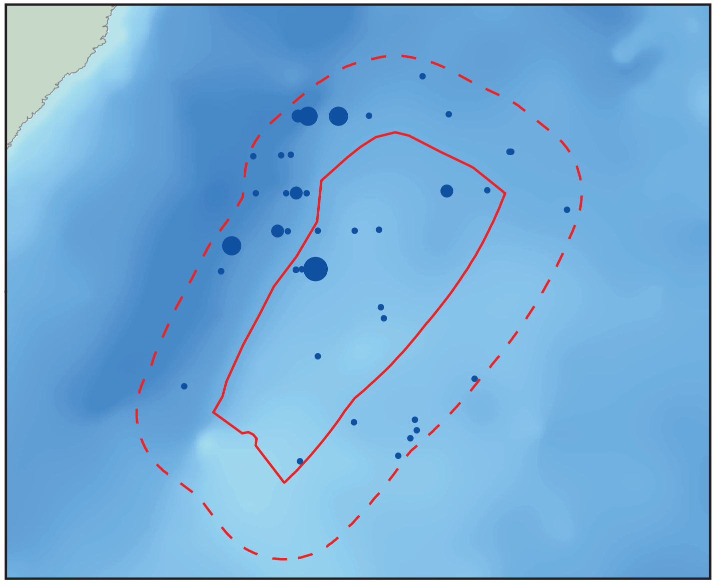
Figure 3.1.4 Average seasonal distribution (± 1 standard error) of Northern Fulmar recorded from the Beatrice Alpha Oil Platform between 2005 – 2008 for the Beatrice Demonstrator Project.



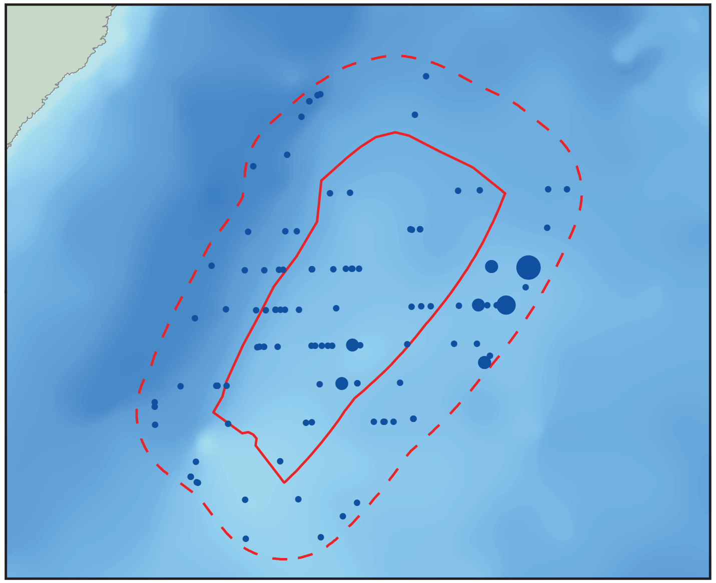
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km 0 1 2 3 4 5 Nm

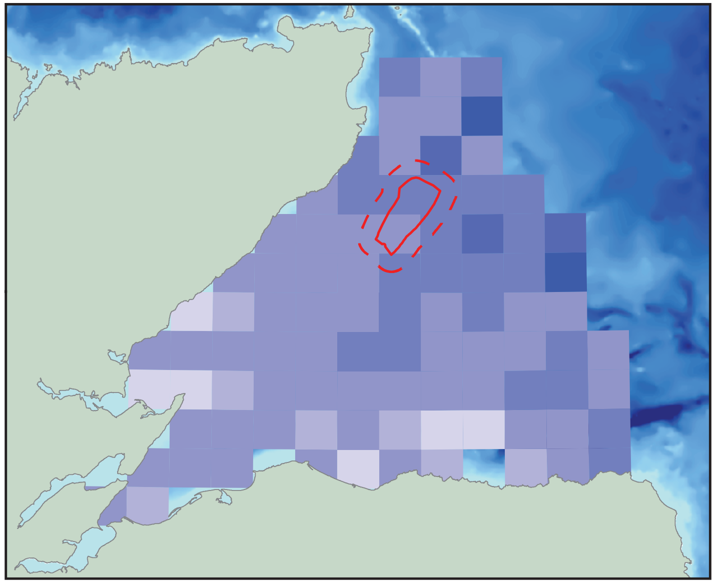
Beatrice Offshore Wind Farm

Figure 3.1.1

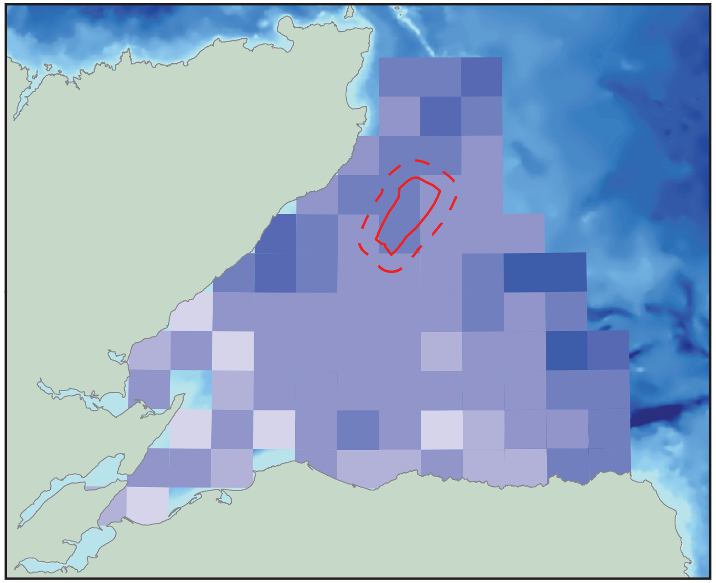
Boat based observations of Fulmar between October 2009 and July 2011

Drawn:	CH	**Checked:**	MT	**Approved:**	MT
Date:	02/09/2011	**Scale:**	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2	**Revision:**	03		
Datum:	WGS84	**Projection:**	UTM Zone 30 N		

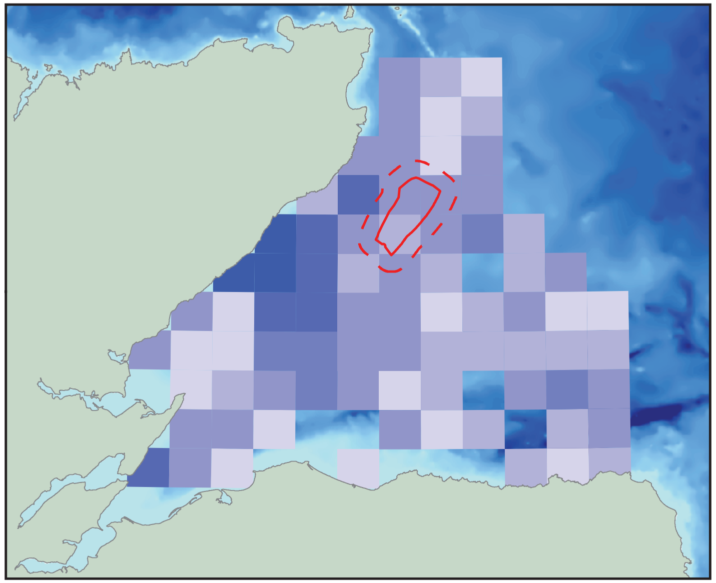
Beatrice Offshore Windfarm Ltd



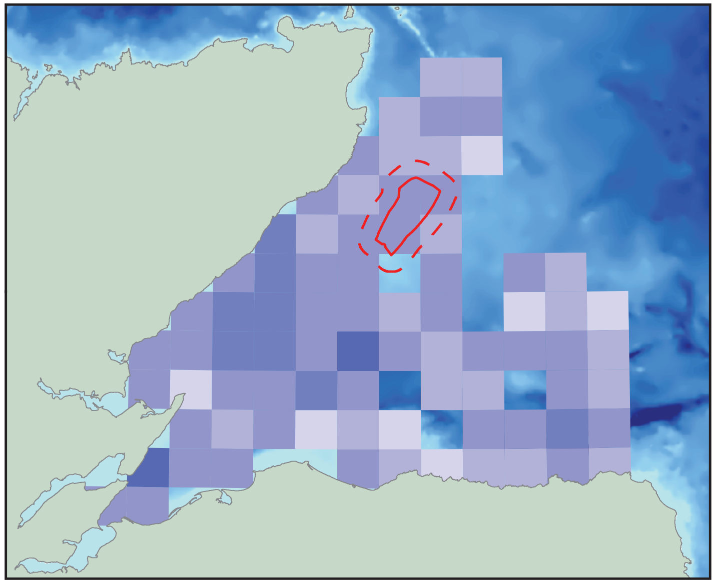
May to July



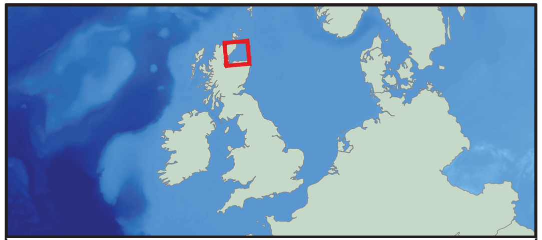
August to October



November to January



February to April



Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km

0 5 10 20 Nm

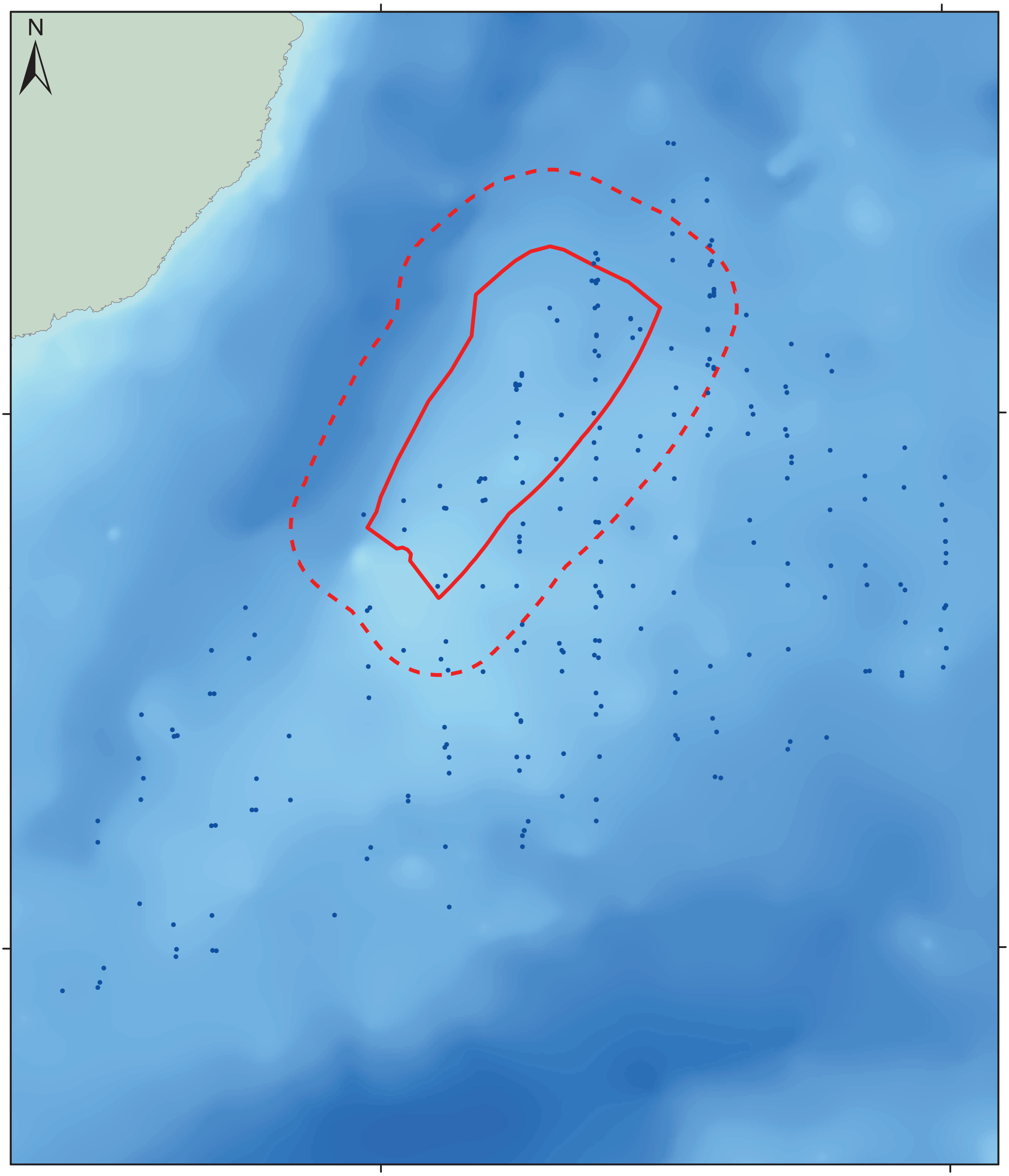
Beatrice Offshore Wind Farm

Figure 3.1.3

Mean density of Fulmar derived from boat-based observations between January 1982 and December 1983

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice
Offshore Windfarm Ltd



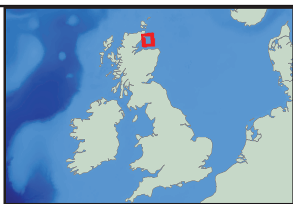
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

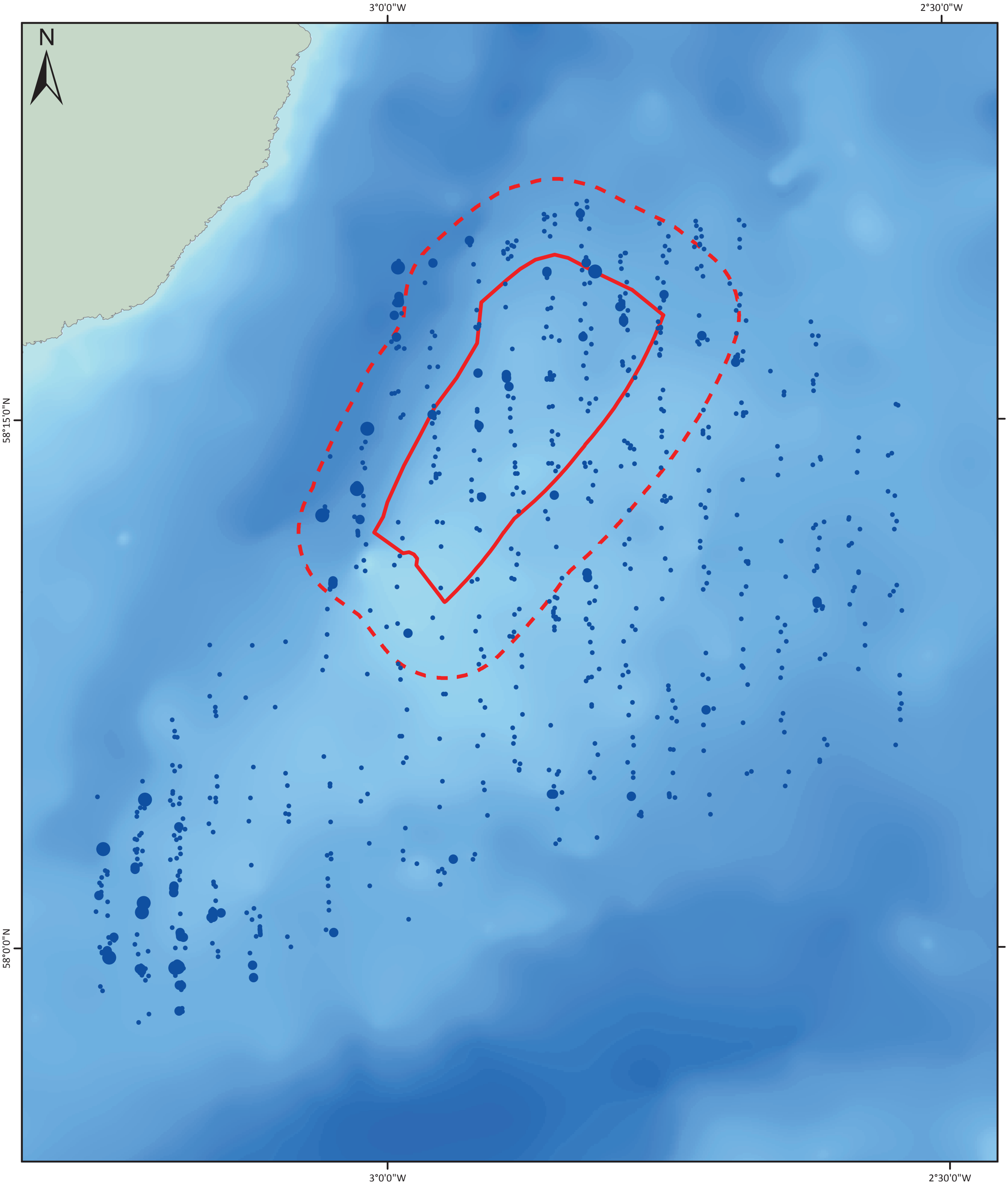
Beatrice Offshore Wind Farm

Figure 3.1.5

Aerial survey observations of Fulmar between May and August 2009

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_5_aerial_hidefBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



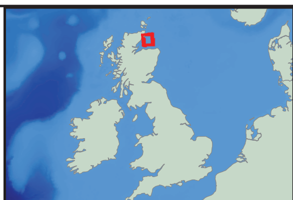
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

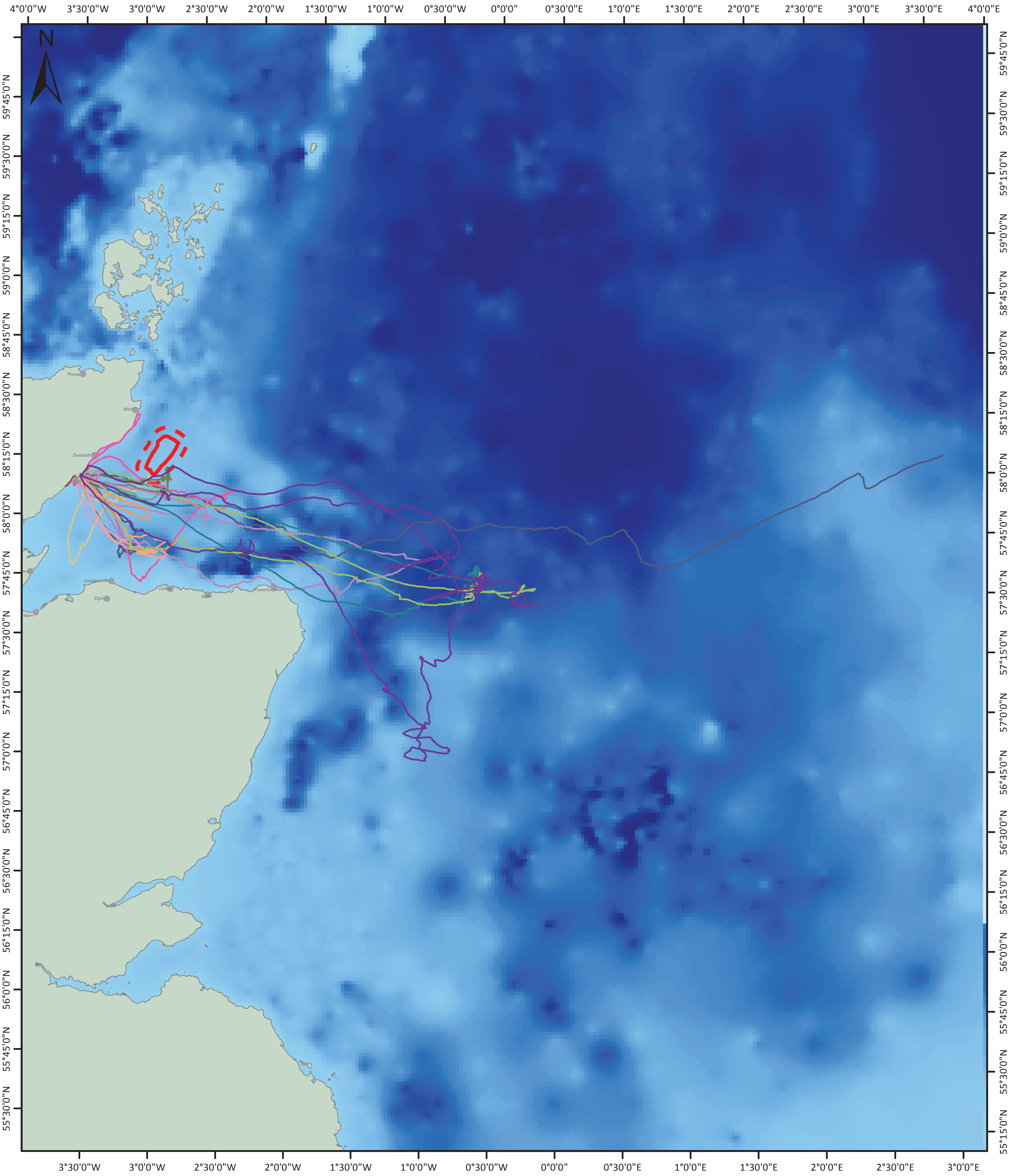
Beatrice Offshore Wind Farm

Figure 3.1.6

Aerial survey observations of Fulmar between November 2009 and February 2010

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_6_aerial_wwtBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Different coloured lines represent individual birds

0 15 30 60 km

0 5 10 20 Nm

Beatrice Offshore Wind Farm

Figure 3.1.7

The foraging range of individual breeding Fulmar tracked by satellite telemetry during spring 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	30/08/2011	Scale:	1:2,415,000		
Drawing Number:	sgp6355_Beatrice_3_01_7_satTracks1			Revision:	01
Datum:	WGS1984	Projection:	UTM Zone 30N		

Beatrice
Offshore Windfarm Ltd

Sooty Shearwater

3.26 The world population of sooty shearwater is over 20 million individuals, with approximately a quarter of these residing in New Zealand (Heather and Robertson 1997). However, this species is of moderate global conservation concern due to steady declines in population (Brooke 2004).

3.27 Sooty shearwaters do not breed in Scotland, but migrate across the North Sea in large numbers on their way too and from their summer foraging grounds in the Arctic. Birds are observed in British waters between July and November, with the majority sighted in Cornish waters or throughout the North Sea (Brown and Grice 2005).

3.28 Survey observations from the proposed Wind Farm Site are consistent with this pattern, with no birds sighted between October and July, and minimal numbers seen during the late summer (Figure 3.2.2). The estimated peak density, calculated from boat surveys, is 0.53 km^2 with an estimated peak population of 200 individuals using the Wind Farm Site and buffer area.

3.29 The same pattern of observations was seen in the Beatrice Demonstrator observations, with sightings made only during August, September and October (Figure 3.2.4), and also from the RSPB surveys (Figure 3.2.3).

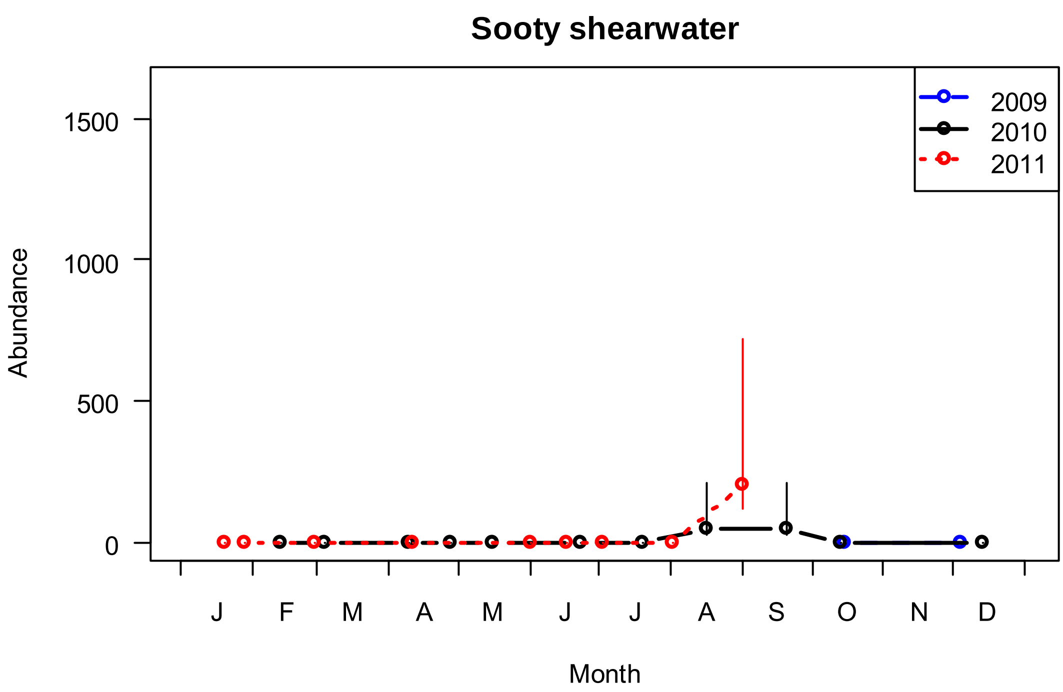


Figure 3.2.2 Sooty shearwater seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).

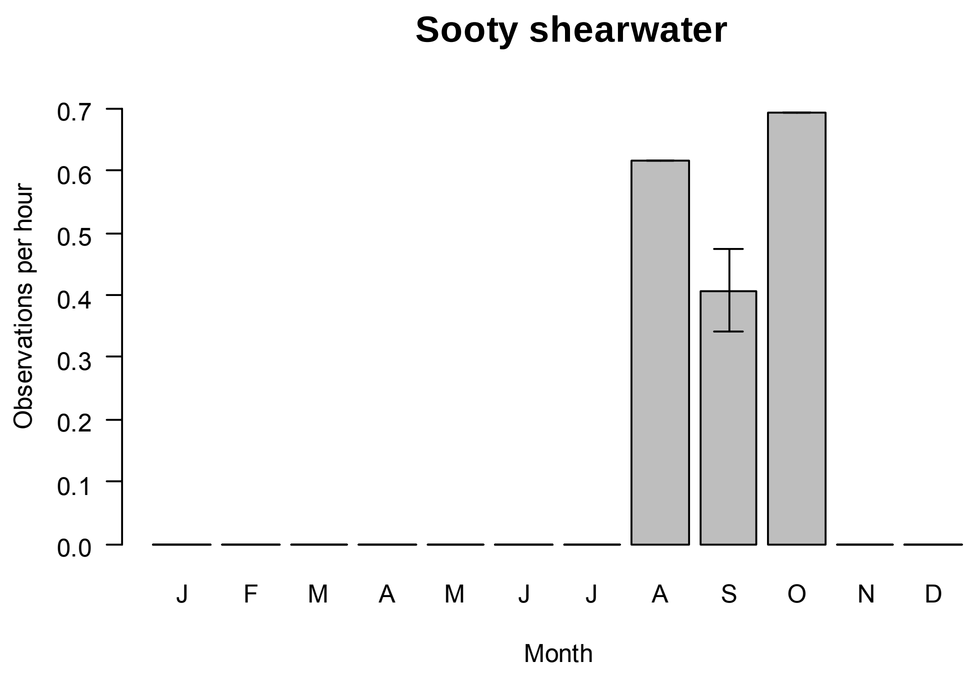
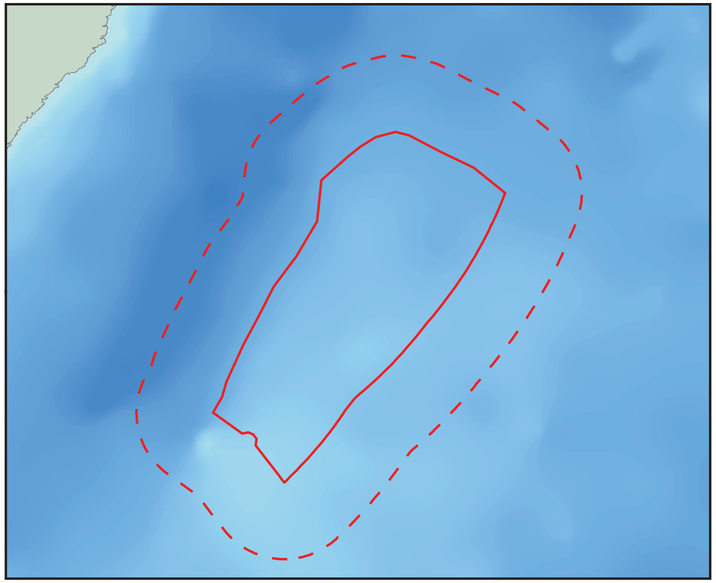
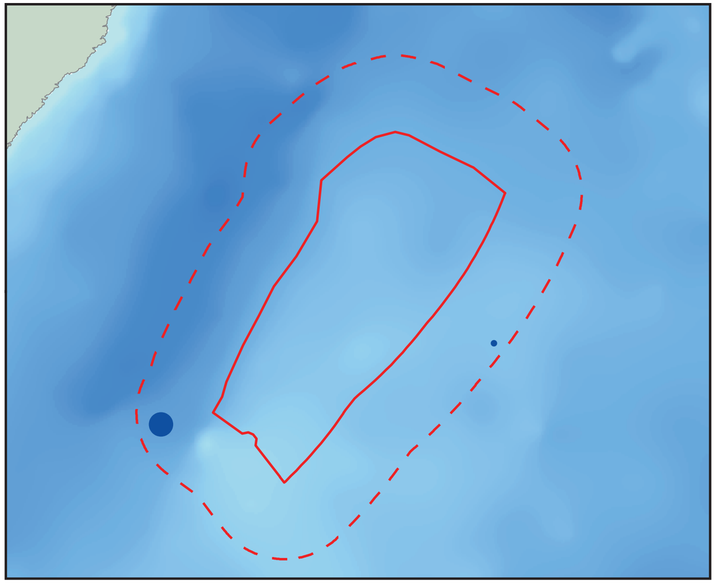


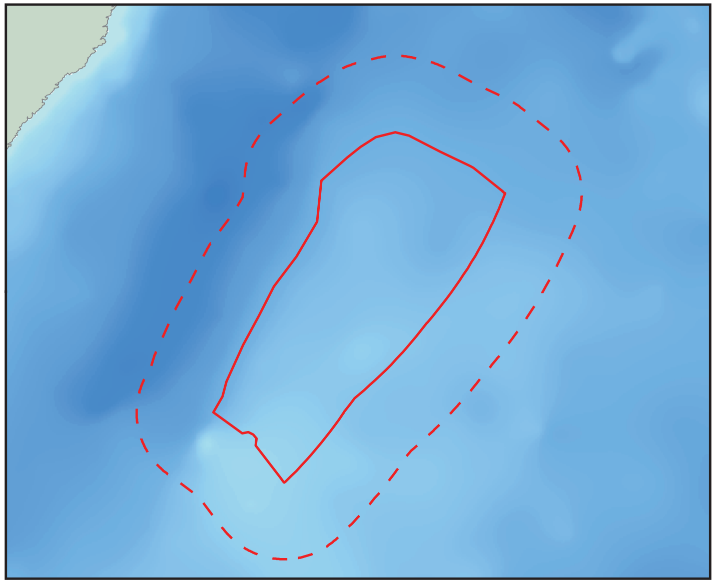
Figure 3.2.4 Average seasonal distribution (± 1 standard error) of Sooty Shearwater recorded from the Beatrice Alpha Oil Platform between 2005 – 2008 for the Beatrice Demonstrator Project



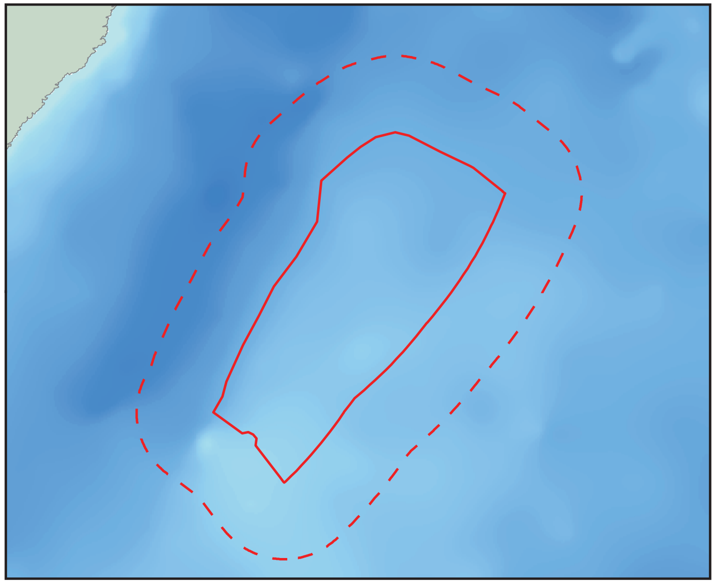
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km 0 1 2 3 4 5 Nm

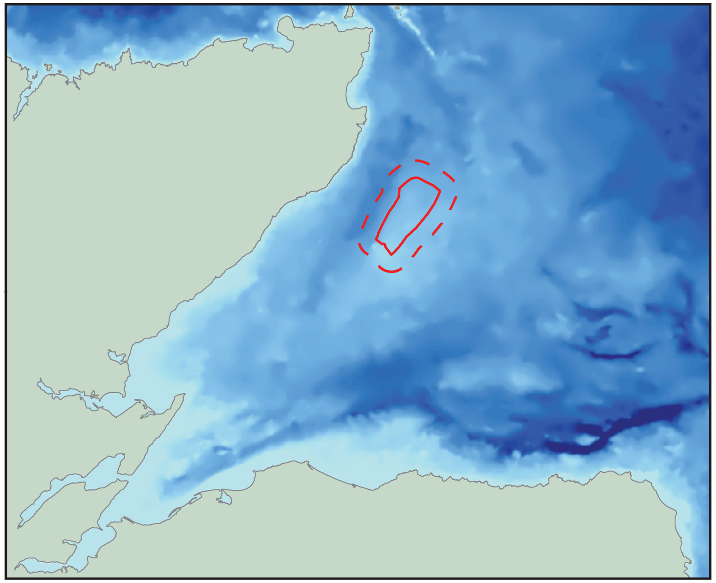
Beatrice Offshore Wind Farm

Figure 3.2.1

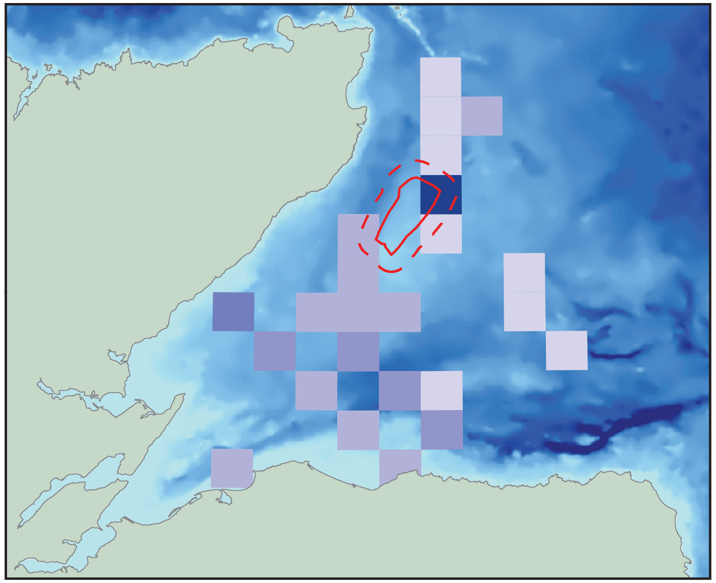
Boat based observations of Sooty shearwater between October 2009 and July 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2			Revision:	03
Datum:	WGS84	Projection:	UTM Zone 30 N		

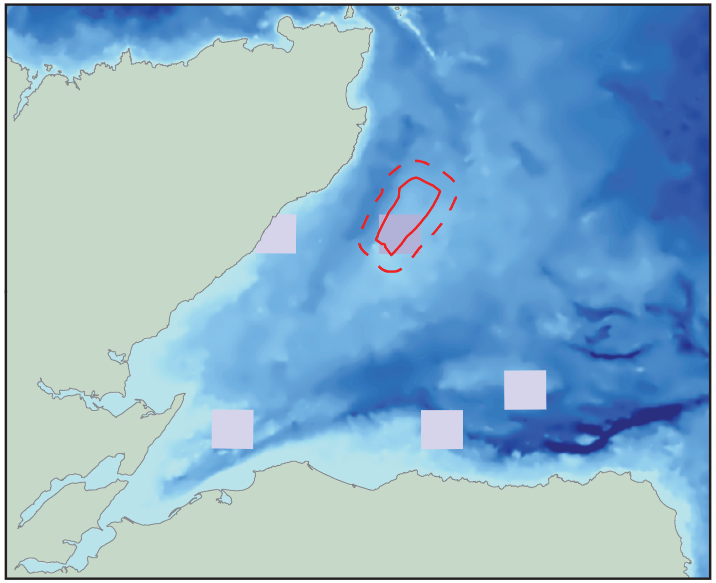
Beatrice
Offshore Windfarm Ltd



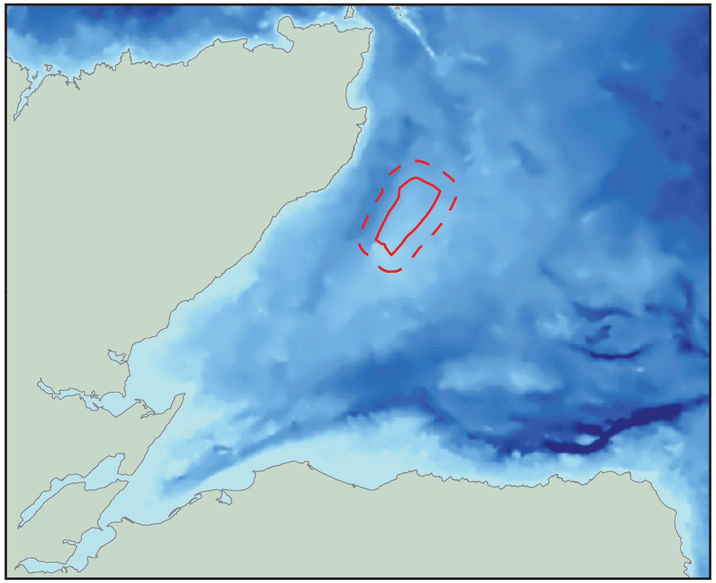
May to July



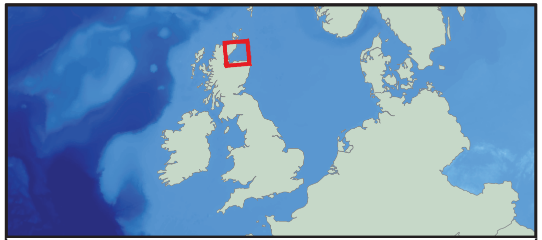
August to October



November to January



February to April



Legend

- Site boundary buffered by 4 km
- Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km   0 5 10 20 Nm

Beatrice Offshore Wind Farm

Figure 3.2.3

Mean density of Sooty Shearwater derived from boat-based observations between January 1982 and December 1983

Drawn: CH	Checked: MT	Approved: MT
Date: 02/09/2011	Scale: 1:1,700,000	
Drawing Number: sgp6355_Beatrice_3_01_3_RSPB1		Revision: 02
Datum: WGS84	Projection: UTM Zone 30 N	

Beatrice Offshore Windfarm Ltd

Gannet

3.30 Great Britain is home to over half of the world breeding population of northern gannet, which is estimated to be about 390,000 pairs (Mitchell *et al.* 2004). Gannet is of conservation concern (amber status) within the UK (BirdLife International *et al.* 2007) because the British population represents over 20% of the European breeding population. Furthermore, over half of the British gannet breeding population occurs at less than ten sites. The Scottish gannet population accounts for 70% of the GB population (Mavor *et al.* 2004).

3.31 Site Condition Monitoring of gannet colonies in north east Scotland has revealed significant increases in the breeding population, with an annual rate of increase of 8 % between 2001 and 2004 (Murray *et al.* 2006).

3.32 Gannets return to breeding colonies in January with variable attendance until April when the first eggs are laid (Cramp *et al.* 1974). Boat surveys of the Beatrice Offshore Wind Farm recorded peak numbers in August and September (Figure 3.3.1). The peak density on the boat based study area was 1.21 km^2, giving a peak abundance estimate of 458 individuals. Some of these sightings may be the result of the addition of juvenile birds which fledge in July or August (Taylor *et al.* 1999).

3.33 The seasonal trend in sightings is very similar from the boat surveys and the Beatrice Demonstrator observations (Figures 3.3.2 and 3.3.4), and also from the RSPB surveys, with a much wider distribution of observations made across the Moray Firth during August to September than during any other period (Figure 3.3.3). The aerial surveys during summer (Figure 3.3.5) also recorded many more gannet sightings than during the winter (Figure 3.3.6). The results of all these surveys are therefore consistent with the boat observations.

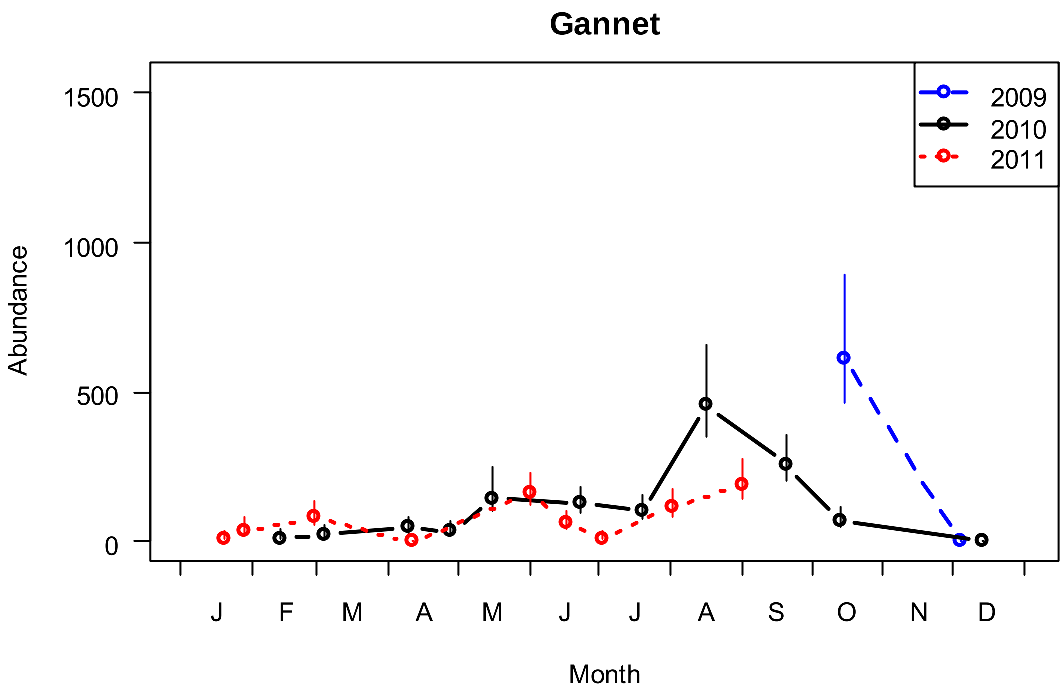


Figure 3.3.2: Northern gannet seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).

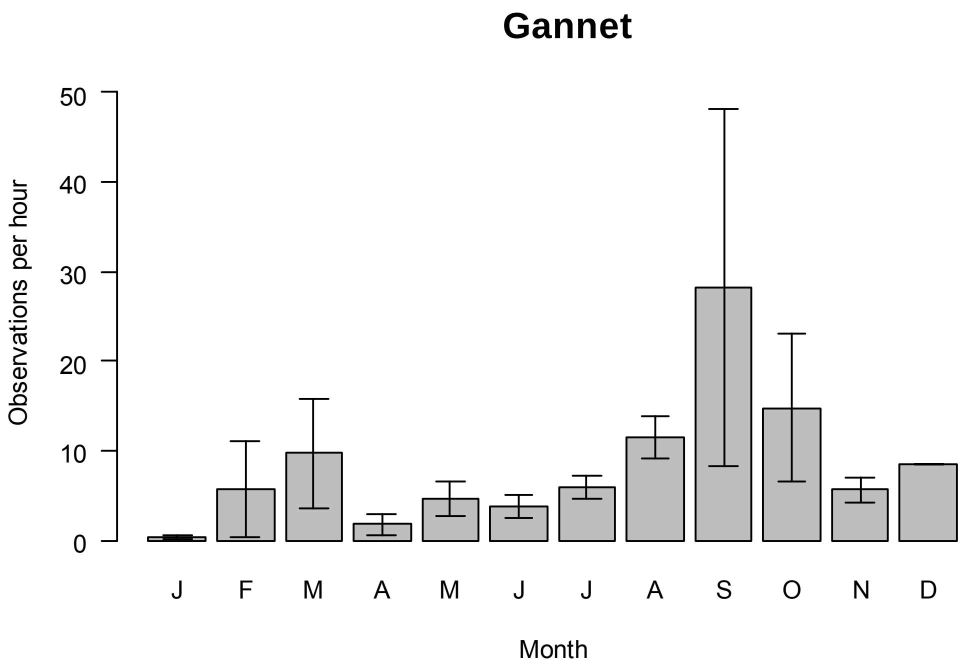
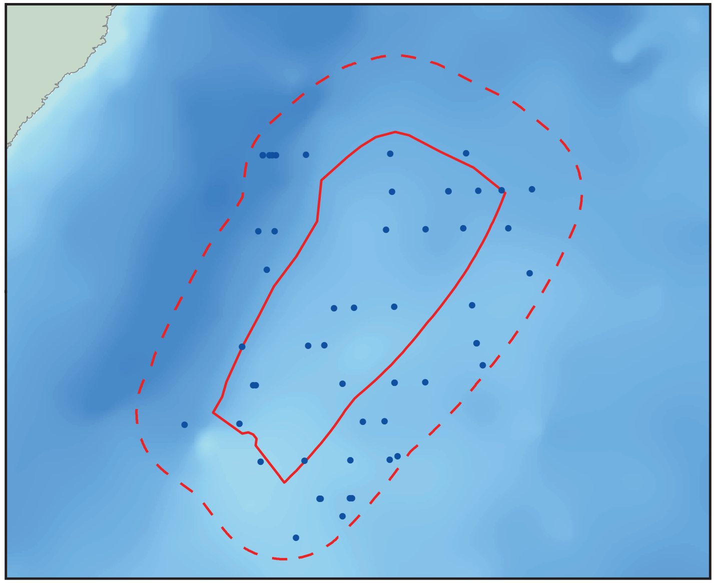
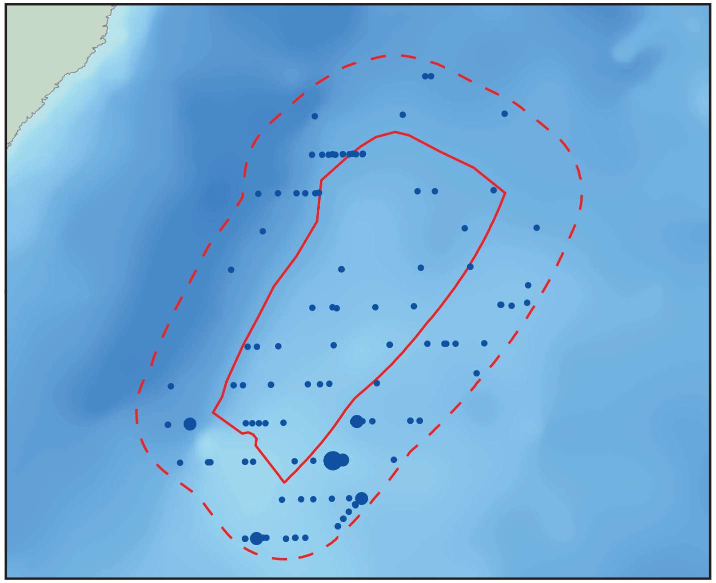


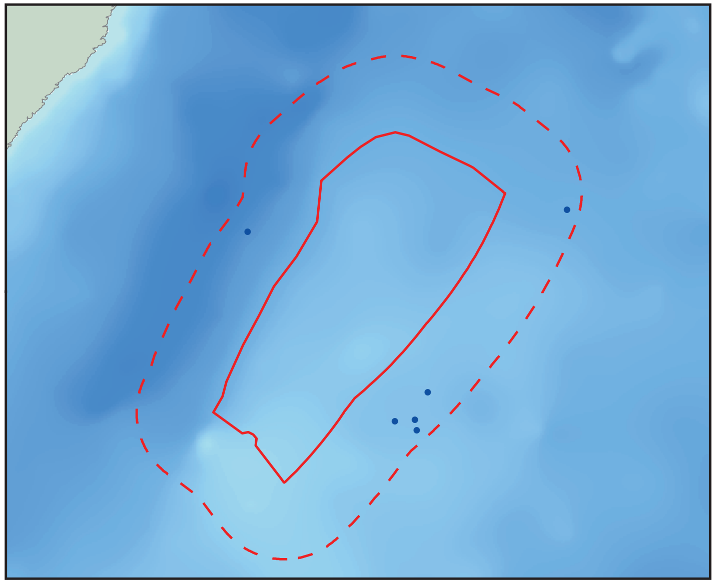
Figure 3.3.4 Average seasonal distribution (± 1 standard error) of Northern Gannet recorded from the Beatrice Alpha Oil Platform between 2005 – 2008 for the Beatrice Demonstrator Project



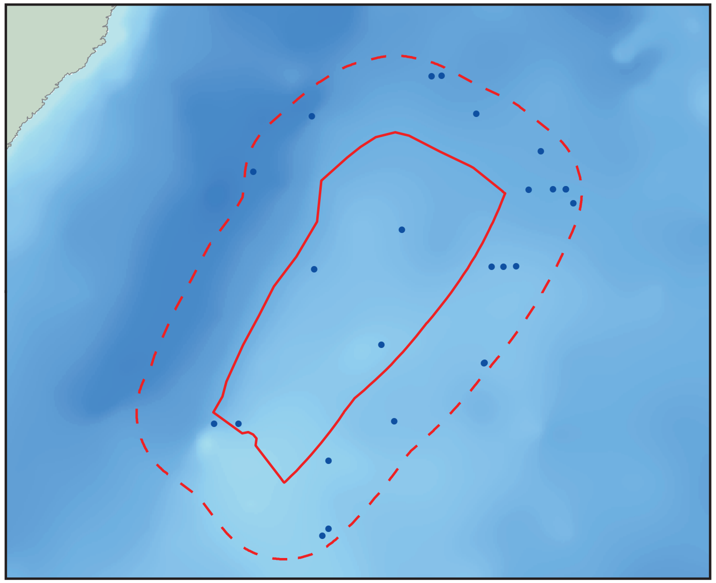
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km

0 1 2 3 4 5 Nm

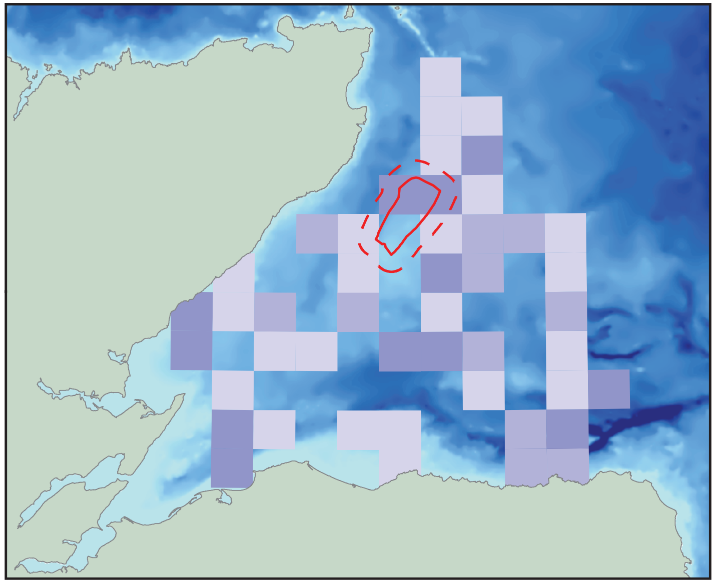
Beatrice Offshore Wind Farm

Figure 3.3.1

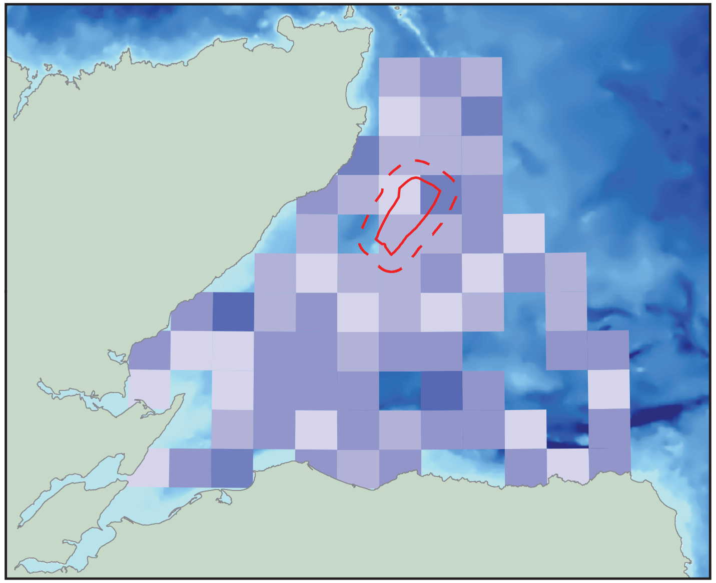
Boat based observations of Gannet between October 2009 and July 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2	Revision:	03		
Datum:	WGS84	Projection:	UTM Zone 30 N		

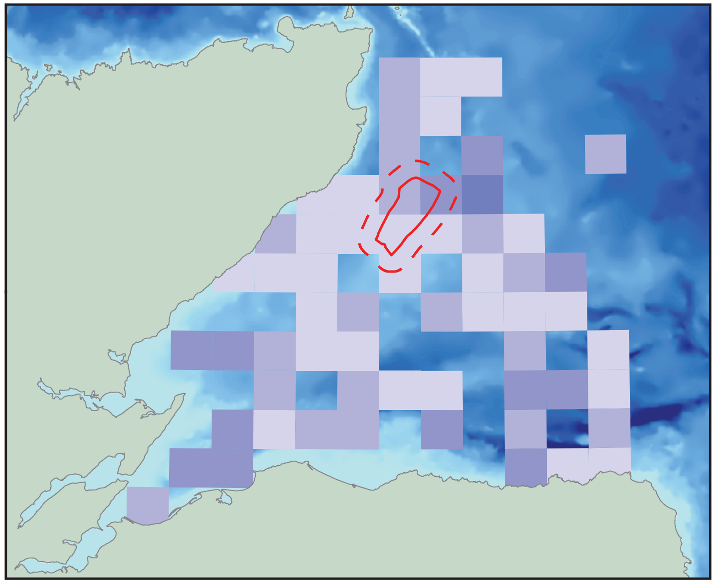
Beatrice
Offshore Windfarm Ltd



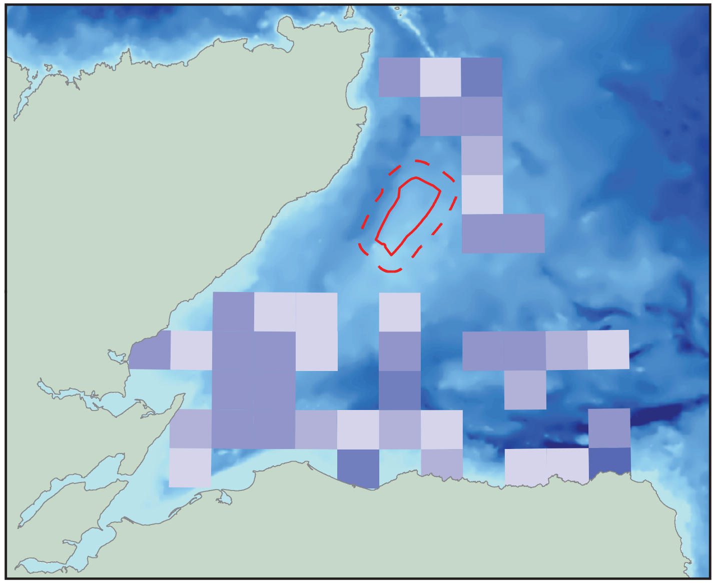
May to July



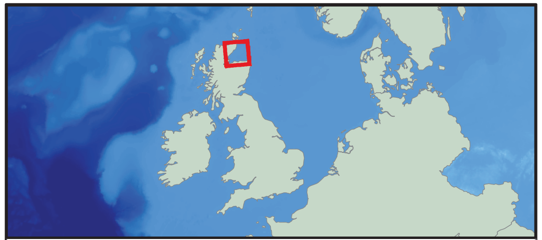
August to October



November to January



February to April



Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km

0 5 10 20 Nm

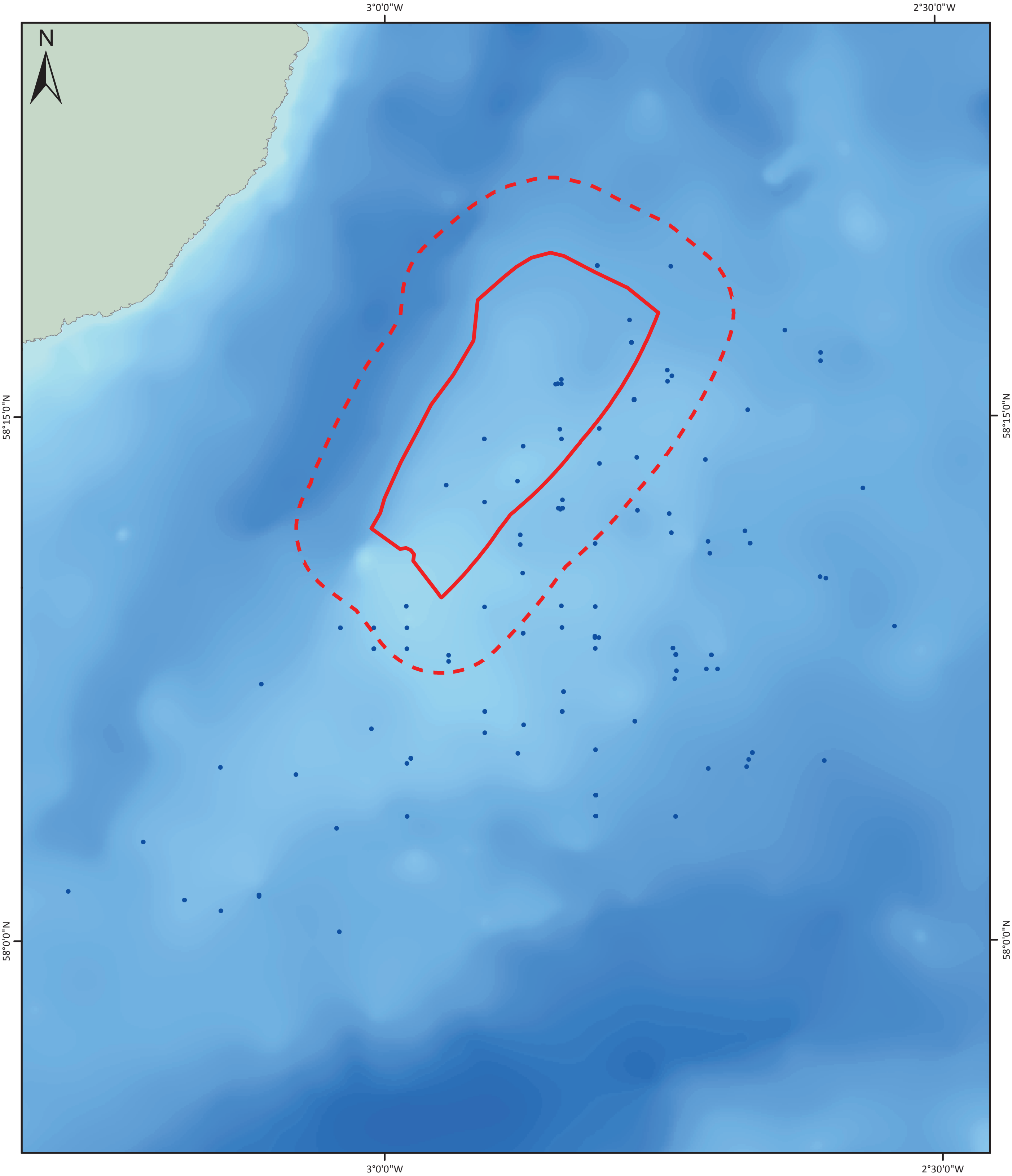
Beatrice Offshore Wind Farm

Figure 3.3.3

Mean density of Gannet derived from boat-based observations between January 1982 and December 1983

Drawn: CH	Checked: MT	Approved: MT	
Date: 02/09/2011	Scale: 1:1,700,000		
Drawing Number: sgp6355_Beatrice_3_01_3_RSPB1		Revision: 02	
Datum: WGS84	Projection: UTM Zone 30 N		

Beatrice
Offshore Windfarm Ltd

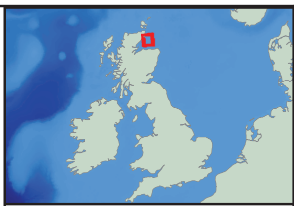


Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

This map contains TCarta and UKCS Bathymetry, 2009.

NOT TO BE USED FOR NAVIGATION

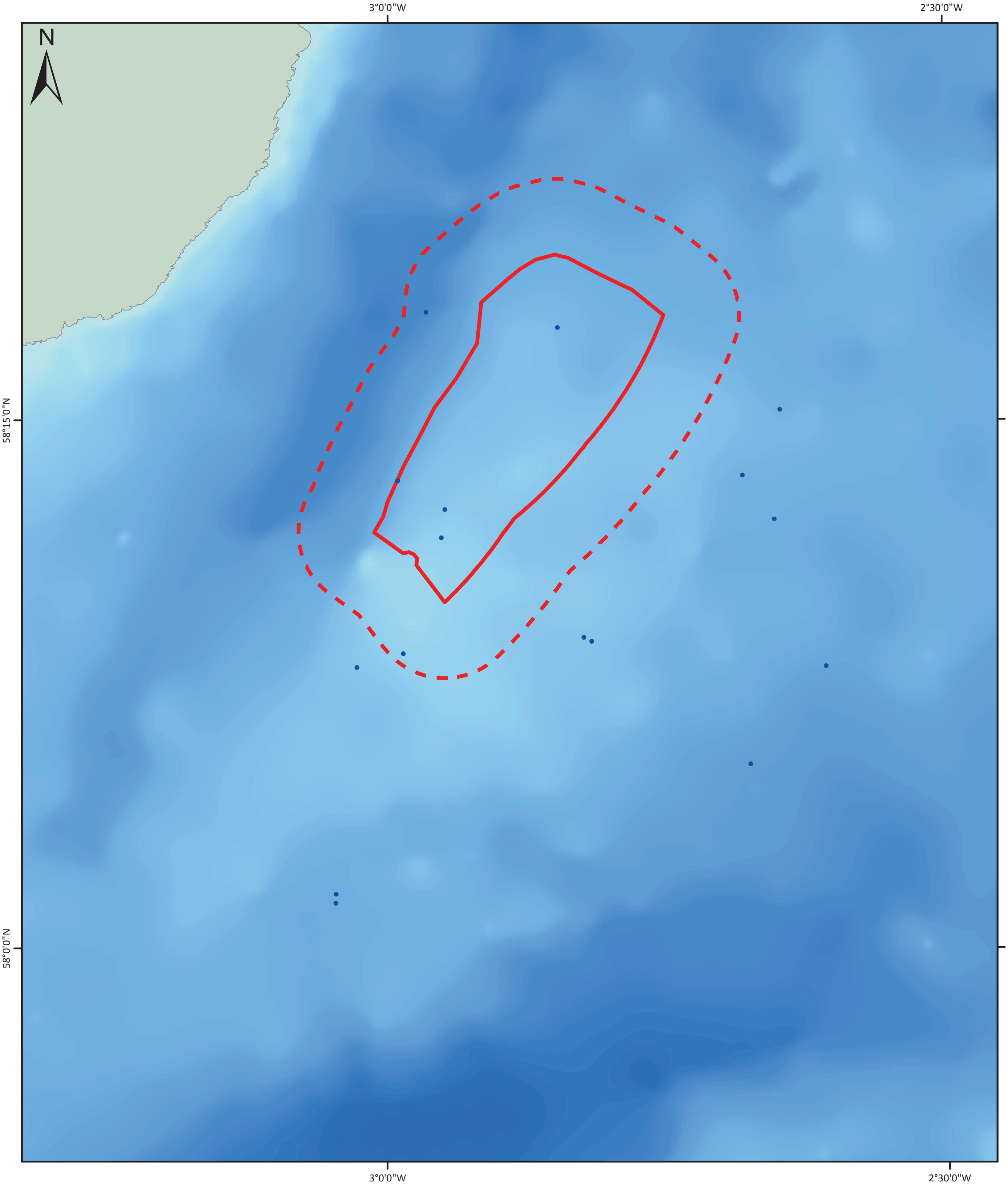
Beatrice Offshore Wind Farm

Figure 3.3.5

Aerial survey observations of Gannet between May and August 2009

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_5_aerial_hidefBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



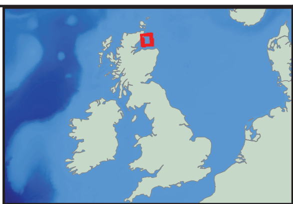
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

Beatrice Offshore Wind Farm

Figure 3.3.6

Aerial survey observations of Gannet between November 2009 and February 2010

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_6_aerial_wwtBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

European Shag

3.34 The European shag is listed as a species of low conservation concern in Europe, with between 75,000 and 81,000 breeding pairs. The estimated number of pairs in the UK is 26,000, comprising 38.3 % of the biogeographic population and 34.1 % of the global population (Mitchell *et al.* 2004). This species is of moderate conservation concern in Britain due to its localised populations and recent breeding population declines.

3.35 Eighty percent of the breeding European shag population in Britain nests in Scotland. Of these birds, 1,056 pairs are estimated to breed on the East Caithness cliffs where the birds are resident year round and generally forage close to shore.

3.36 Boat surveys recorded low numbers of European shags throughout the year (Figures 3.4.1 and 3.4.2), with a peak observed between November and February. The estimated peak density from these surveys was 0.23 km^2, which equates to a peak abundance of 87 birds.

3.37 This seasonal pattern was also seen in the Beatrice Demonstrator data (Figure 3.4.4), while the RSPB surveys of the entire Moray Firth clearly show the coastal nature of this species, with very few observations as far as offshore as the Wind Farm Site (Figure 3.4.3). Further evidence for their coastal preferences can be seen from the aerial surveys, with only a single observation during the summer and none in the winter (Figure 3.4.5).

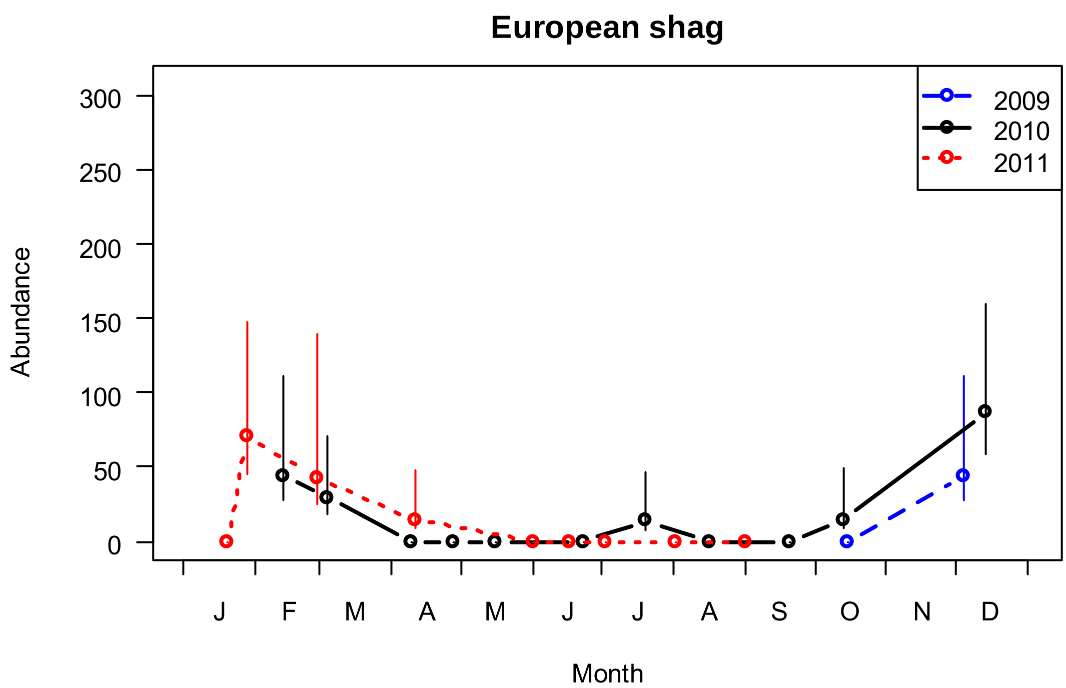


Figure 3.4.2: European shag seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).

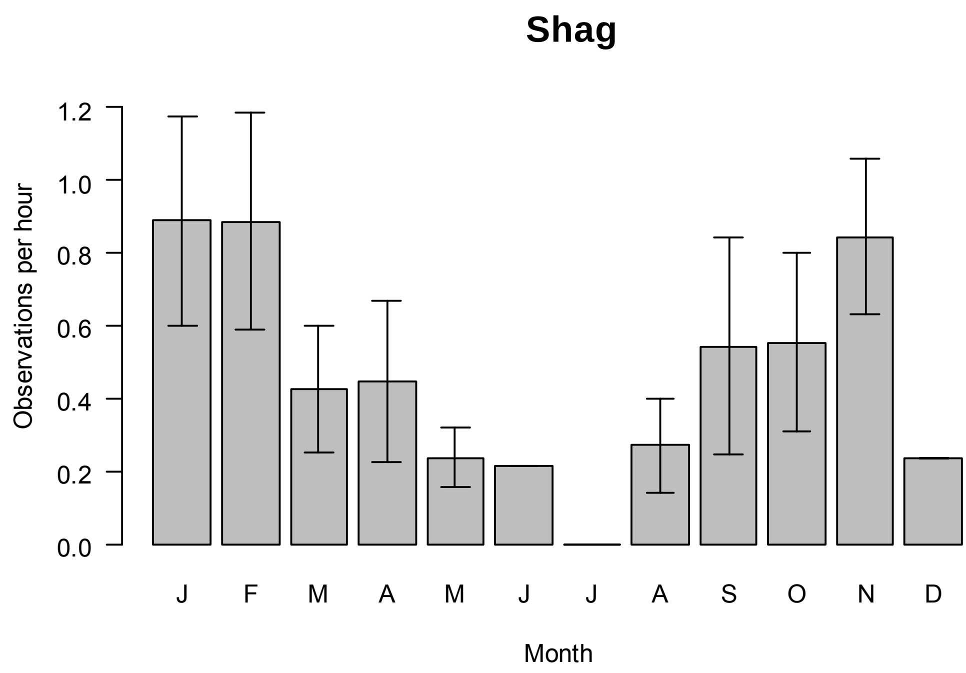
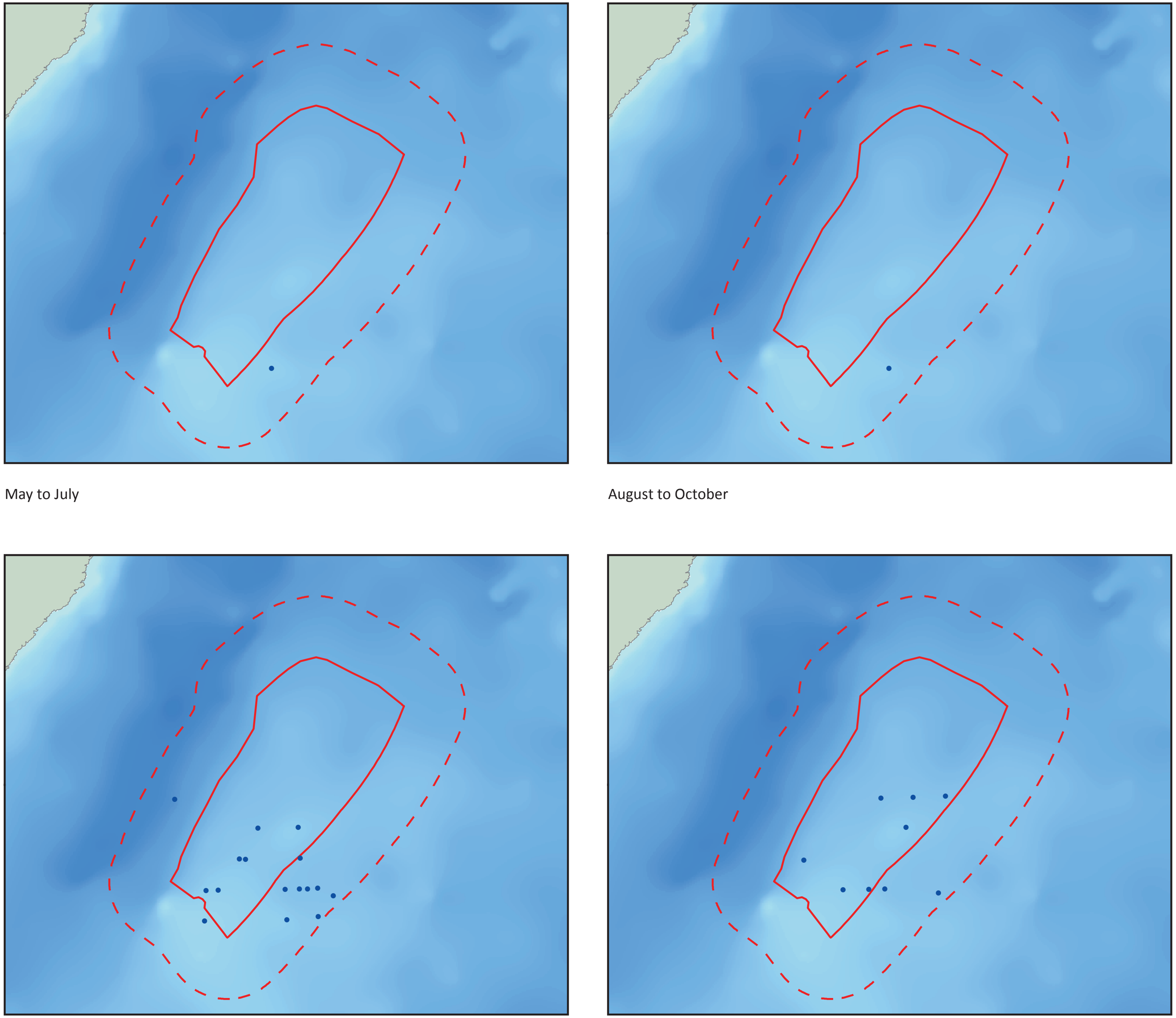


Figure 3.4.4: Average seasonal distribution (± 1 standard error) of European Shag recorded from the Beatrice Alpha Oil Platform between 2005 – 2008 for the Beatrice Demonstrator Project



May to July

August to October

November to January

February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km   0 1 2 3 4 5 Nm

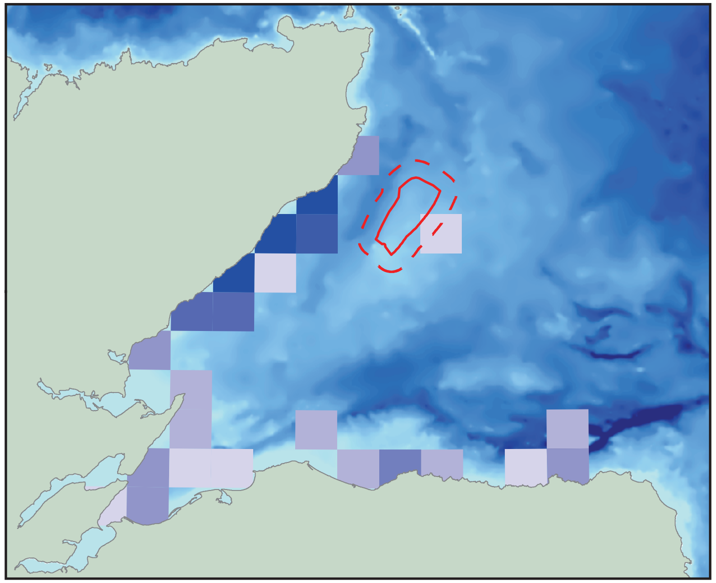
Beatrice Offshore Wind Farm

Figure 3.4.1

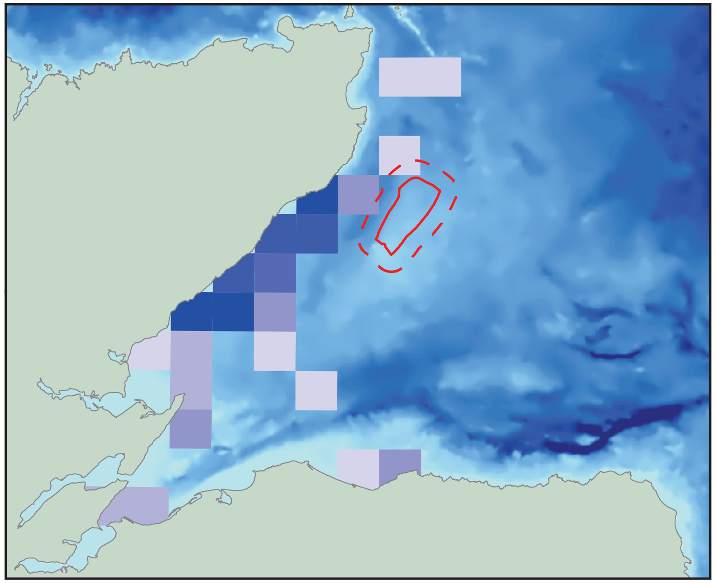
Boat based observations of Shag between October 2009 and July 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2			Revision:	03
Datum:	WGS84	Projection:	UTM Zone 30 N		

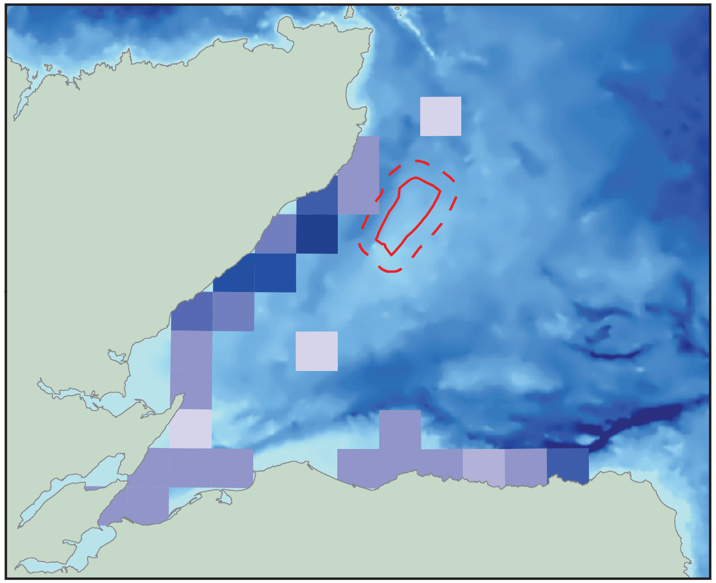
Beatrice
Offshore Windfarm Ltd



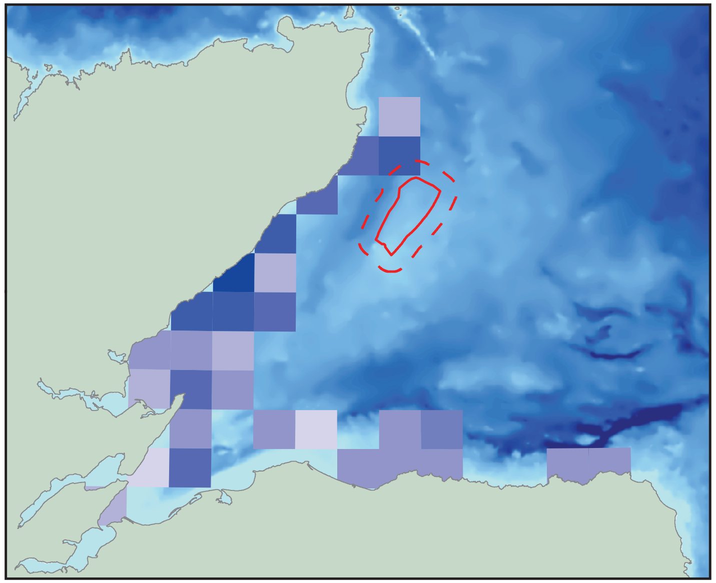
May to July



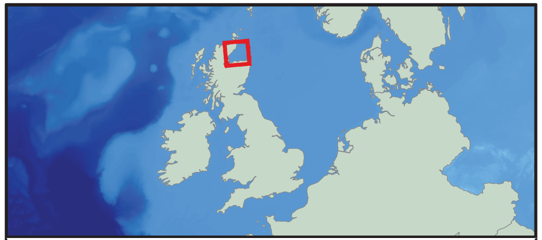
August to October



November to January



February to April



Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km

0 5 10 20 Nm

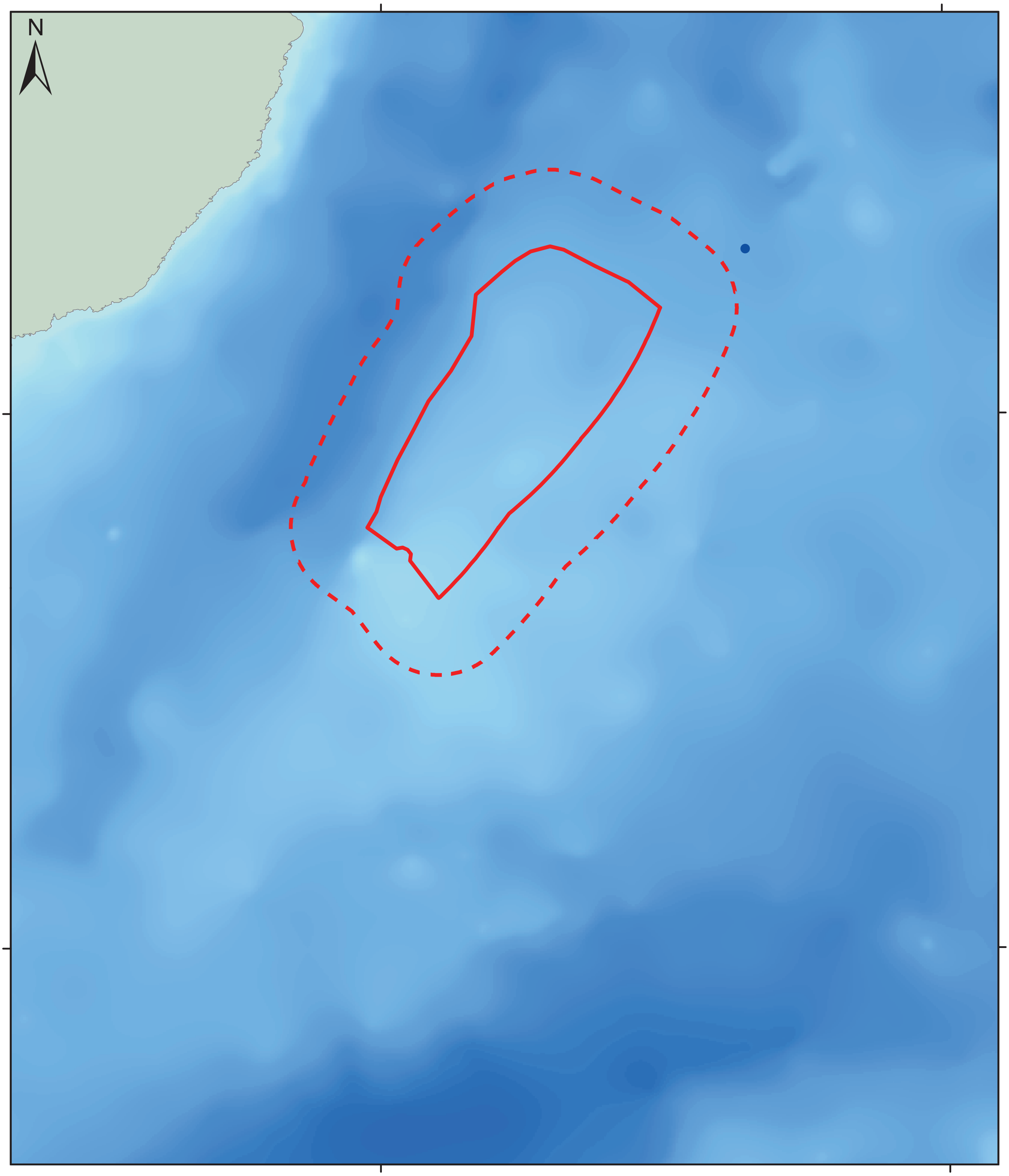
Beatrice Offshore Wind Farm

Figure 3.4.3

Mean density of Shag derived from boat-based observations between January 1982 and December 1983

Drawn: CH	Checked: MT	Approved: MT
Date: 02/09/2011	Scale: 1:1,700,000	
Drawing Number: sgp6355_Beatrice_3_01_3_RSPB1		Revision: 02
Datum: WGS84	Projection: UTM Zone 30 N	

Beatrice Offshore Windfarm Ltd



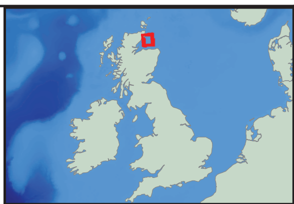
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

This map contains TCarta and UKCS Bathymetry, 2009.

NOT TO BE USED FOR NAVIGATION

Beatrice Offshore Wind Farm

Figure 3.4.5

Aerial survey observations of Shag between May and August 2009

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_5_aerial_hidefBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

Arctic Skua

3.38 An estimated 2,100 pairs of Arctic skua breed in Britain, comprising 8.4 % of the biogeographic population and 1 % of the world population (Mitchell *et al.* 2004). All of the British population nests in Scotland, predominantly in Shetland and Orkney with a combined total of 1,840 pairs recorded on these island groups (Mitchell *et al.* 2004).

3.39 Seventy one breeding pairs have been recorded in Caithness, or 3.4 % of the total British population (Mitchell *et al.* 2004). However, as Arctic skuas travel widely in search of food (Tasker *et al*. 1987), the birds sighted on the boat based study area could be drawn from much further afield.

3.40 Arctic skuas have experienced a dramatic population decline in Scotland between 1986 and 2008, with current populations at 30 % to 50 % of their original numbers (Mitchell *et al.* 2004). Because of these trends, Arctic skuas are considered a species of high conservation concern in Britain.

3.41 Seventeen Arctic skuas were recorded during the boat surveys, during May to August inclusive (Figure 3.5.1), giving a peak density estimate of 0.23 km^2, however with so few observations density estimation is unreliable so this figure needs to be treated with caution.

3.42 Arctic skua were observed during the Beatrice Demonstrator study between April and October (Figure 3.5.2), covering a wider period than was seen on the Wind Farm Site. A similar seasonal spread is evident in the RSPB data (Figure 3.5.3). These observations also reveal an apparent preference for coastal and near coastal waters, particularly during the breeding season. This presumably reflects the better opportunities for kleptoparasitism (food stealing) to be found in the vicinity of seabird breeding colonies. Very few Arctic skuas were seen during the aerial surveys (Figure 3.5.5).

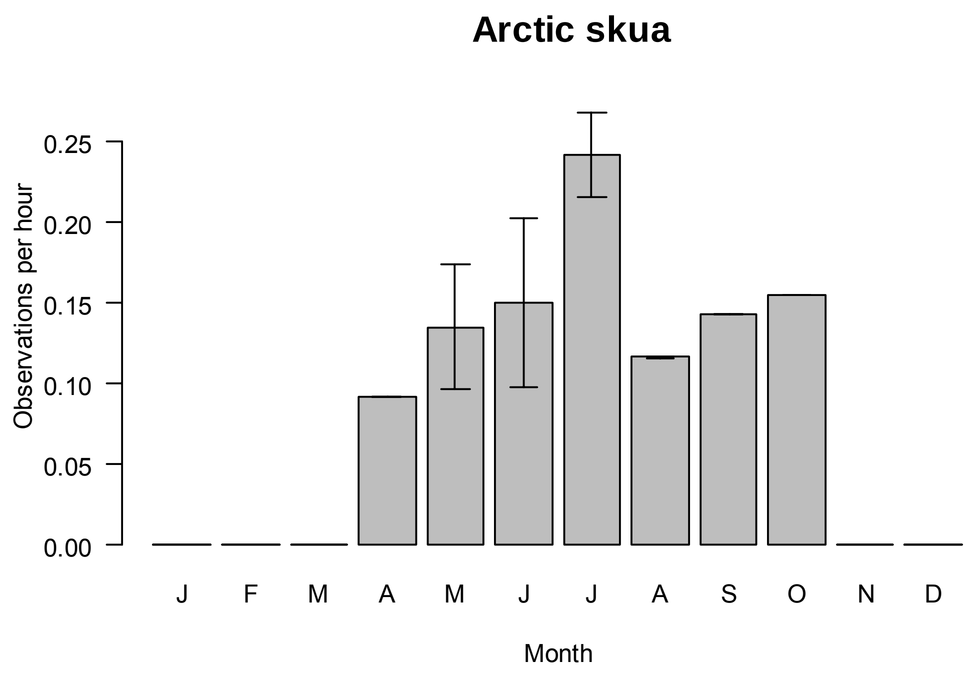
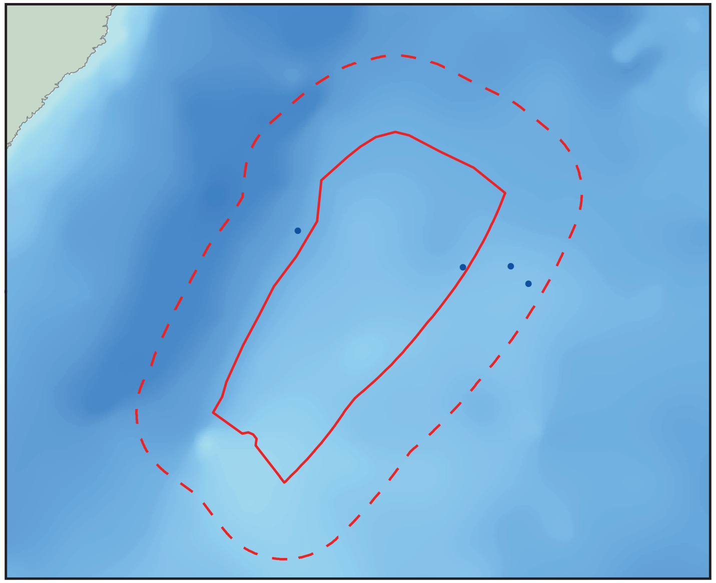
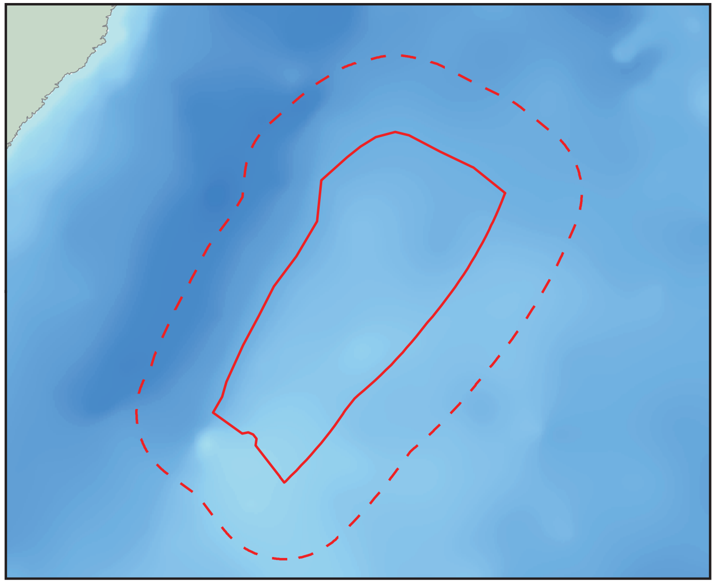


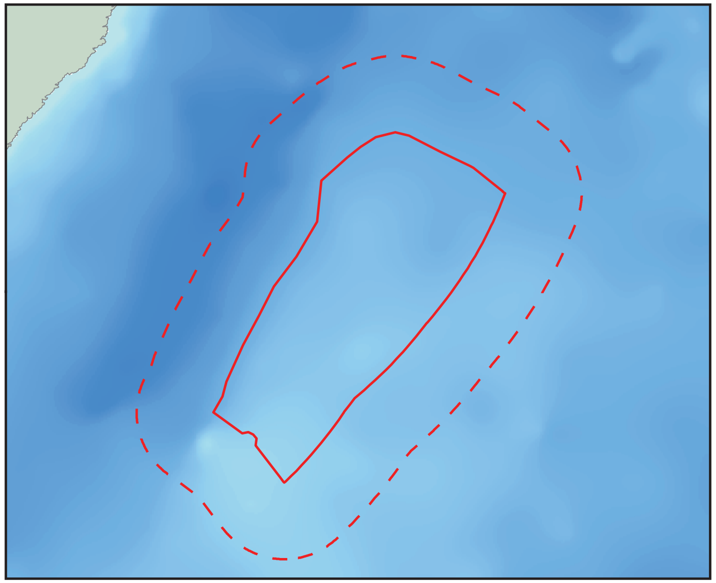
Figure 3.5.2: Average seasonal distribution (± 1 standard error) of Arctic Skua recorded from the Beatrice Alpha Oil Platform between 2005 – 2008 for the Beatrice Demonstrator Project



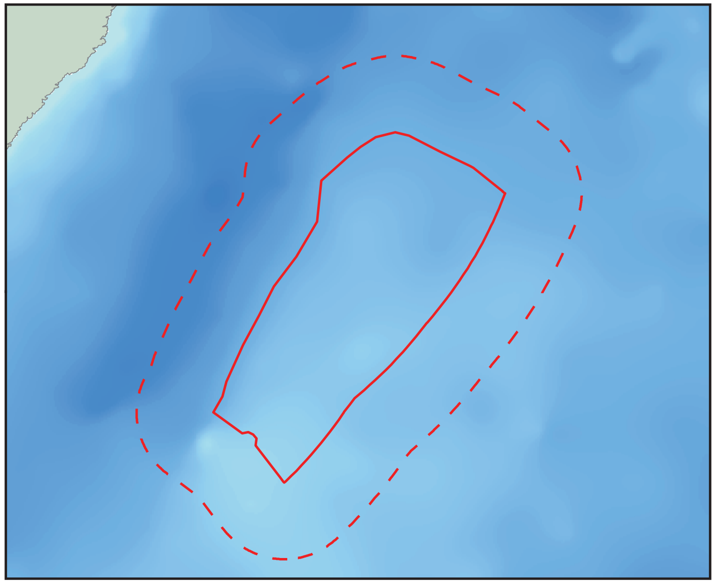
May to July



August to October



November to January



February to April

Legend

- Site boundary buffered by 4 km
- Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km 0 1 2 3 4 5 Nm

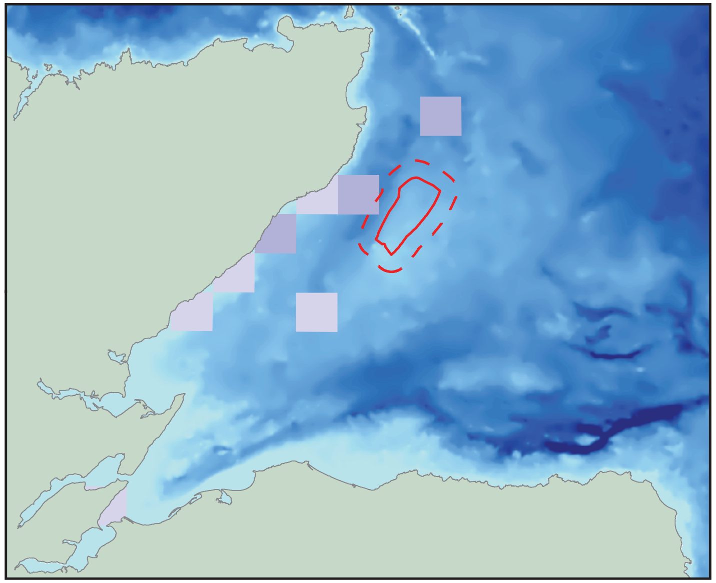
Beatrice Offshore Wind Farm

Figure 3.5.1

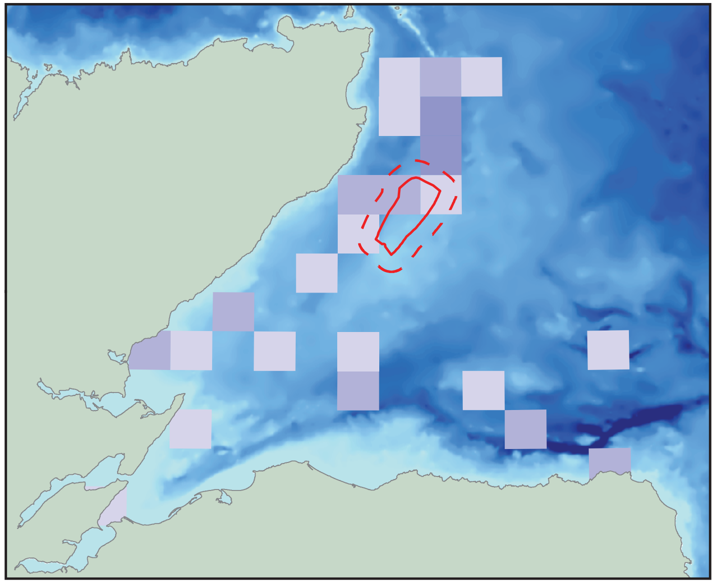
Boat based observations of Arctic skua between October 2009 and July 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2			Revision:	03
Datum:	WGS84	Projection:	UTM Zone 30 N		

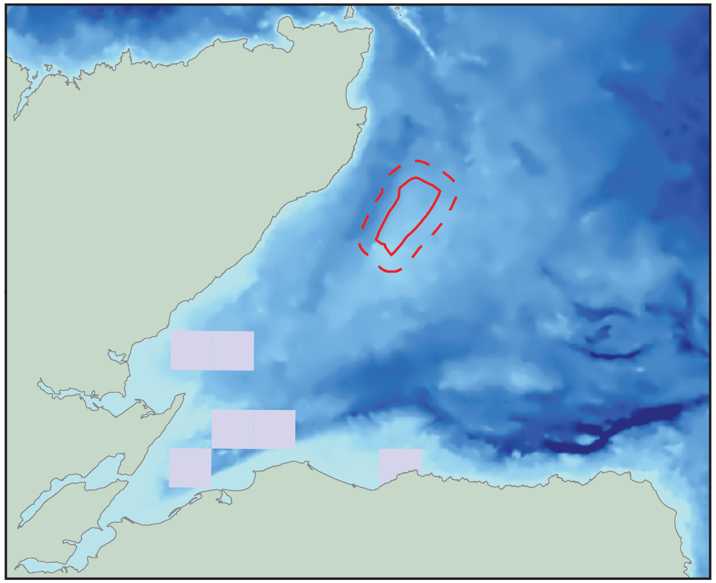
Beatrice
Offshore Windfarm Ltd



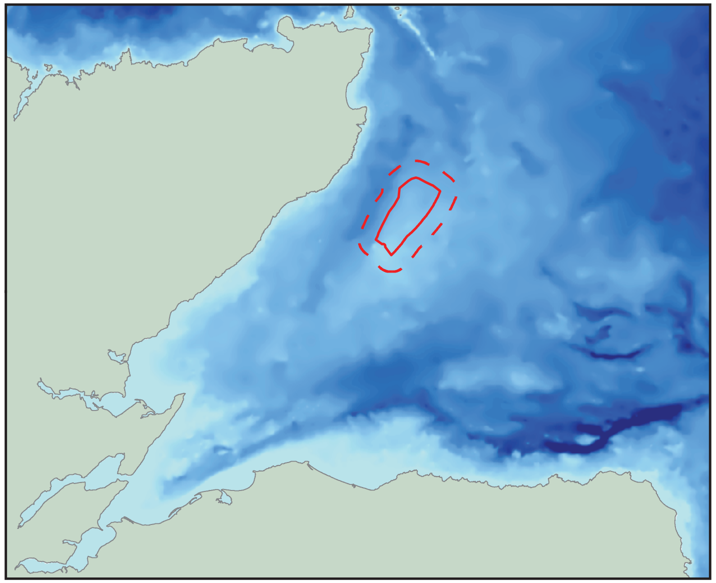
May to July



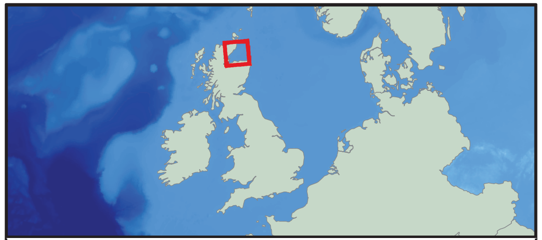
August to October



November to January



February to April



Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km
0 5 10 20 Nm

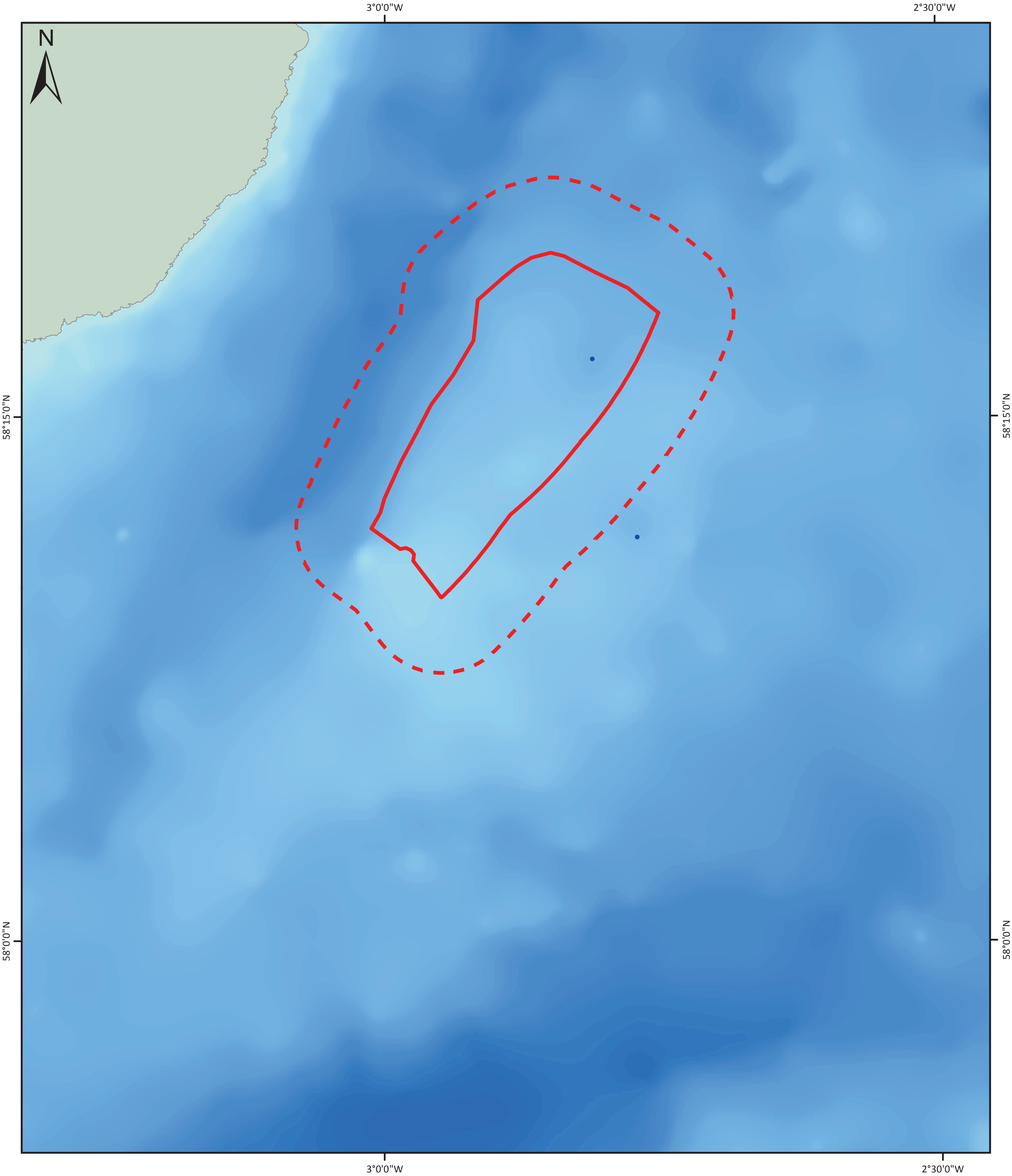
Beatrice Offshore Wind Farm

Figure 3.5.3

Mean density of Arctic Skua derived from boat-based observations between January 1982 and December 1983

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice Offshore Windfarm Ltd



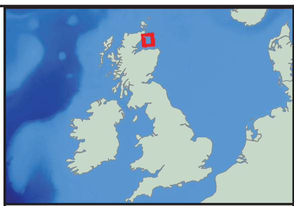
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

Beatrice Offshore Wind Farm

Figure 3.5.5

Aerial survey observations of Arctic skua between May and August 2009

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	30/08/2011	Scale:	1:275,000		
Drawing Number:	sgp6355_Beatrice_3_01_5_aerial_hidefBirdObs1			Revision:	01
Datum:	WGS1984	Projection:	UTM Zone 30N		

Beatrice Offshore Windfarm Ltd

Great skua

3.43 The entire British breeding population of great skua nests in Scotland, primarily in Shetland. Mitchell *et al.* (2004) estimate that 9,600 pairs breed in Britain, accounting for 60 % of the global breeding population; this count, however, was taken before the sandeel fishery collapse and is a peak number (Furness 2007). No breeding pairs have been recorded in the Caithness area.

3.44 Great skuas are a summer visitor to Britain and spend their winters at sea, typically off Iberia (seabird.wikispaces). Records from the boat surveys (Figure 3.6.1) are consistent with this pattern, with a peak in sightings between May and July (Figure 3.6.2), and an absence of birds during the rest of the year. The peak density on the Wind Farm Site and buffer area was estimated to be 0.43 km^2, with an estimated peak abundance of 164 birds.

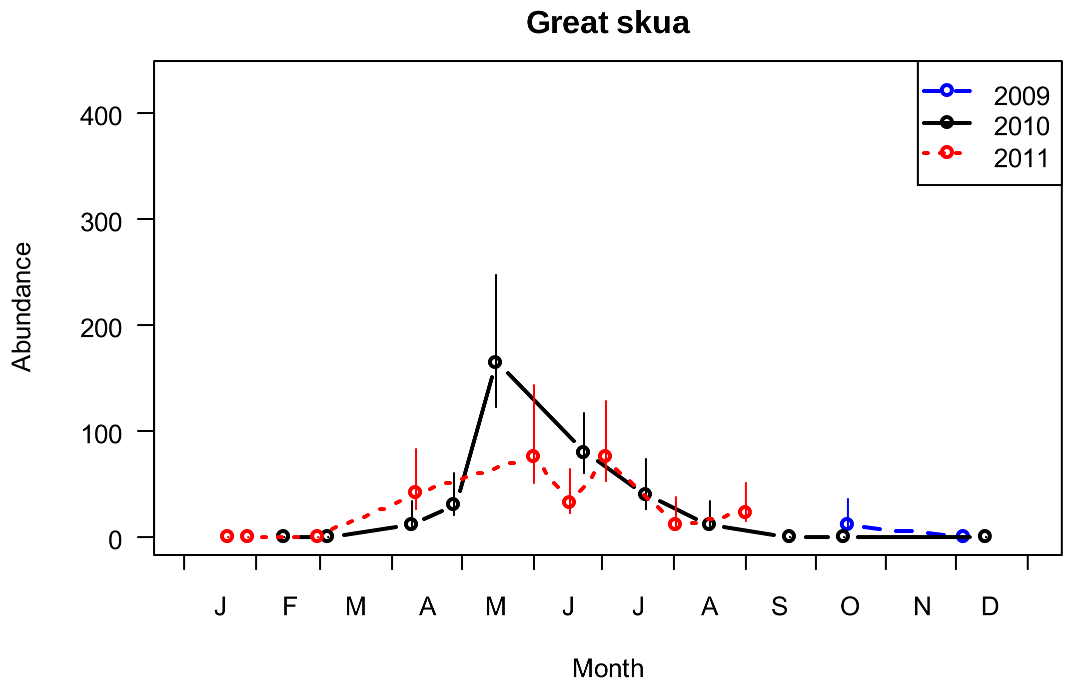


Figure 3.6.2: Great skua seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).

3.45 A very similar seasonal pattern of great skua observations was obtained from the Beatrice Demonstrator data, with a rapid climb to a peak in numbers in May followed by a gradual decline towards the autumn (Figure 3.6.4). This seasonal pattern was repeated with the RSPB data (Figure 3.6.3), which also revealed the wide spread of observations during this period, with a concentration towards the northern half of the Moray Firth. With the nearest breeding colonies in Orkney, this distribution is to be expected.

3.46 Great skua were also recorded by the aerial surveys, but only during summer, as expected given their seasonal movements (Figure 3.6.5).

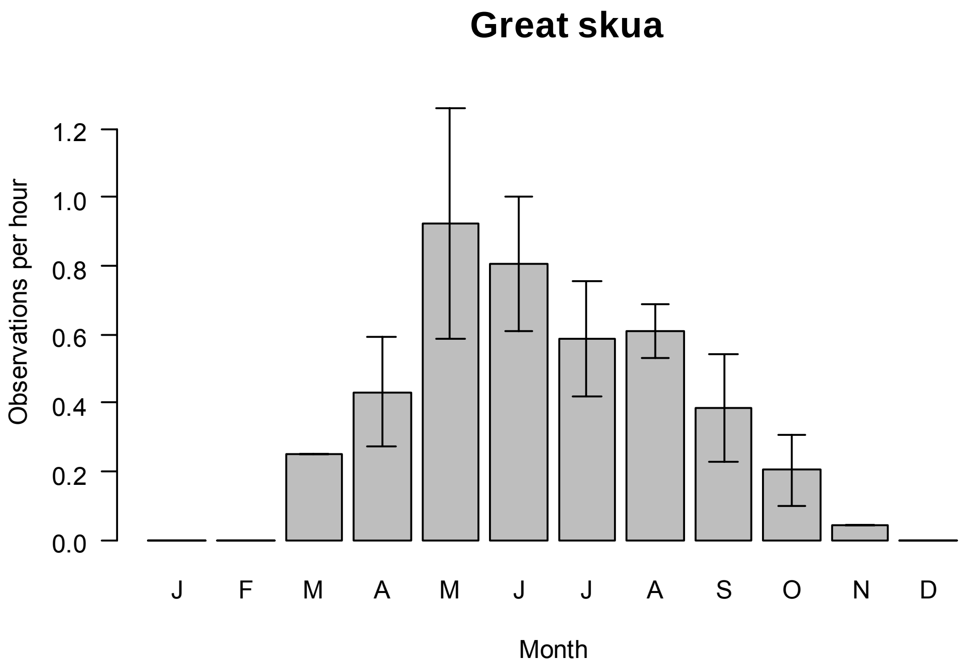
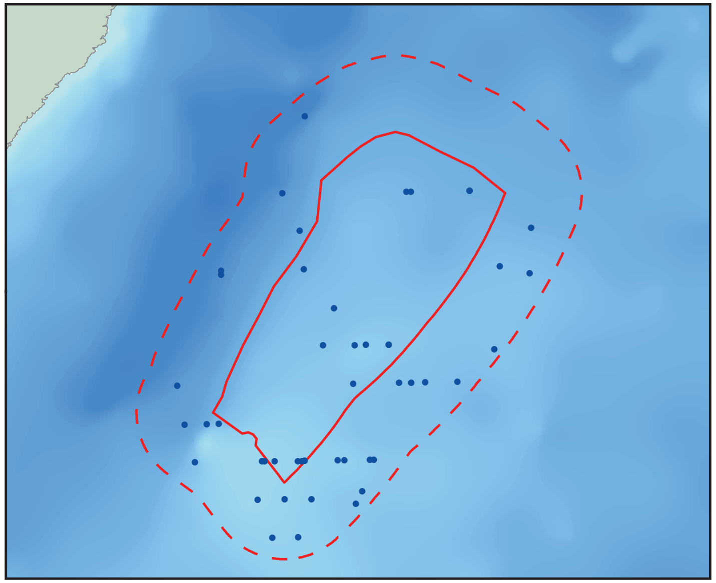
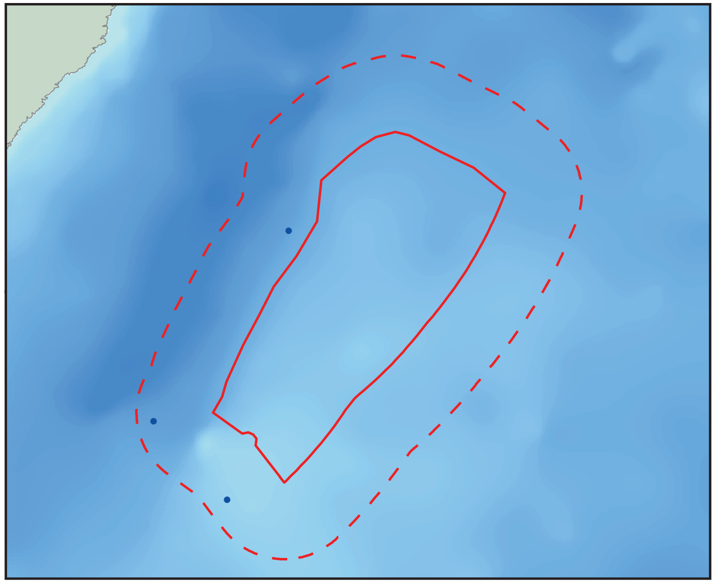


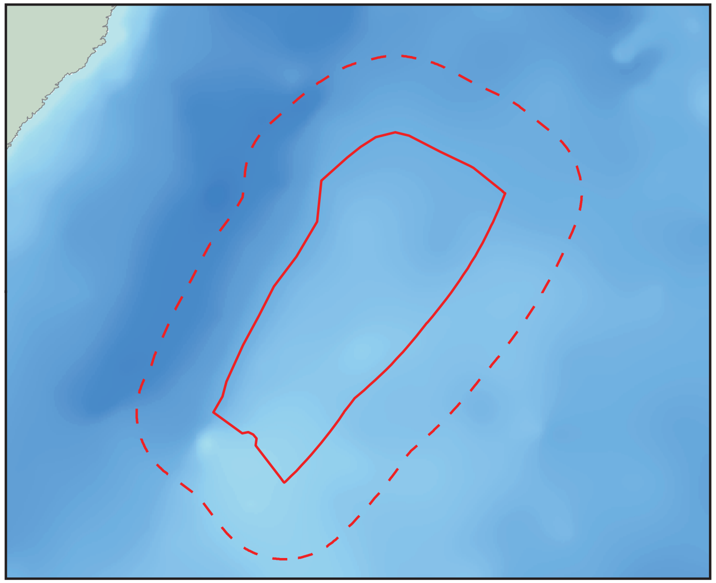
Figure 3.6.4: Average seasonal distribution (± 1 standard error) of {species} recorded from the Beatrice Alpha Oil Platform between 2005 – 2008 for the Beatrice Demonstrator Project



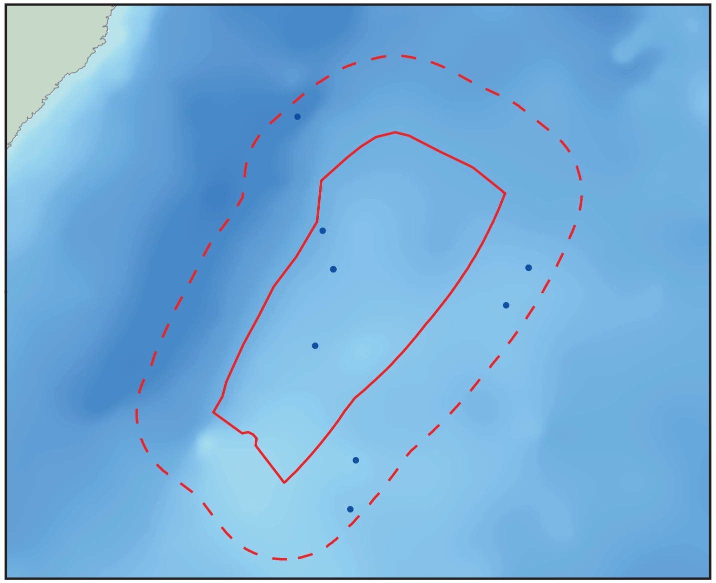
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km   0 1 2 3 4 5 Nm

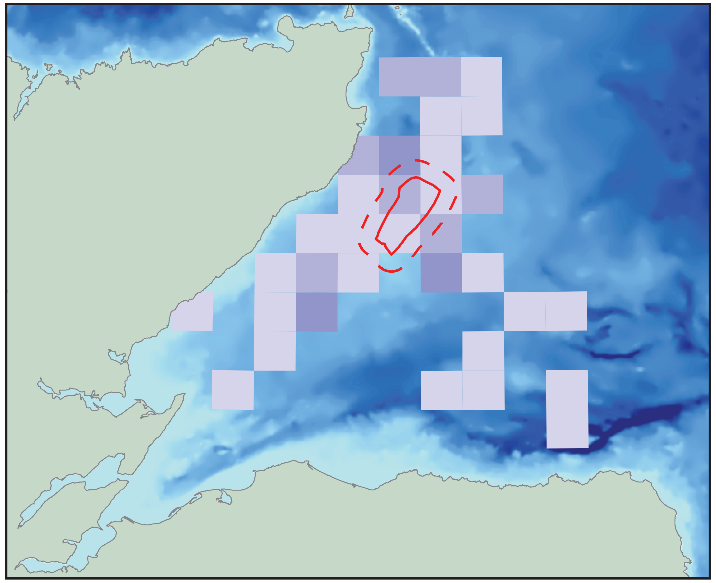
Beatrice Offshore Wind Farm

Figure 3.6.1

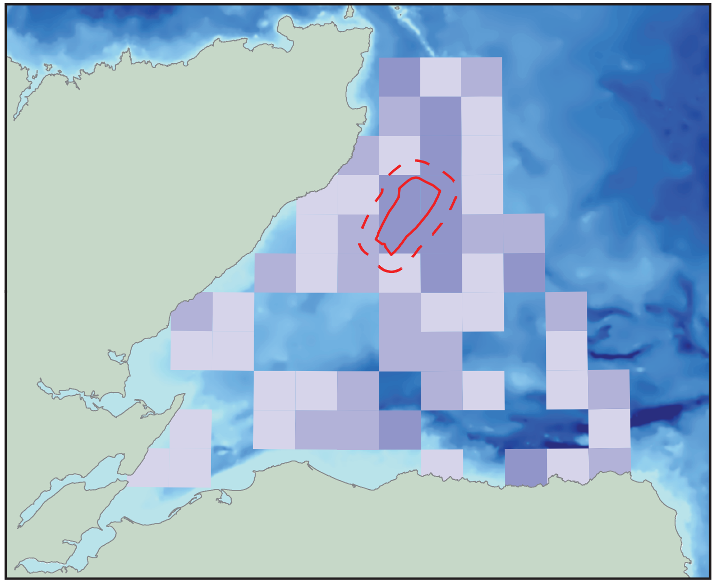
Boat based observations of Great skua between October 2009 and July 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2	Revision:	03		
Datum:	WGS84	Projection:	UTM Zone 30 N		

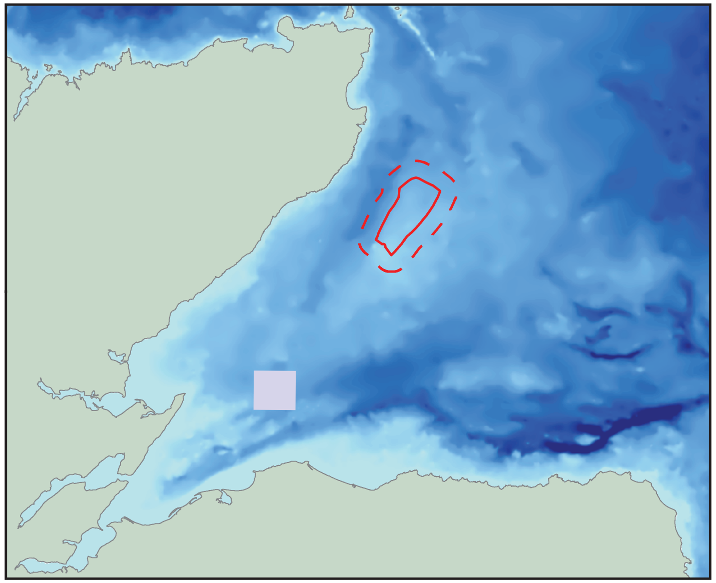
Beatrice Offshore Windfarm Ltd



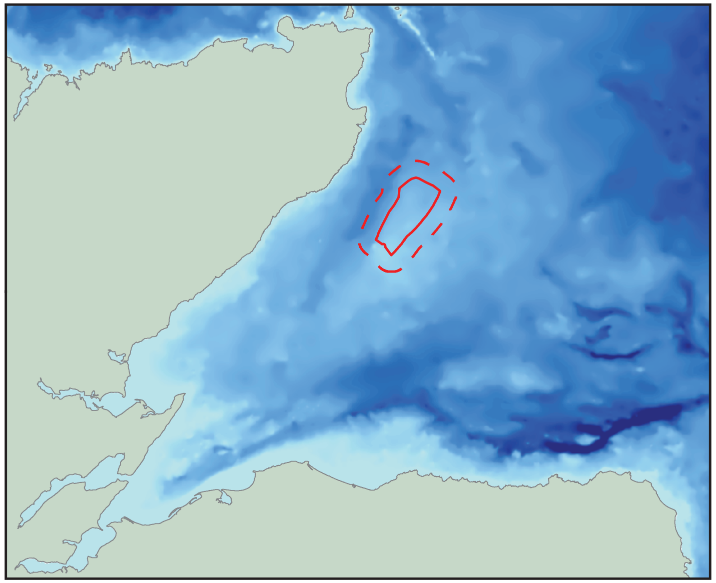
May to July



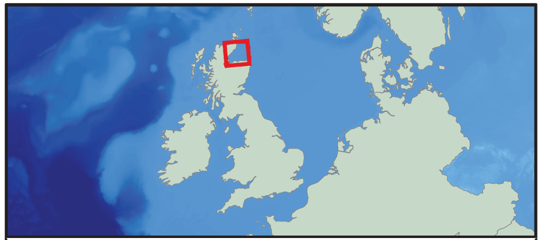
August to October



November to January



February to April



Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km

0 5 10 20 Nm

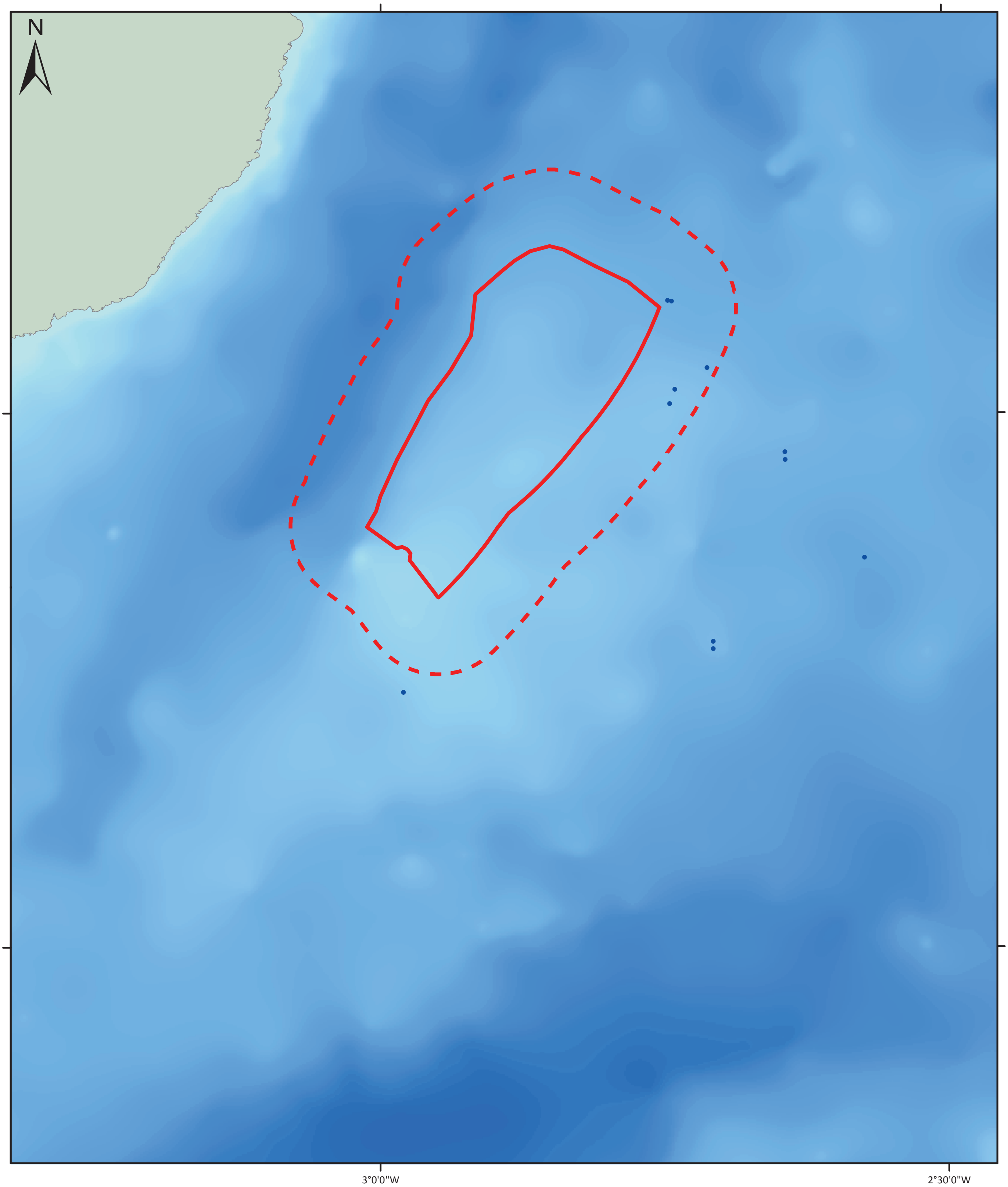
Beatrice Offshore Wind Farm

Figure 3.6.3

Mean density of Great Skua derived from boat-based observations between January 1982 and December 1983

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice
Offshore Windfarm Ltd



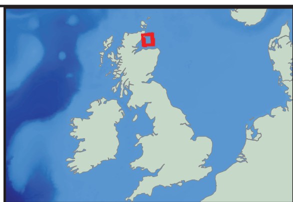
Legend

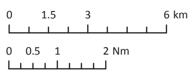
Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100





This map contains TCarta and UKCS Bathymetry, 2009.

NOT TO BE USED FOR NAVIGATION

Beatrice Offshore Wind Farm

Figure 3.6.5

Aerial survey observations of Great skua between May and August 2009

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_5_aerial_hidefBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

Black-legged kittiwake

3.47 The European population of black-legged kittiwake (hereafter, kittiwake) of 2,100,000 -3,000,000 pairs has fluctuated over time and within different countries but has been provisionally evaluated as secure (BirdLife International 2004). Kittiwakes are the most numerous breeding gull in Britain and Ireland with 415,995 pairs (Mitchell *et al.* 2004).

3.48 40,410 breeding pairs of kittiwakes were recorded in the East Caithness Cliffs SPA, which accounts for nearly 10 % of the kittiwake population in Great Britain and Ireland. An additional 131,000 birds are estimated to breed in the North Caithness Cliffs SPA.

3.49 These high numbers are reflected in the distribution of kittiwakes between June and July, when the highest densities are found around the large breeding colonies in Orkney and the north and north east of Scotland (Stone *et al*. 1995). Outside the breeding season, the species is essentially pelagic as they disperse widely across the North Sea, although high densities remain in the Moray Firth between August and October (Stone *et al*. 1995). During the winter, it is likely that populations from many breeding localities mix together in the North Sea (Mitchell *et al*. 2005).

3.50 In recent years breeding colonies in the north east have experienced large declines in reproductive success. However, these declines have been least in those colonies in those regions which do not border the North Sea (Mavor *et al.* 2004)

3.51 Kittiwakes have been recorded during boat surveys throughout the year (Figures 3.7.1 and 3.7.2). Peak sightings occurred between April and June, with a peak density of 5.88 per km^2 on the boat based study area, equating to an estimated peak abundance of 2,222 individuals foraging in this area. Aerial survey data (Figures 3.7.5 and 3.7.6) also recorded kittiwake throughout the area surveyed, albeit in much greater numbers during the summer.

3.52 The Beatrice Demonstrator data reveal a slightly different seasonal pattern from that seen in the boat data, with a later peak in sightings occurring during July (Figure 3.7.4). The RSPB observations may offer an explanation for this different peak (Figure 3.7.5). These data suggested that during the early part of the breeding season there was a preference for the northern areas of the Moray Firth (where the Wind Farm Site is located). Later in the breeding season higher densities were observed through the southern half of the region, and this includes the Beatrice Alpha platform from which the observations were made.

3.53 Further support for the importance of the southern half of the Moray Firth for kittiwake during the breeding season can be seen from the results of the 2011 tracking study (Figure 3.7.7, Figure A4.2), which revealed kittiwake making extensive foraging trips to sites within the southern half of the region. It should be noted however, that these data represent snapshots of kittiwake distribution and were collected during different periods, nonetheless it does seem plausible that kittiwake make use of large areas within the Moray Firth and as such the Wind Farm Site does not appear to represent a site of high importance.

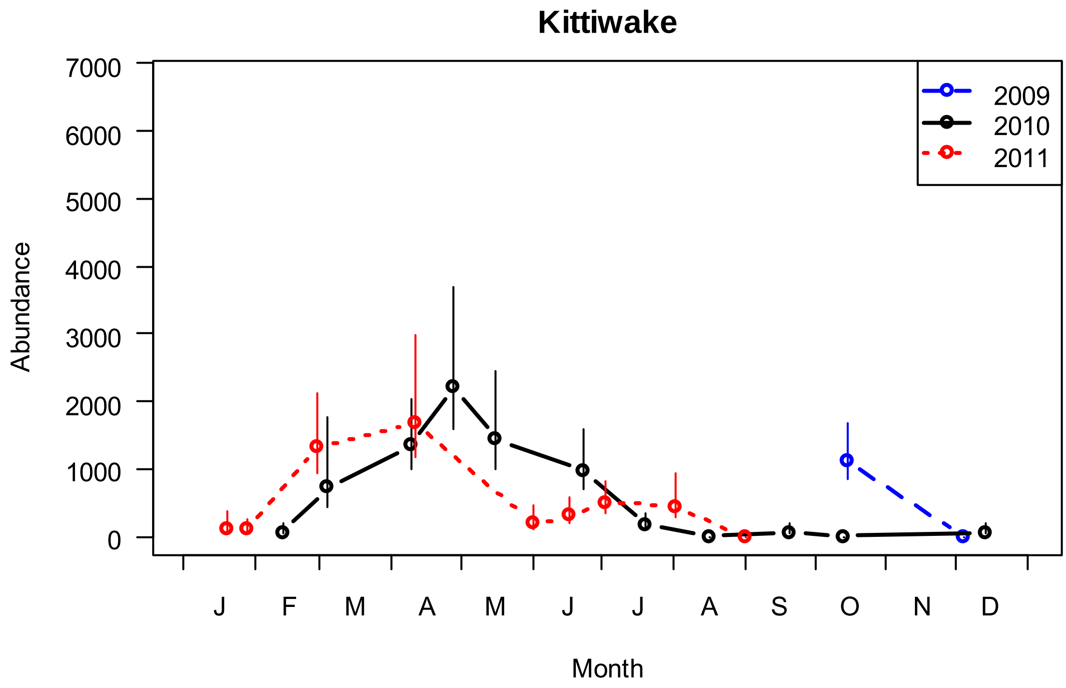


Figure3.7.2: Kittiwake seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).

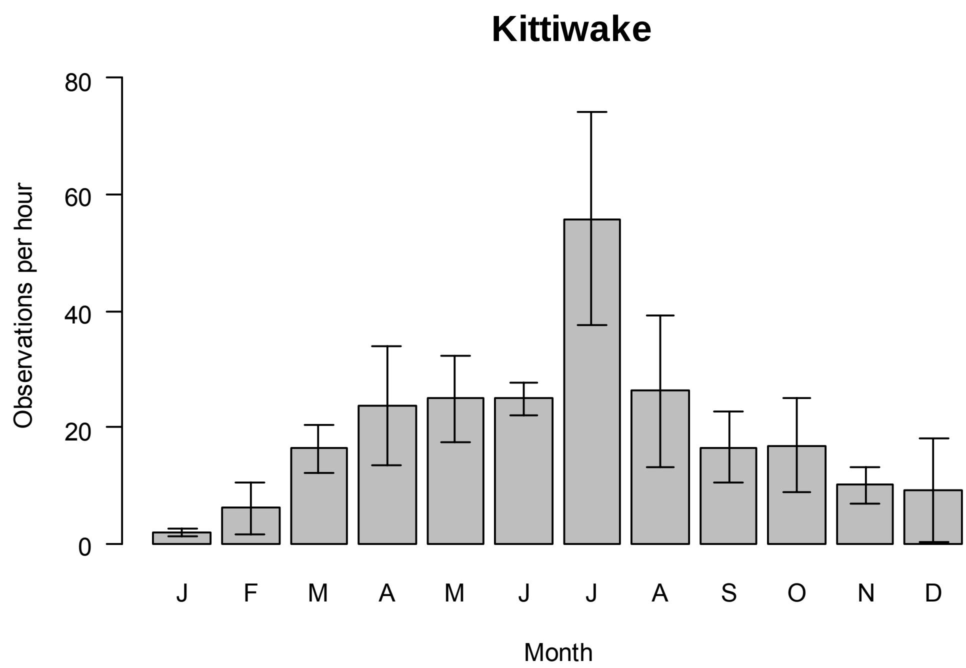
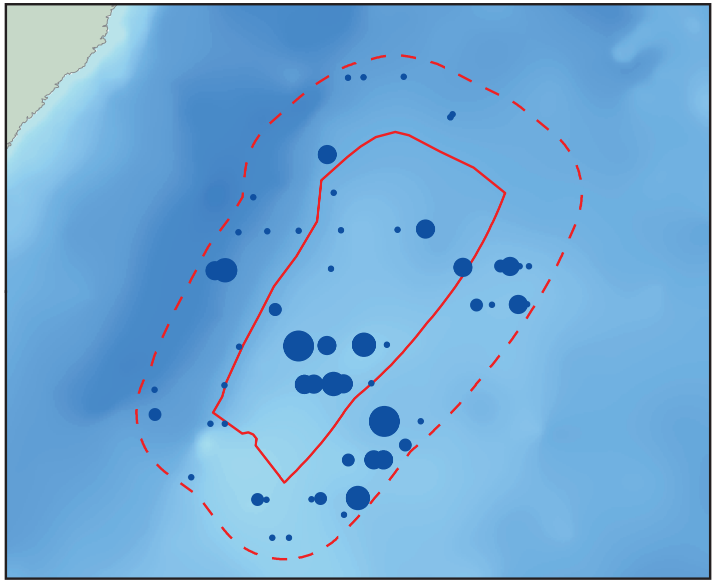
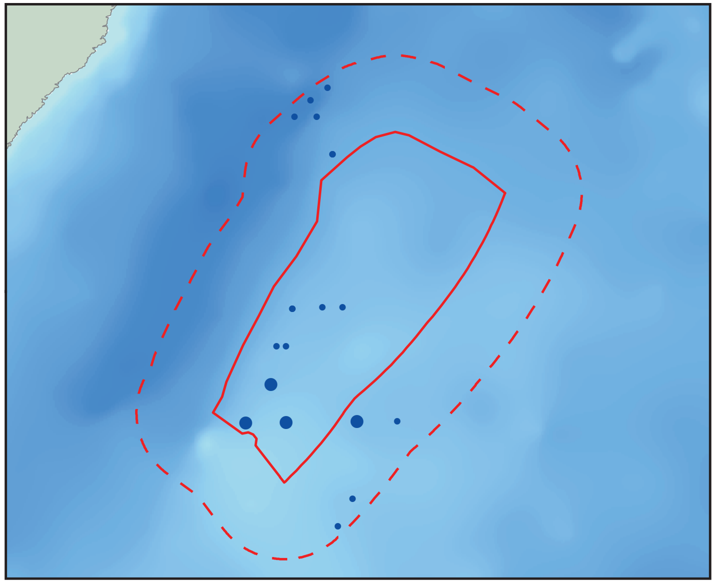


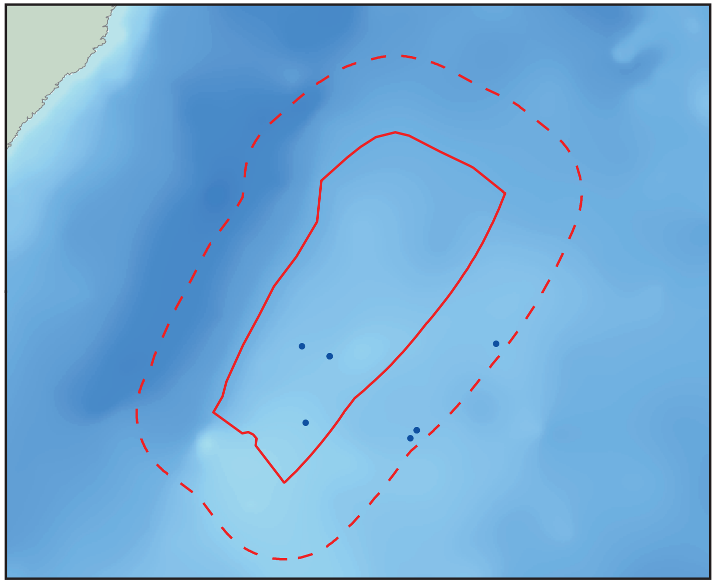
Figure 3.7.4: Average seasonal distribution (± 1 standard error) of Bla ck-legged Kittiwake recorded from the Beatrice Alpha O il Platform between 2005 – 200 8 for the Beatri ce Demonstrator Project



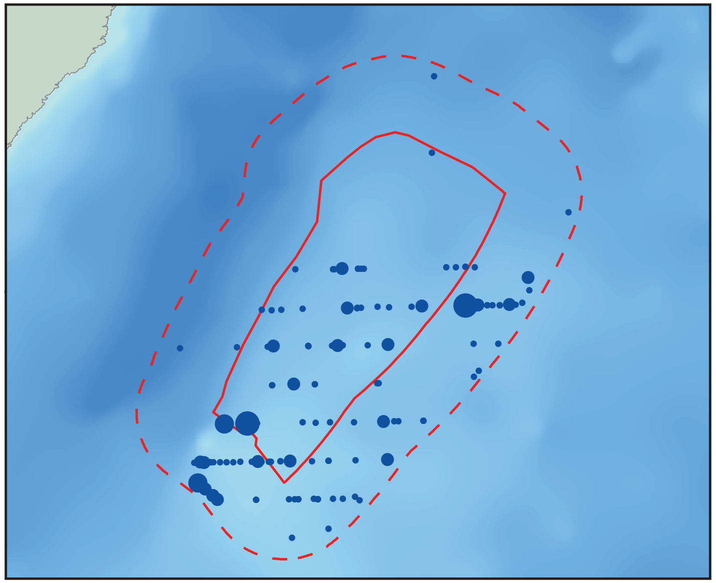
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km   0 1 2 3 4 5 Nm

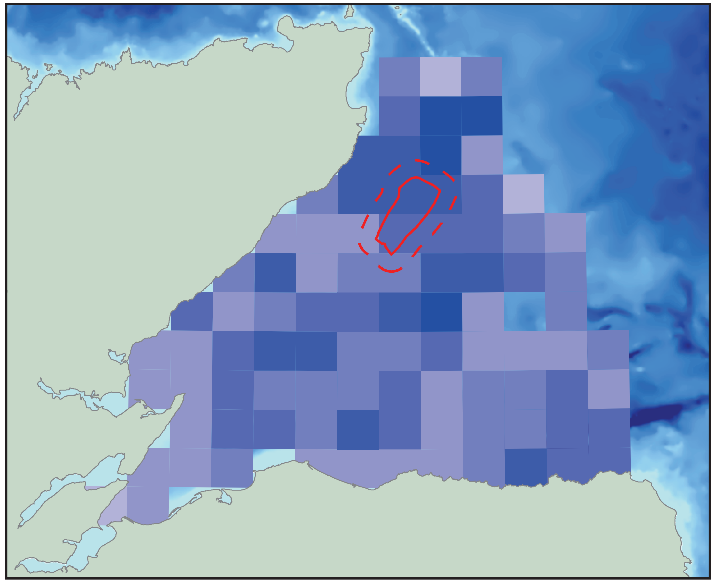
Beatrice Offshore Wind Farm

Figure 3.7.1

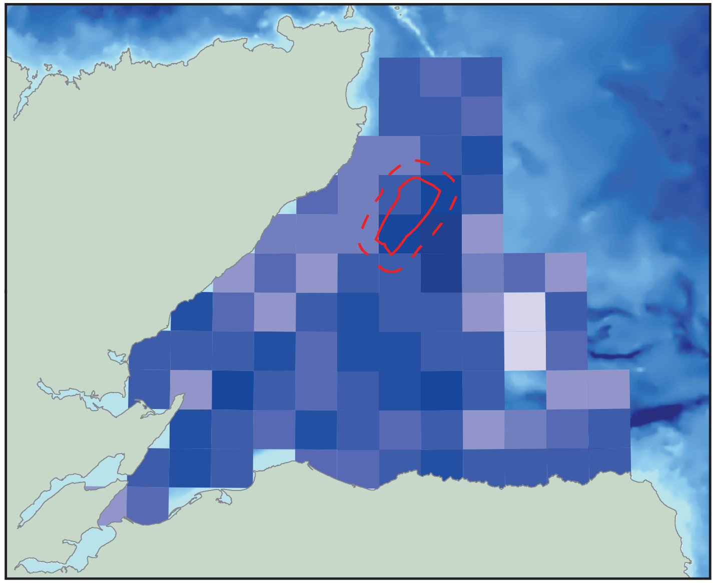
Boat based observations of Kittiwake between October 2009 and July 2011

Drawn:	CH	**Checked:**	MT	**Approved:**	MT
Date:	02/09/2011	**Scale:**	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2			**Revision:**	03
Datum:	WGS84	**Projection:**	UTM Zone 30 N		

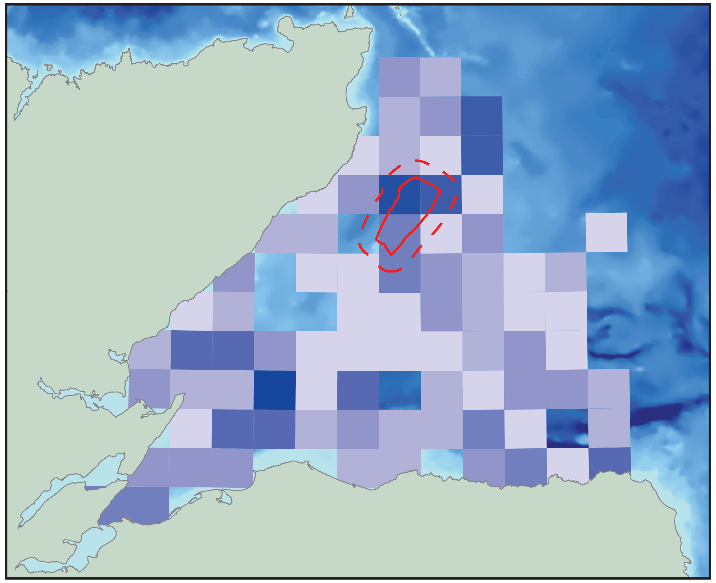
Beatrice
Offshore Windfarm Ltd



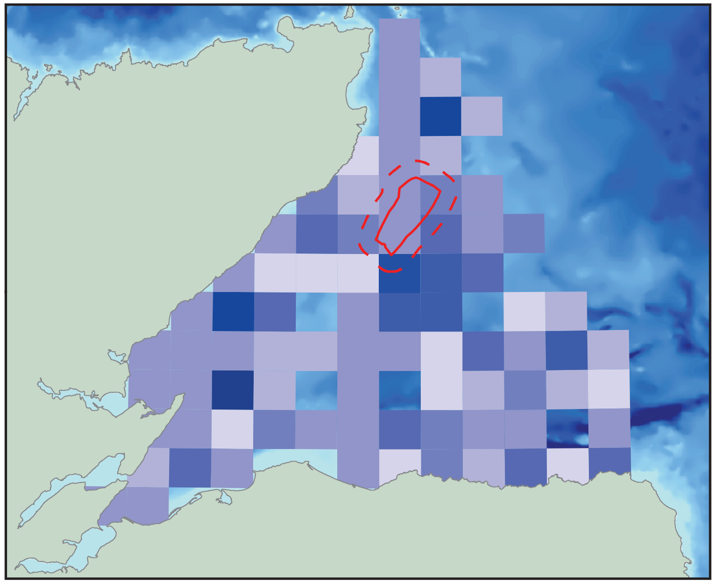
May to July



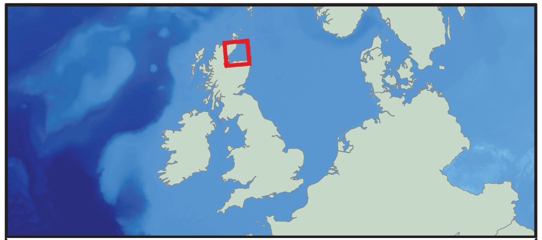
August to October



November to January



February to April



Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km

0 5 10 20 Nm

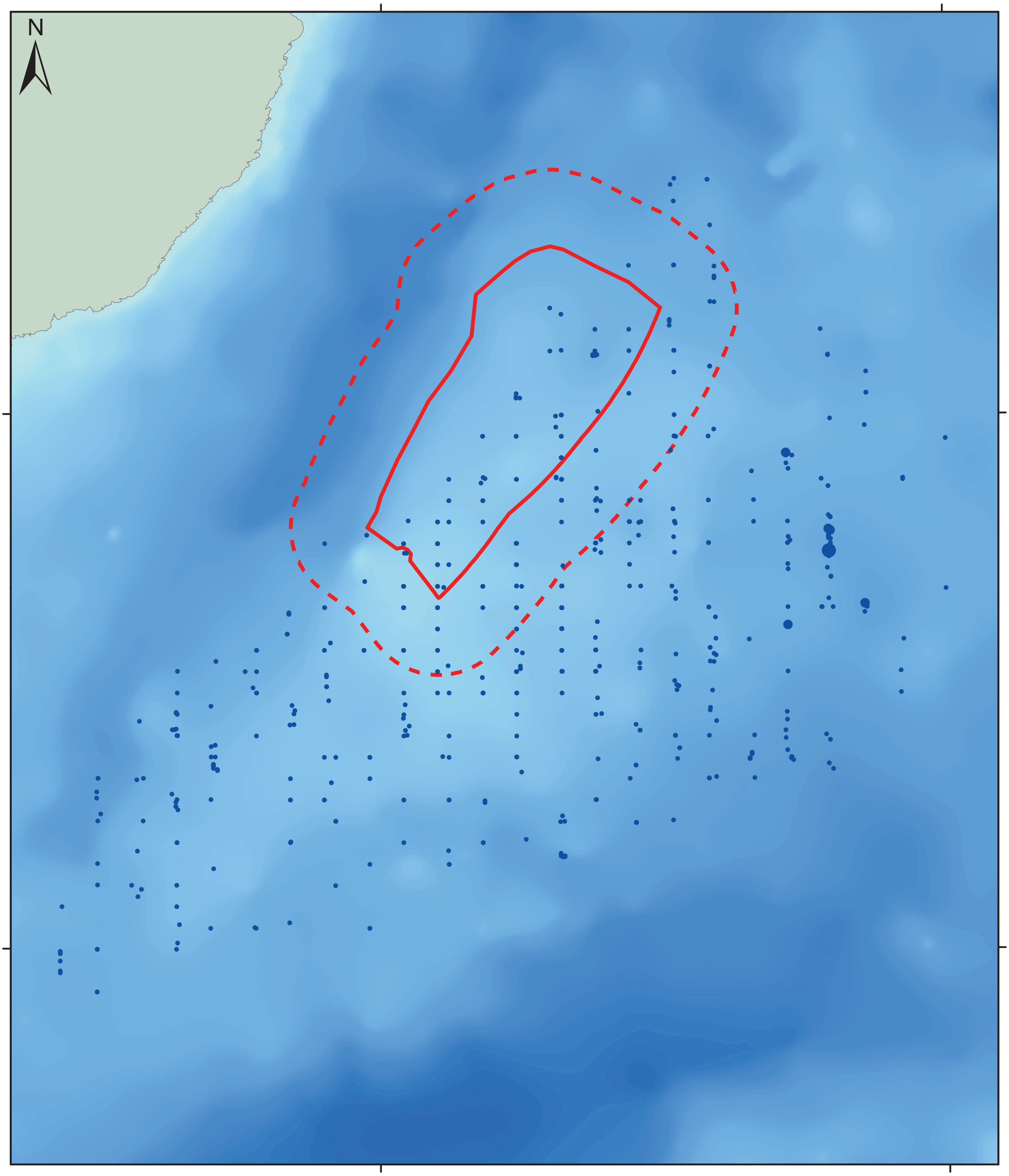
Beatrice Offshore Wind Farm

Figure 3.7.3

Mean density of Kittiwake derived from boat-based observations between January 1982 and December 1983

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice
Offshore Windfarm Ltd



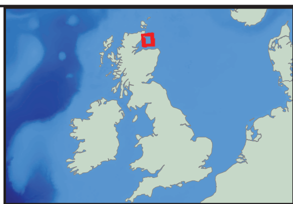
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

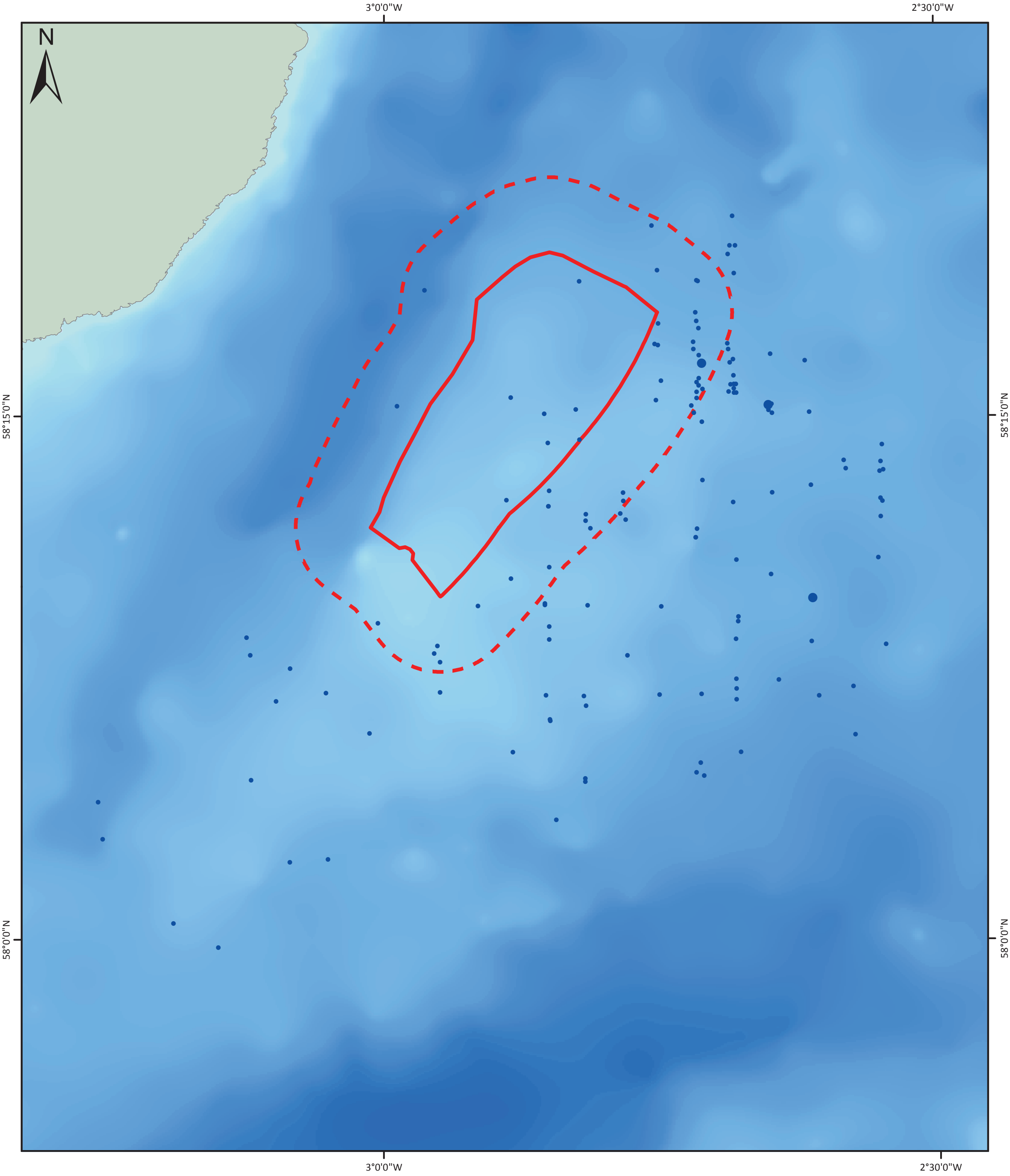
Beatrice Offshore Wind Farm

Figure 3.7.5

Aerial survey observations of Kittiwake between May and August 2009

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_5_aerial_hidefBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



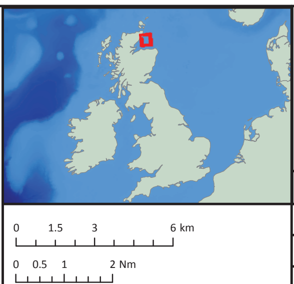
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



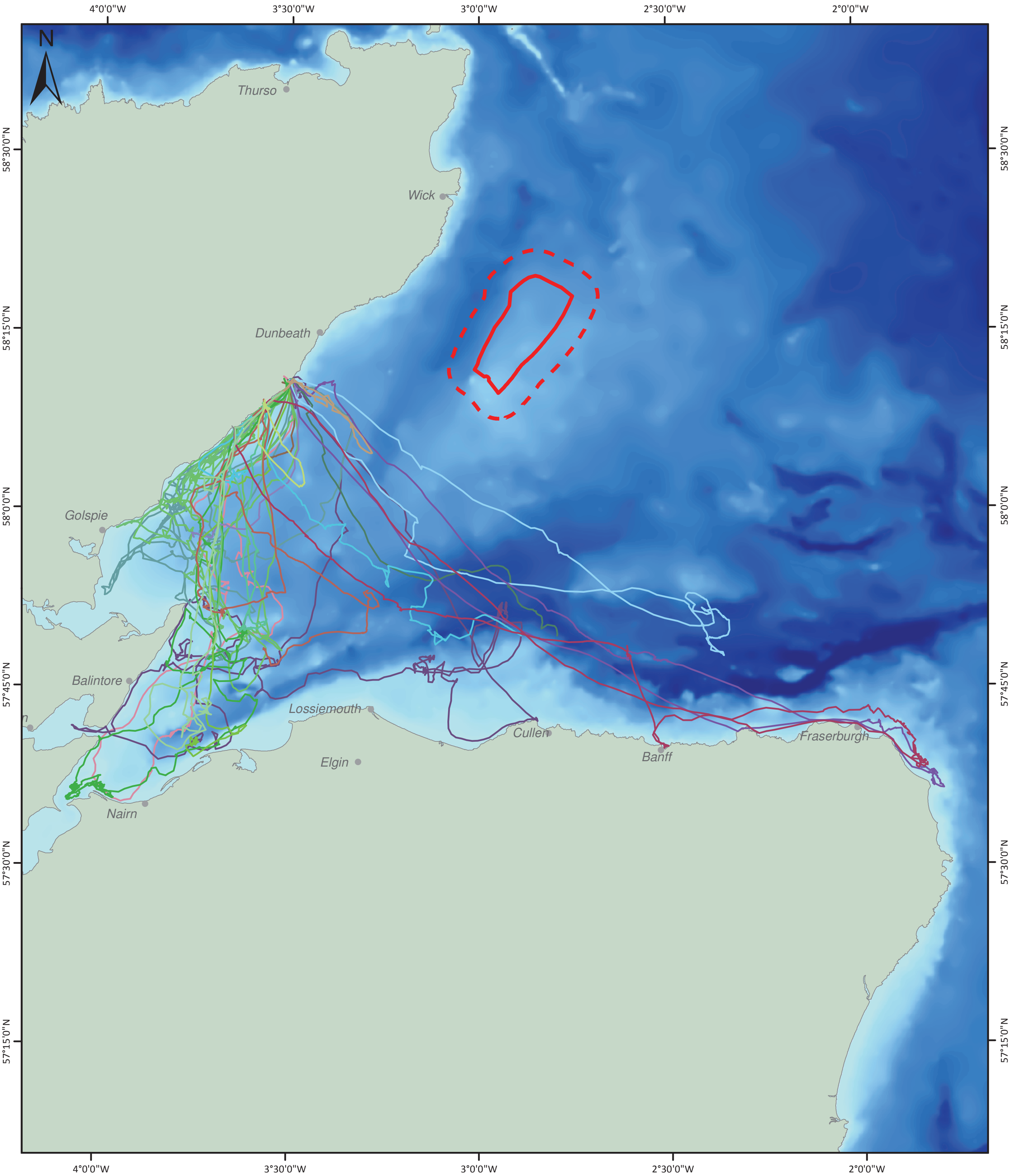
Beatrice Offshore Wind Farm

Figure 3.7.6

Aerial survey observations of Kittiwake between November 2009 and February 2010

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_6_aerial_wwtBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

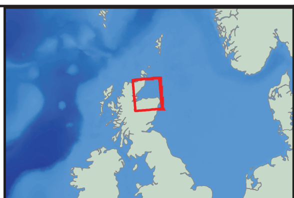


Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Different coloured lines represent individual birds



0 5 10 20 km

0 3 6 12 Nm

Beatrice Offshore Wind Farm

Figure 3.7.7

The foraging range of individual breeding Kittiwake tracked by satellite telemetry during spring 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	30/08/2011	Scale:	1:807,000		
Drawing Number:	sgp6355_Beatrice_3_01_7_satTracks1			Revision:	01
Datum:	WGS1984	Projection:	UTM Zone 30N		

Beatrice
Offshore Windfarm Ltd

Great black-backed gull

3.54 An estimated 95,546 pairs of great black-backed gulls live along the edge of the Atlantic (Hagemeijer and Blair 1997), with about 18,000 of those pairs residing in Britain (Mitchell *et al.* 2004). Of the British population, 85 % breed in Scotland, with the majority of these populations occurring on Orkney, Shetland and the west coast (Lloyd *et al.* 1991).

3.55 An estimated 180 pairs breed on the East Caithness cliffs, with an unknown number in North Caithness. The birds in East Caithness account for about 1 % of the total British great black-backed gull breeding population (Mitchell *et al*. 2004). The British breeding population does not migrate, but remains resident year round (Stone *et al.* 1995). Population declines of up to 30 % have been recorded in the north of Scotland between 2003 and 2004. Complete colony failure occurred in several monitored locations in 1997 and 2003 (Mavor *et al.* 2004).

3.56 The peak density of foraging birds observed on the boat based study area was 1.45 per km^2 with an estimated peak spring abundance (April 2011) of 547 individuals in the area (Figures 3.8.1 and 3.8.2). Between 1998 and 2002, the total number of Moray Firth coast breeding pairs was estimated at 412 (Mitchell *et al*. 2004). However, the key breeding months of May, June and July (Snow and Perrins 1998), correspond to the lowest on site abundances (Figure 3.8.2), with numbers increasing during the post-breeding period from August through until April. Large numbers breed in Orkney (5,505) and North Sutherland (1,058) (Mitchell *et al*. 2004). Thus it seems likely that many of the birds seen on site are seen whilst on passage to and from these breeding colonies.

3.57 The Beatrice Demonstrator data suggest a similar seasonal pattern, with very low numbers recorded during the breeding season (Figure 3.8.4), but climbing immediately afterwards. The RSPB data reveal very even distributions throughout the region and throughout the year (Figure 3.8.3), with similar densities found across the whole area surveyed.

3.58 The seasonal patterns seen during the boat surveys and in the Beatrice Demonstrator data, were repeated in the aerial surveys, with low numbers recorded in summer (Figure 3.8.5), and higher numbers recorded in winter (Figure 3.8.6).

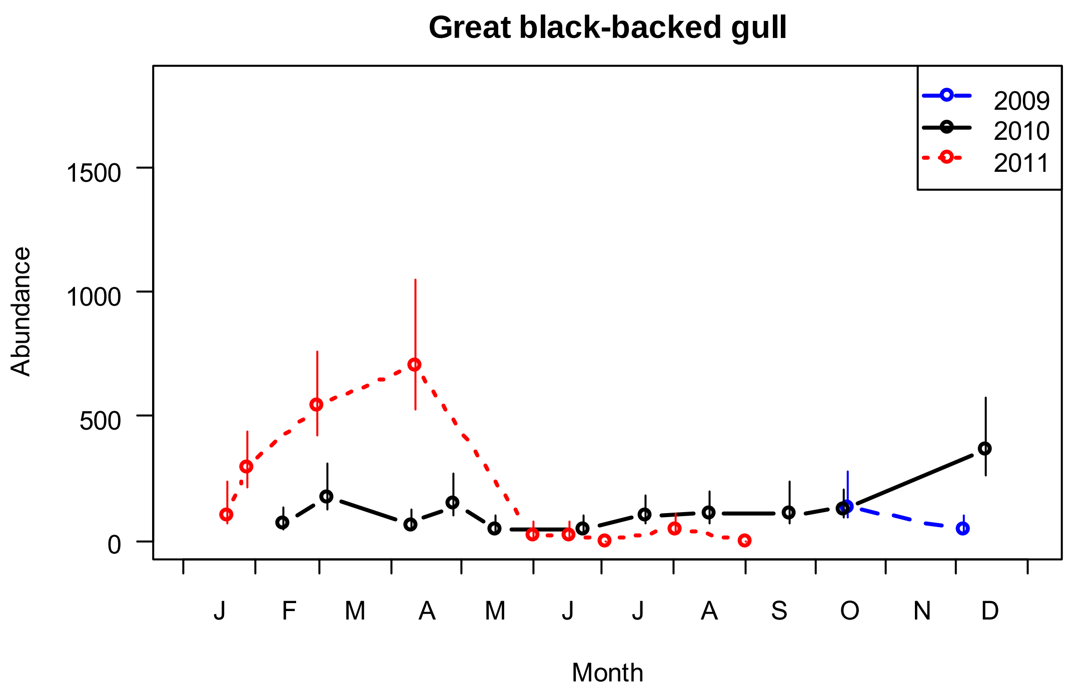


Figure 3.8.2: Great black-backed gull seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).

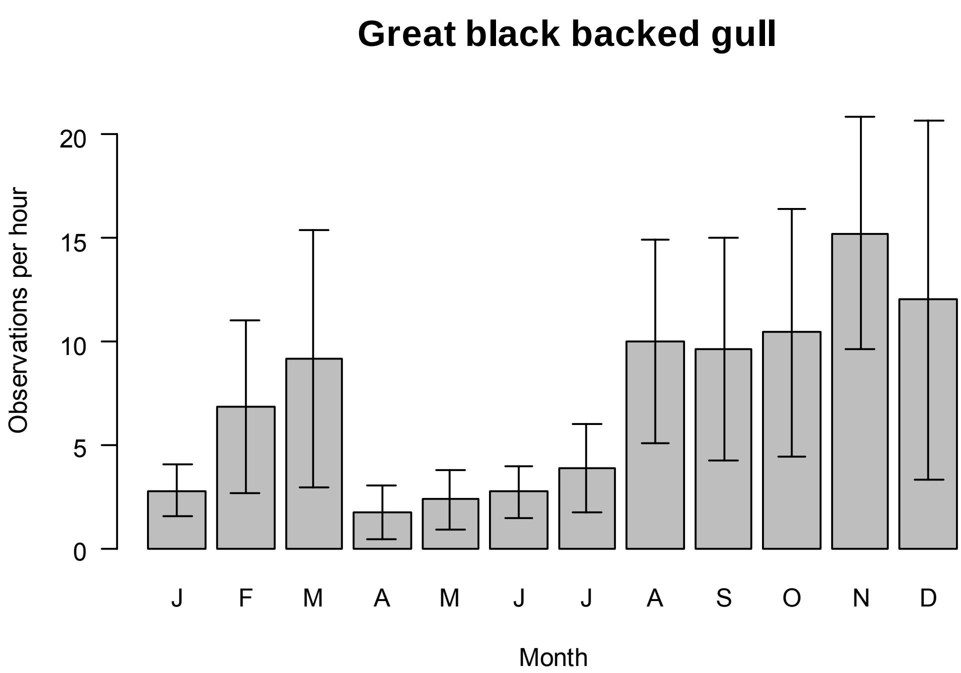
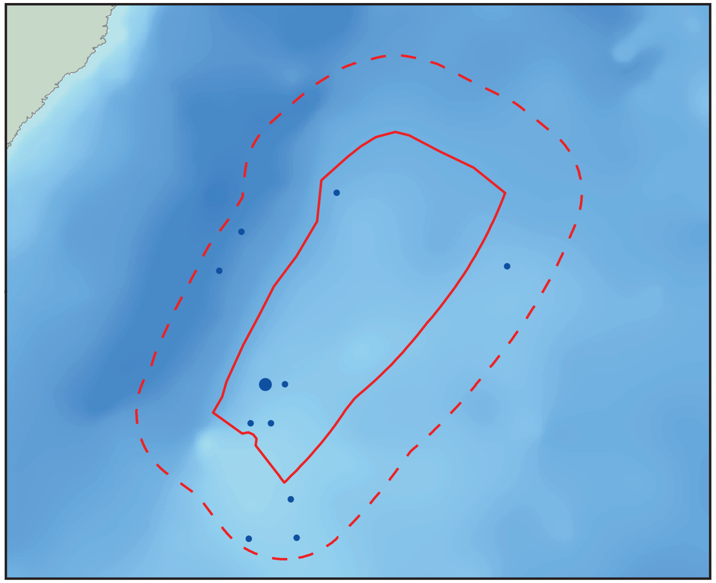
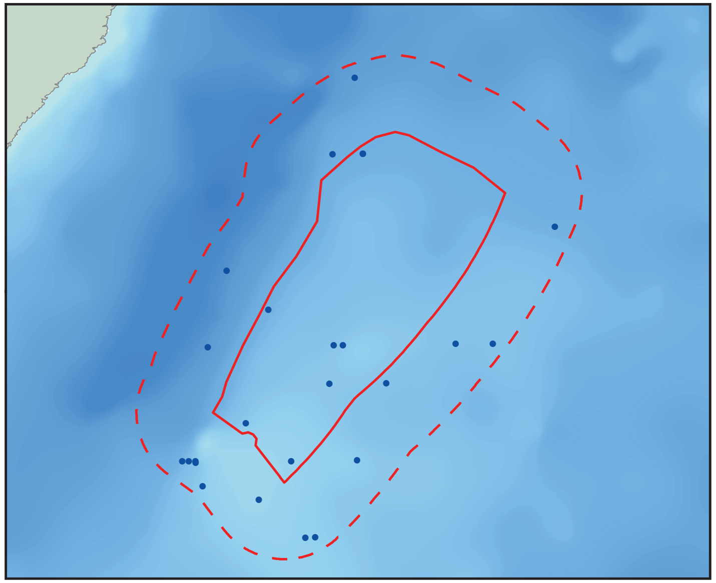


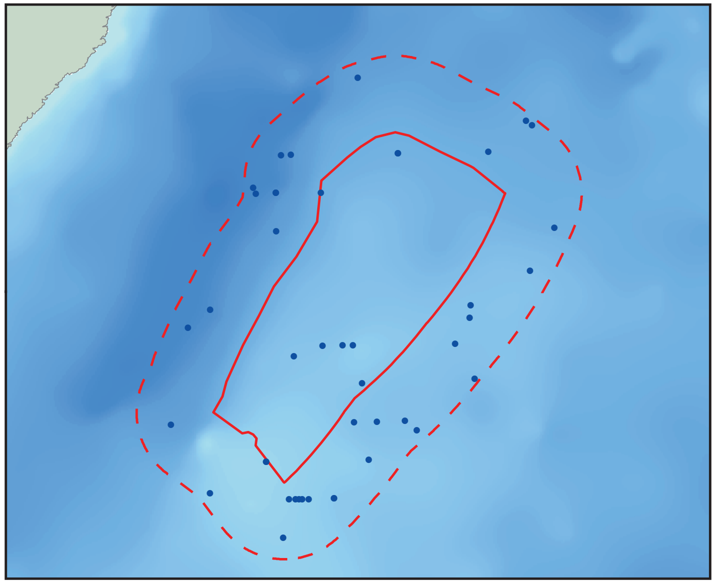
Figure 3.8.4 Average se asonal distribution (± 1 stand ard error) of g reat black-backed gull recorded from the Beatrice Alpha O il Platform between 2005 – 200 8 for the Beatri ce Demonstrator Project



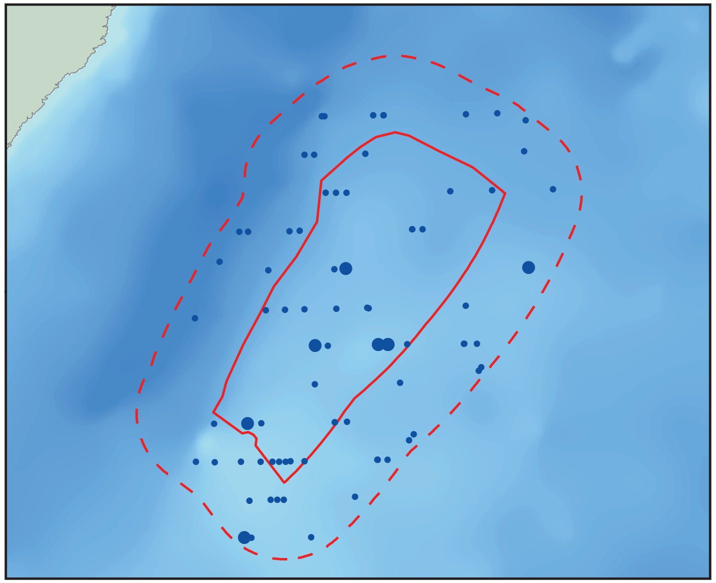
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km   0 1 2 3 4 5 Nm

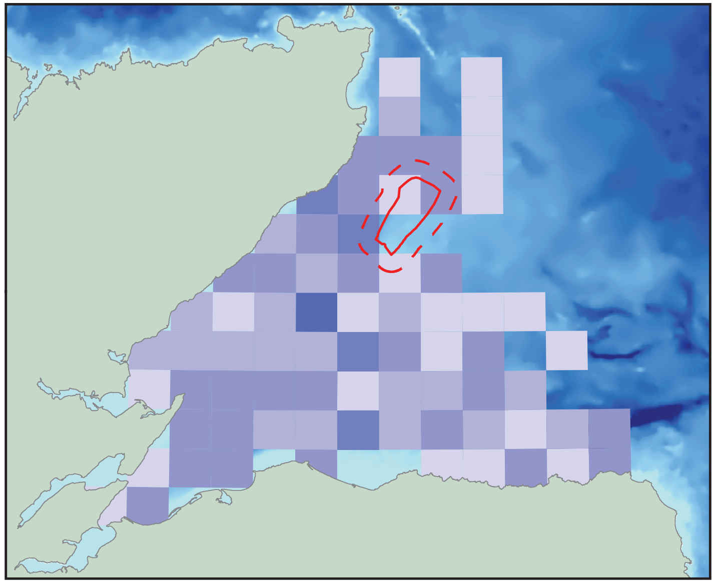
Beatrice Offshore Wind Farm

Figure 3.8.1

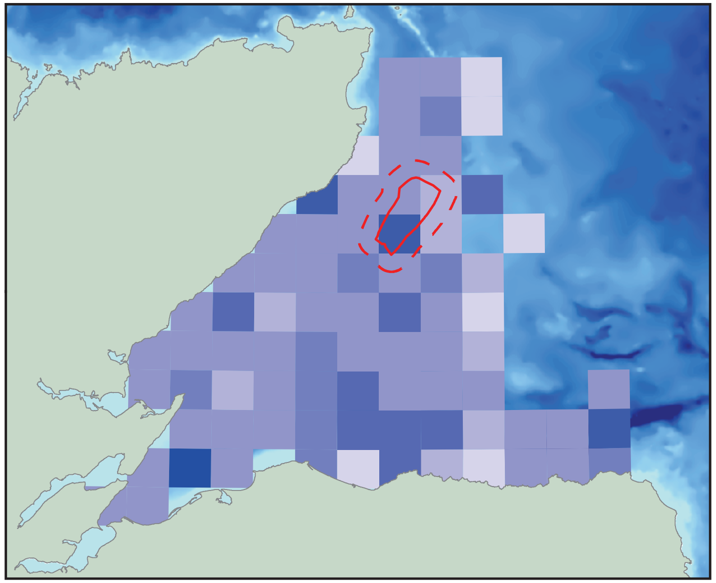
Boat based observations of Great black-backed gull between October 2009 and July 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2	Revision:	03		
Datum:	WGS84	Projection:	UTM Zone 30 N		

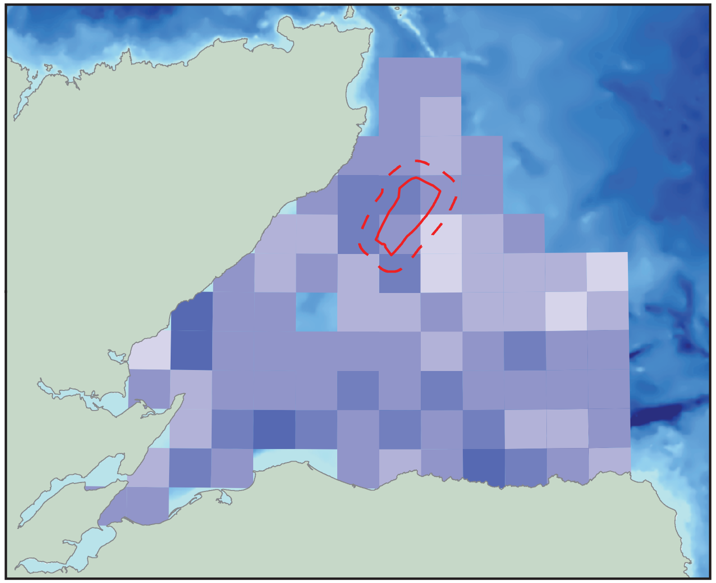
Beatrice
Offshore Windfarm Ltd



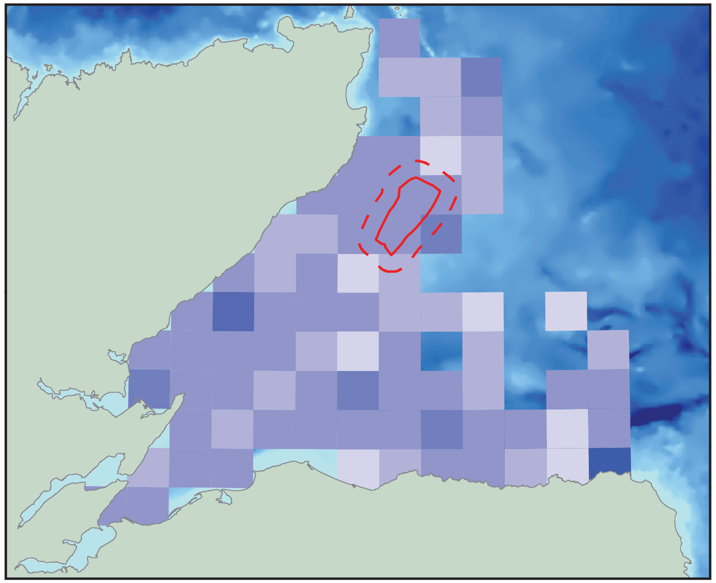
May to July



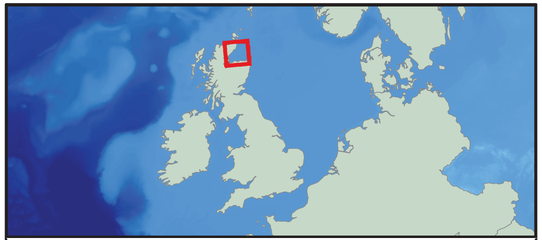
August to October



November to January



February to April



Legend

- Site boundary buffered by 4 km
- Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km
0 5 10 20 Nm

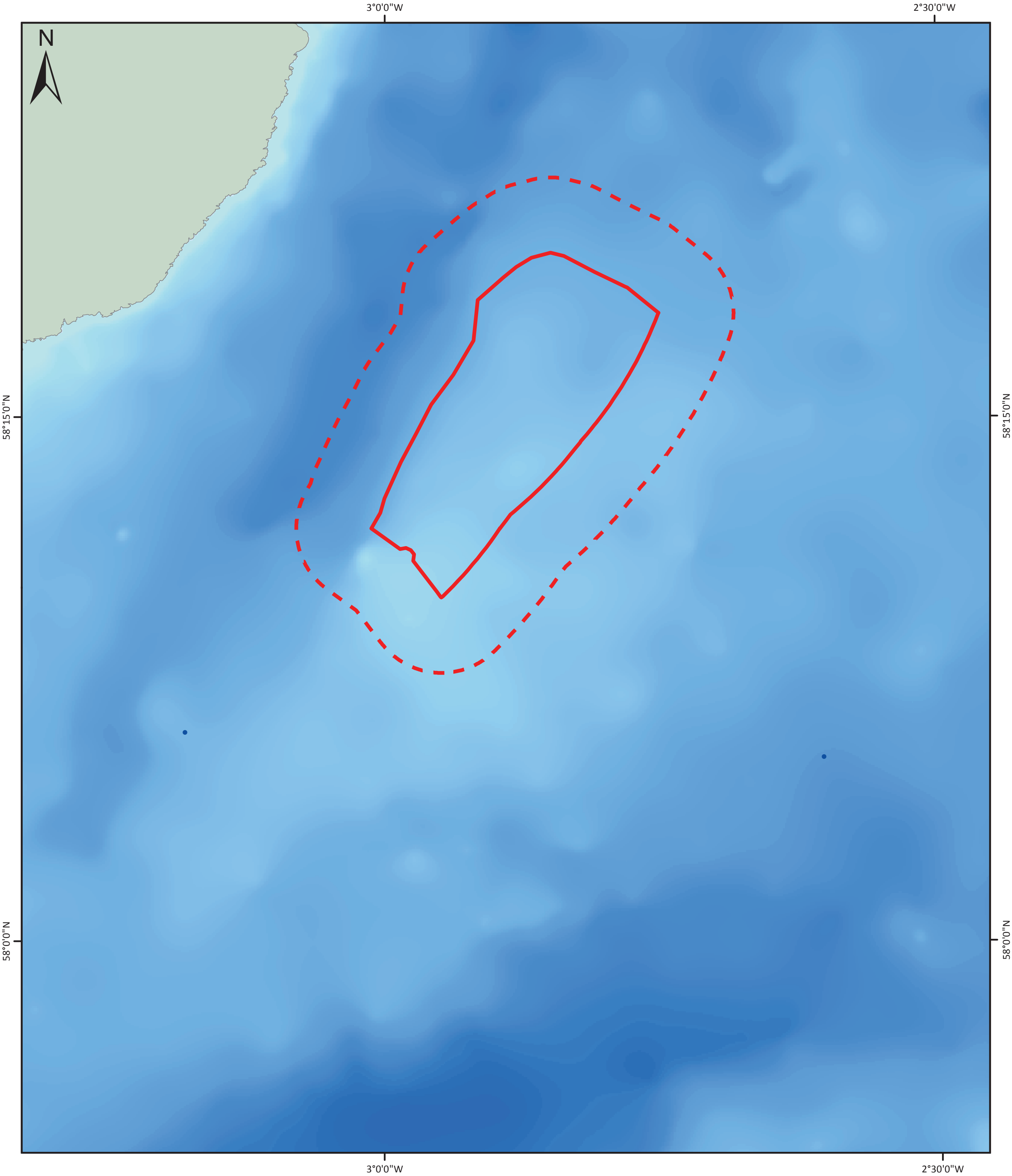
Beatrice Offshore Wind Farm

Figure 3.8.3

Mean density of Great Black-backed Gull derived from boat-based observations between January 1982 and December

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice
Offshore Windfarm Ltd



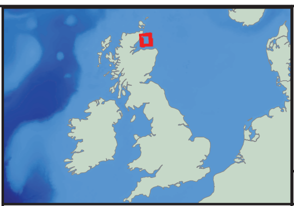
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

This map contains TCarta and UKCS Bathymetry, 2009.

NOT TO BE USED FOR NAVIGATION

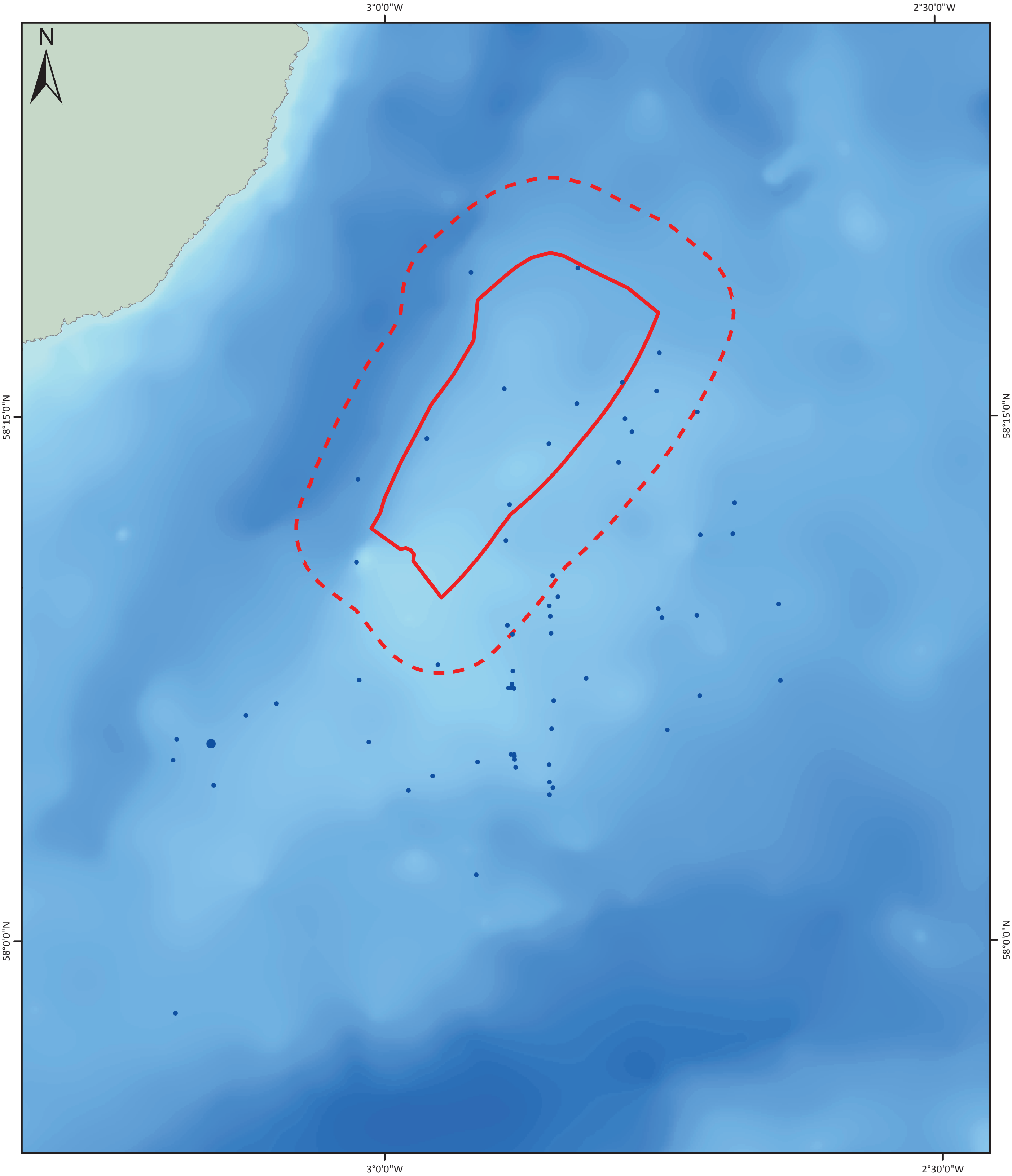
Beatrice Offshore Wind Farm

Figure 3.8.5

Aerial survey observations of Great black-backed gull between May and August 2009

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	30/08/2011	Scale:	1:275,000		
Drawing Number:	sgp6355_Beatrice_3_01_5_aerial_hidefBirdObs1			Revision:	01
Datum:	WGS1984	Projection:	UTM Zone 30N		

Beatrice
Offshore Windfarm Ltd

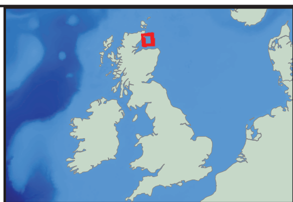


Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

Beatrice Offshore Wind Farm

Figure 3.8.6

Aerial survey observations of Great black-backed gull between November 2009 and February 2010

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	30/08/2011	Scale:	1:275,000		
Drawing Number:	sgp6355_Beatrice_3_01_6_aerial_wwtBirdObs1			Revision:	01
Datum:	WGS1984	Projection:	UTM Zone 30N		

Beatrice
Offshore Windfarm Ltd

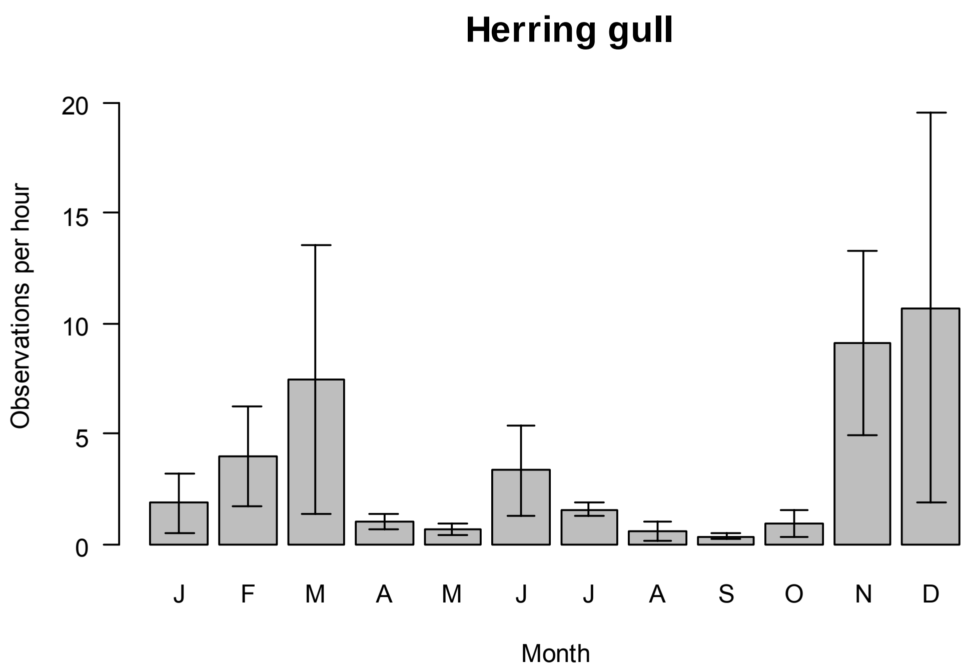
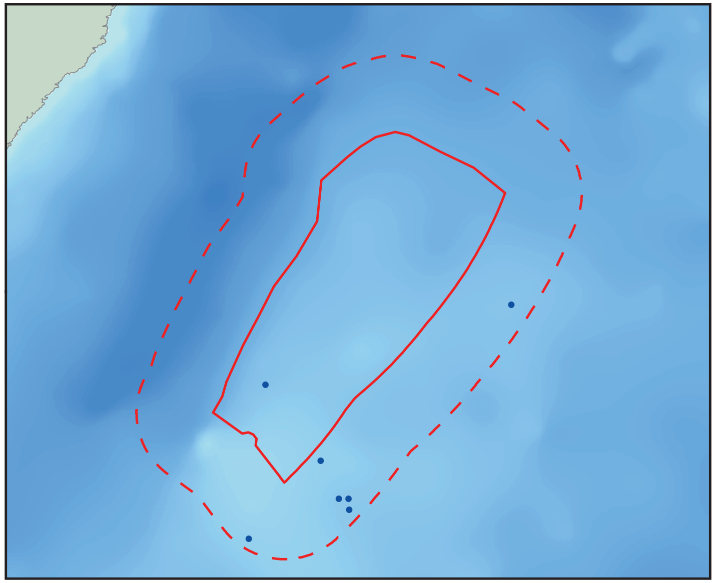
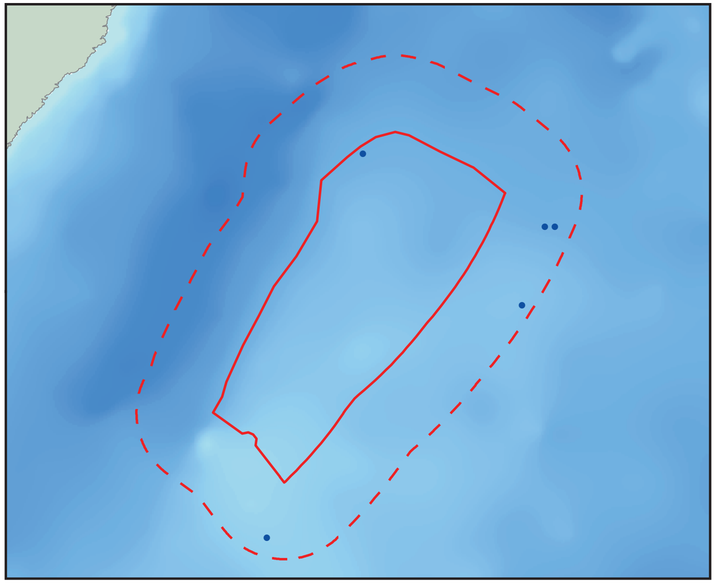


Figure 3.9.4: Average seasonal distribution (± 1 standard error) of {species} recorded from the Beatrice Alpha Oil Platform between 2005 – 2008 for the Beatrice Demonstrator Project

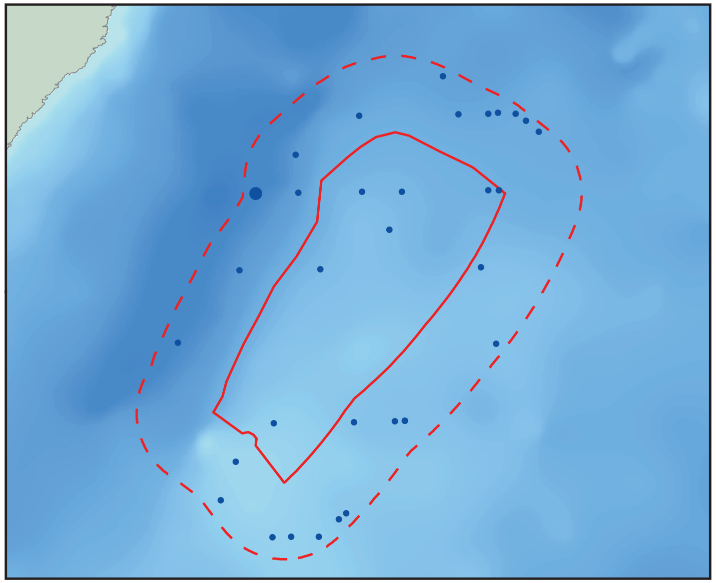
3.62 The RSPB data show very little variation in distribution or density throughout the year throughout the Moray Firth (Figure 3.9.3). However the aerial surveys provide further evidence of the differences in numbers in the area of the Wind Farm Site between the summer (Figure 3.9.5) and winter (Figure 3.9.6).



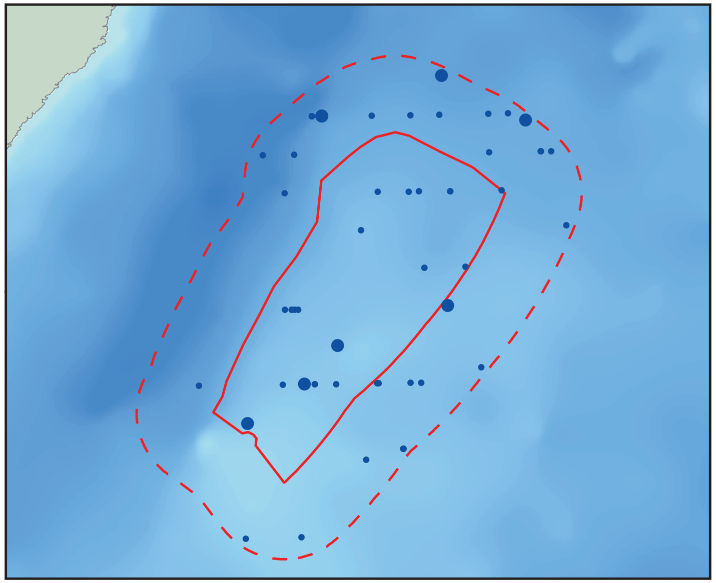
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km | 0 1 2 3 4 5 Nm

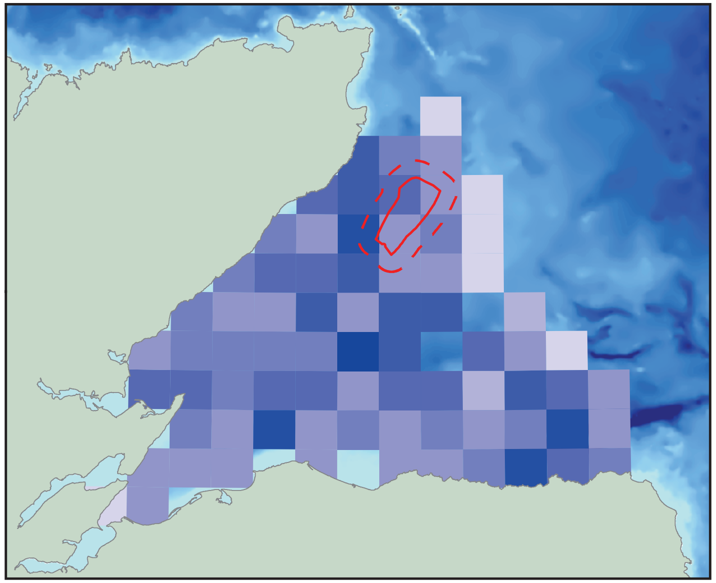
Beatrice Offshore Wind Farm

Figure 3.9.1

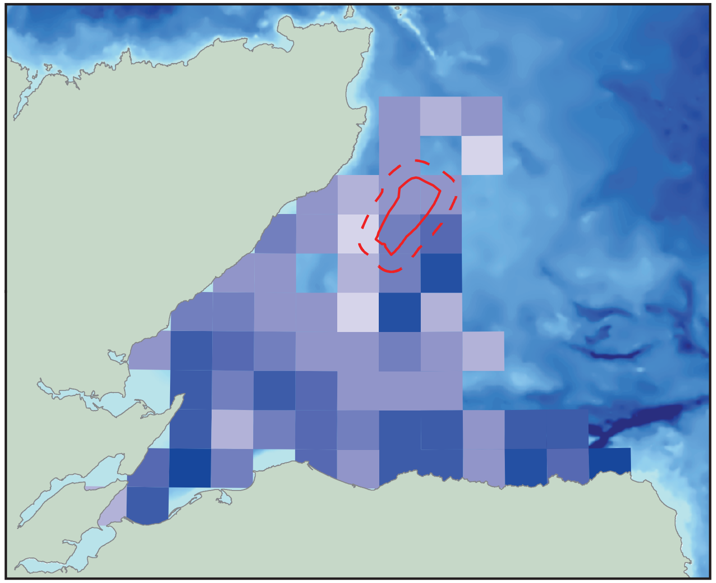
Boat based observations of Herring gull between October 2009 and July 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2	Revision:	03		
Datum:	WGS84	Projection:	UTM Zone 30 N		

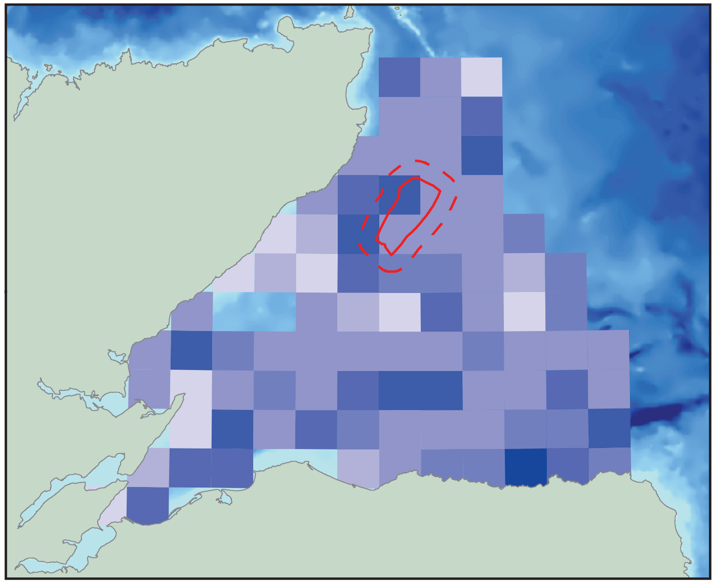
Beatrice
Offshore Windfarm Ltd



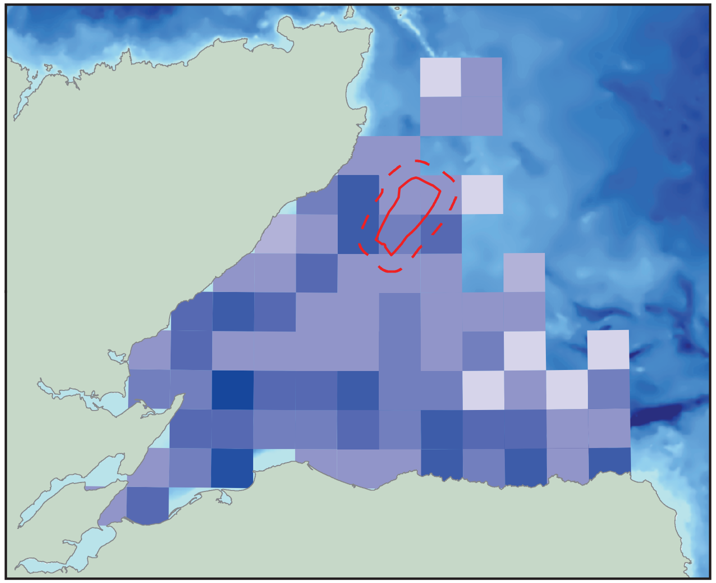
May to July



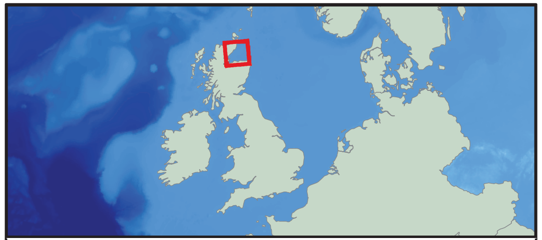
August to October



November to January



February to April



Legend

- Site boundary buffered by 4 km
- Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km   0 5 10 20 Nm

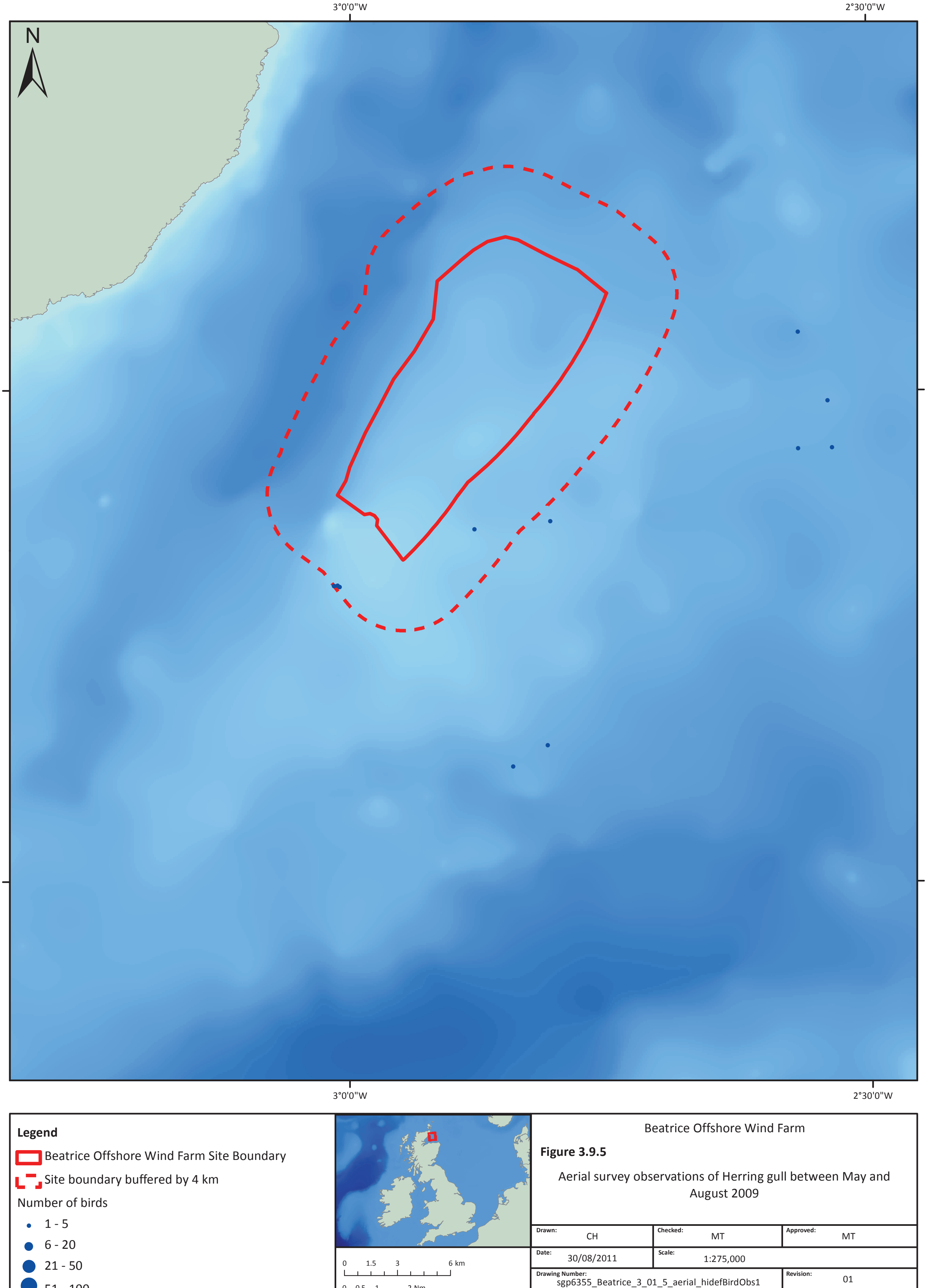
Beatrice Offshore Wind Farm

Figure 3.9.3

Mean density of Herring Gull derived from boat-based observations between January 1982 and December 1983

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice
Offshore Windfarm Ltd



This map contains TCarta and UKCS Bathymetry, 2009.

NOT TO BE USED FOR NAVIGATION

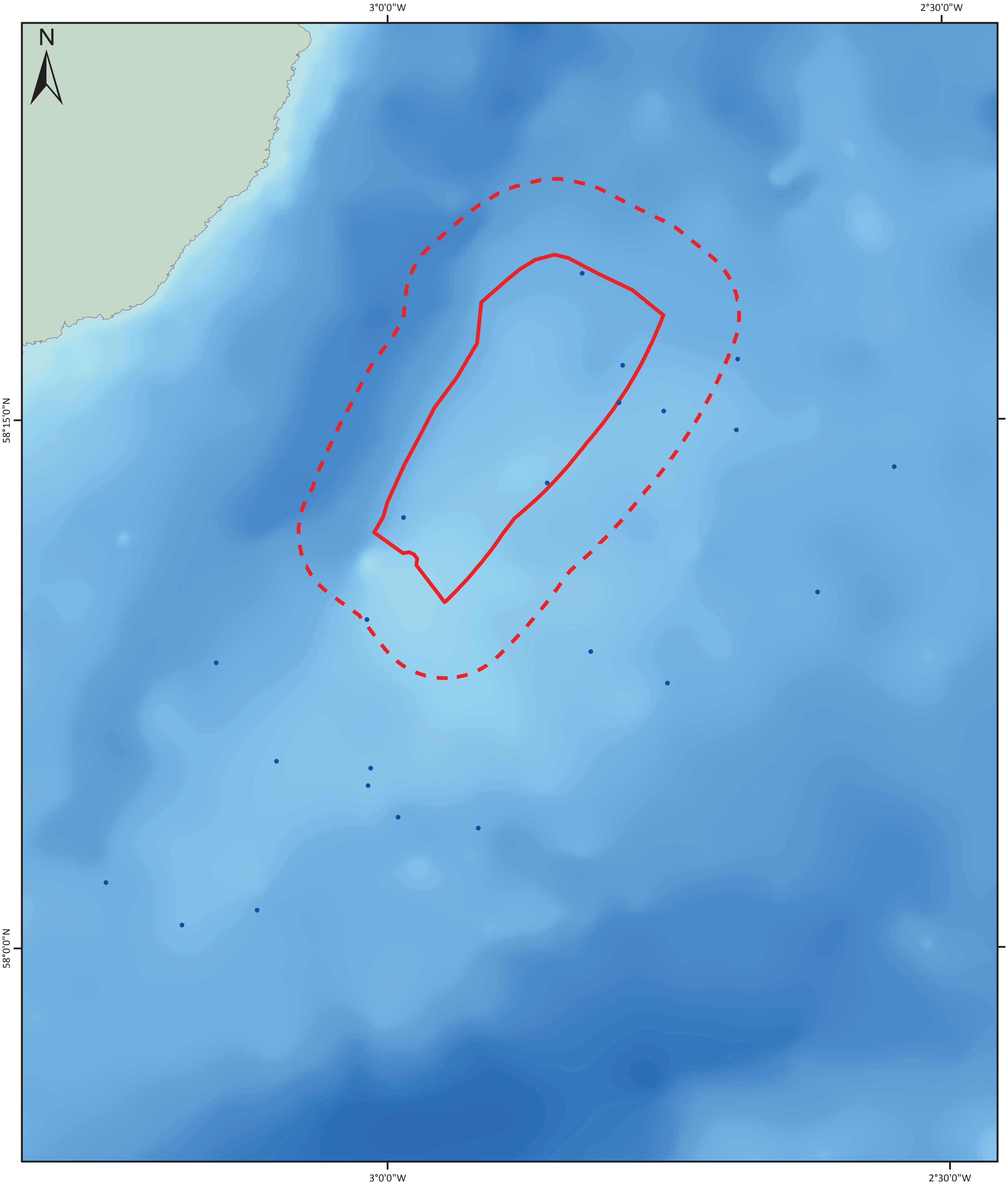
Beatrice Offshore Wind Farm

Figure 3.9.5

Aerial survey observations of Herring gull between May and August 2009

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_5_aerial_hidefBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



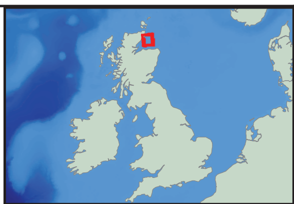
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

Beatrice Offshore Wind Farm

Figure 3.9.6

Aerial survey observations of Herring gull between November 2009 and February 2010

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_6_aerial_wwtBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

Arctic Tern

3.63 About 480,000 - 850,000 pairs of Arctic terns breed in Europe, with about 53,000 of these pairs nesting in Britain. The British breeding population constitutes 4.7 % of the biogeographic population and 3.1 % of the global population (Mitchell *et al.* 2004).

3.64 Mitchell *et al.* (2004) reported that of the British population, 47,306 of these pairs nested in Scotland, predominantly in Shetland and Orkney, with an additional 838 pairs nesting in Caithness and along the Moray Firth. Given the wide-ranging foraging behaviour of these birds, the regional population in this study encompasses the Orkney population.

3.65 Although Arctic terns are not a species of concern in Europe or worldwide, they are of moderate conservation concern in Britain due to recent population declines.

3.66 A total of 29 birds were recorded during the boat surveys (Figure 3.10.1), giving a peak density estimate on the study site of 0.46 which equates to a peak abundance of 174 individuals. However, density estimation using so few observations results in poor estimates, thus these figures should be treated with caution. All individuals were seen between May and August.

3.67 The timing of these observations differs from that recorded for the Beatrice Demonstrator study (Figure 3.10.2), where Arctic terns were only seen in August and September. The RSPB data further reveal the occasional nature of Arctic tern presence within the Moray Firth (Figure 3.10.3).

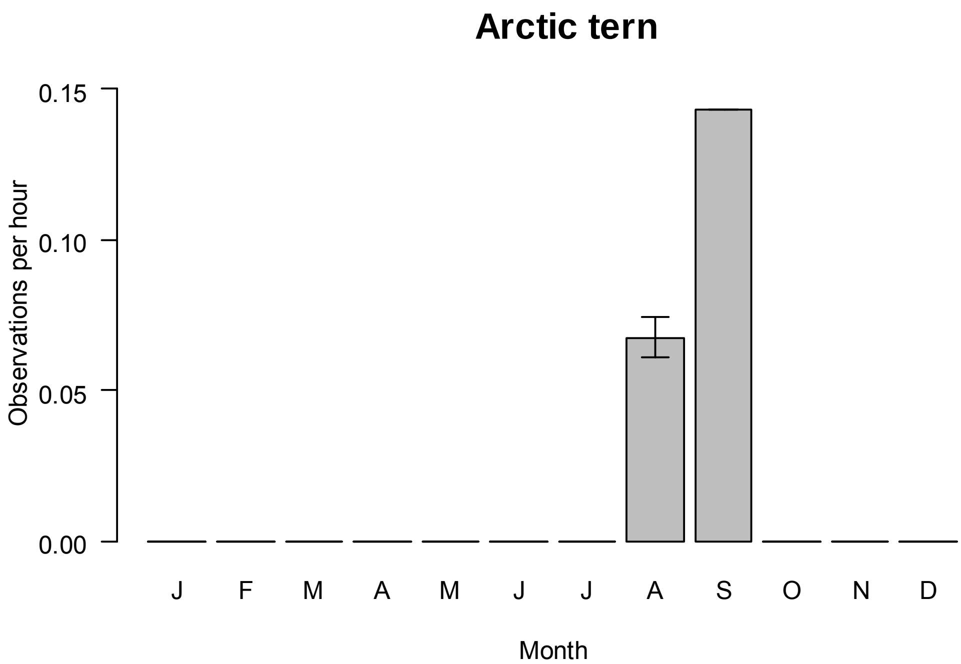
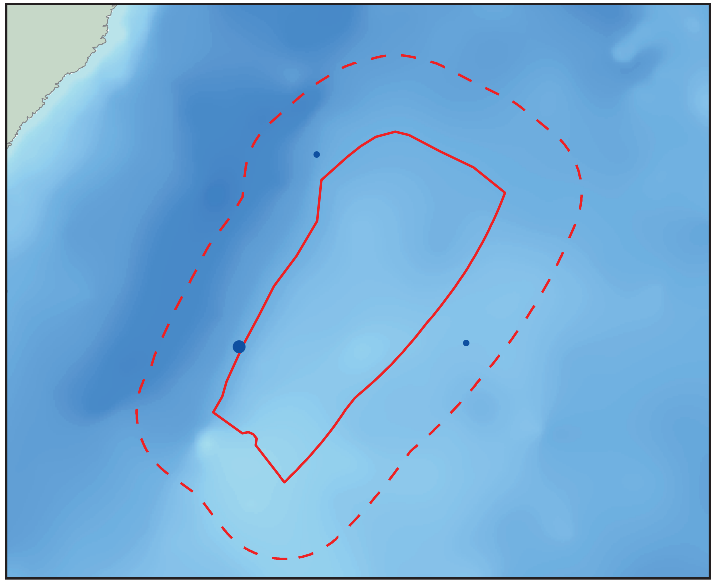
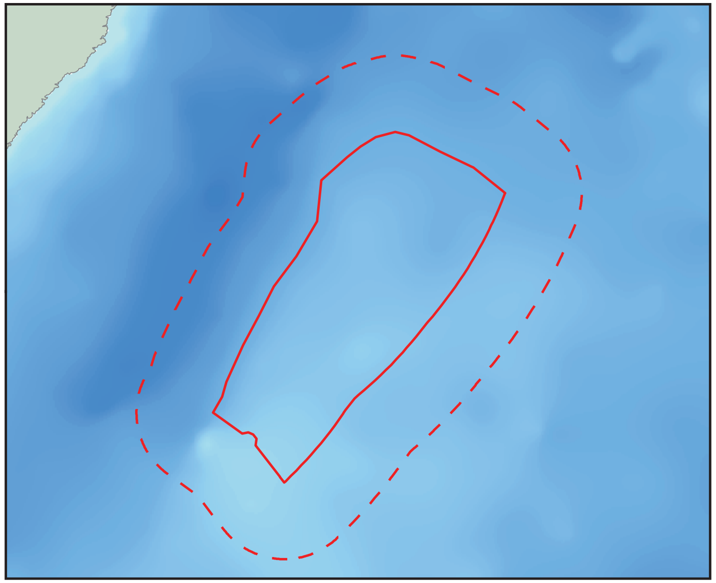


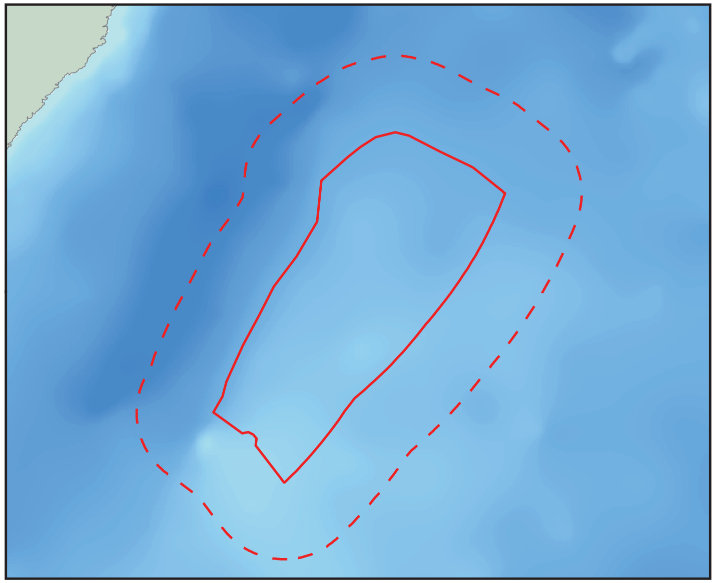
Figure 3.10.2 Average seasonal distribution (± 1 standard error) of {species} recorded from the Beatrice Alpha Oil Platform between 2005 – 2008 for the Beatrice Demonstrator Project



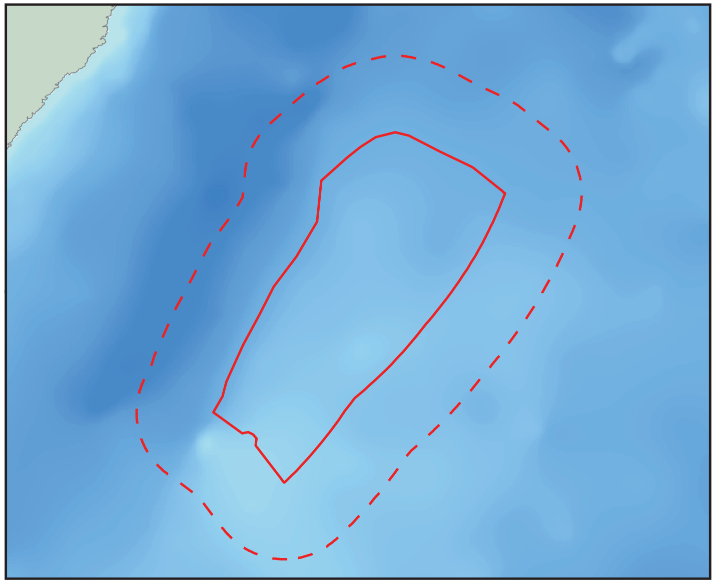
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km   0 1 2 3 4 5 Nm

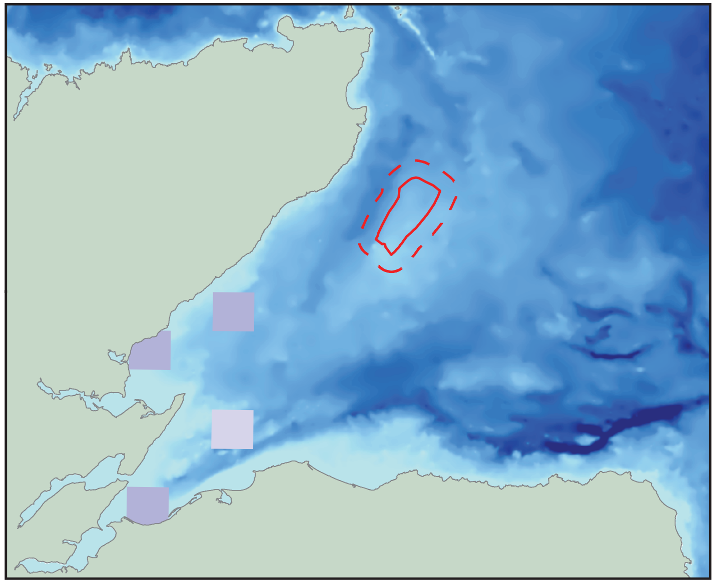
Beatrice Offshore Wind Farm

Figure 3.10.1

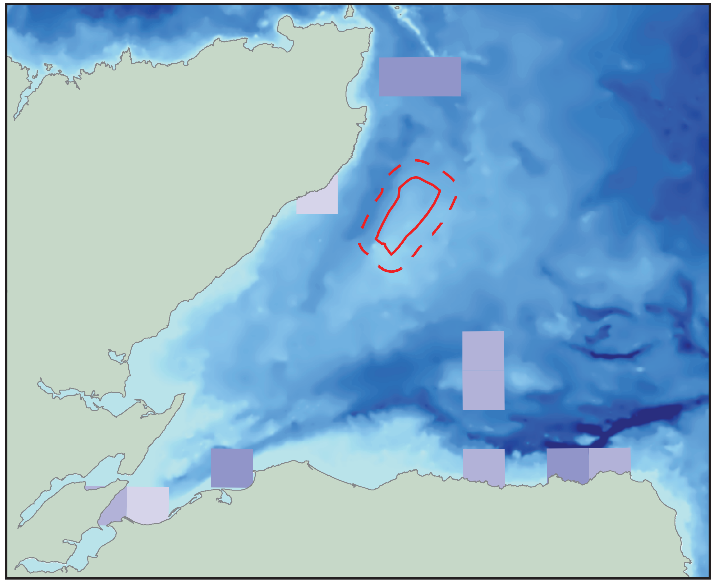
Boat based observations of Arctic tern between October 2009 and July 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2	Revision:	03		
Datum:	WGS84	Projection:	UTM Zone 30 N		

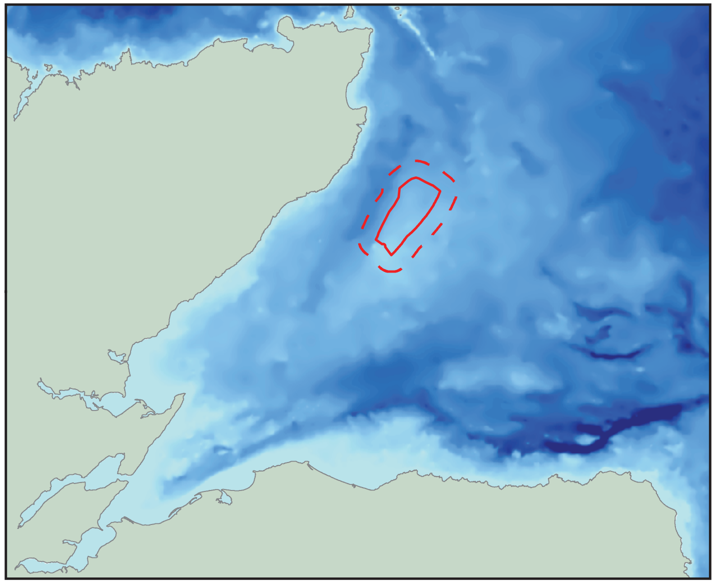
Beatrice
Offshore Windfarm Ltd



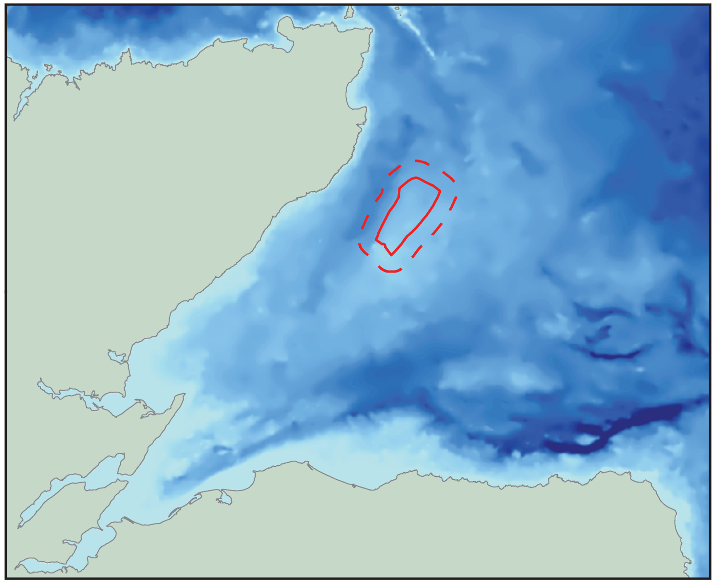
May to July



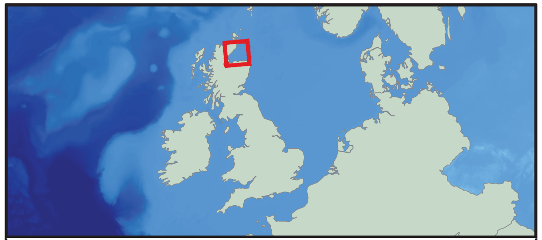
August to October



November to January



February to April



Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km   0 5 10 20 Nm

Beatrice Offshore Wind Farm

Figure 3.10.3

Mean density of Arctic Tern derived from boat-based observations between January 1982 and December 1983

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice
Offshore Windfarm Ltd

Common Guillemot

3.68 Common guillemot (hereafter, guillemot) are considered a species of low conservation concern worldwide. Between 2 and 2.7 million pairs breed in Europe, with 1.3 million individuals in Britain, 1.1 million of which breed in Scotland. However, the species is of moderate conservation concern in Britain, as British guillemots account for a third of the biogeographic population (Mitchell *et al.* 2004).

3.69 An estimated 158,985 individuals breed in the East Caithness Cliffs SPA (SNH 2008a), with an additional 67,074 breeding adults in the North Caithness Cliffs SPA (SNH 2008b). Birds breeding within the East Caithness Cliffs SPA account for about 10 % of the total British guillemot population.

3.70 Data from boat surveys yielded a peak density estimate of 52.83 per km^2 which equated to an estimated peak abundance of 19,961. Peak numbers were observed between April and July inclusive (Figure 3.11.2), with birds seen throughout the boat based study area, although greatest concentrations were recorded in the southern half of the site (Figure 3.11.1).

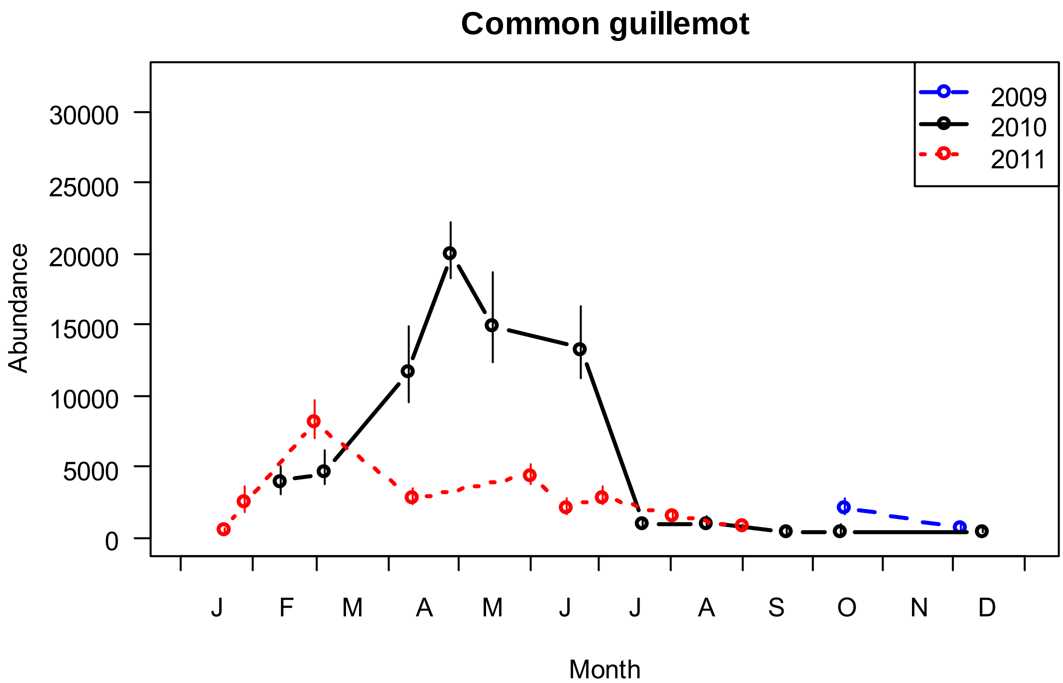


Figure 3.11.2: Common guillemot seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).

3.71 Data from the Beatrice Demonstrator study did not differentiate between auk species, thus only combined seasonal estimates are available (Figure 3.11.4). These data showed a very similar breeding season peak as was recorded during the boat surveys.

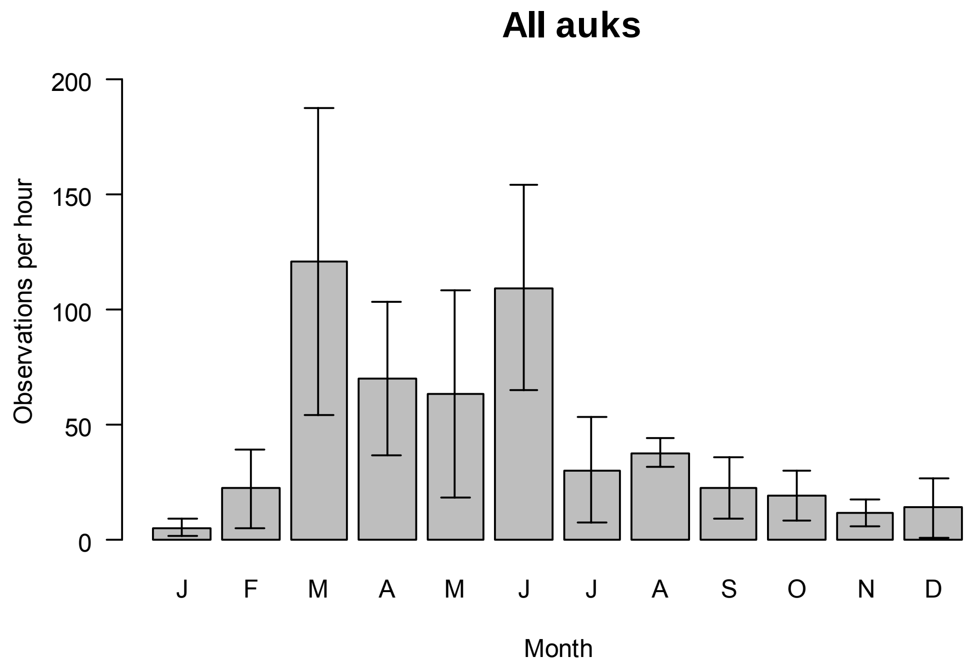
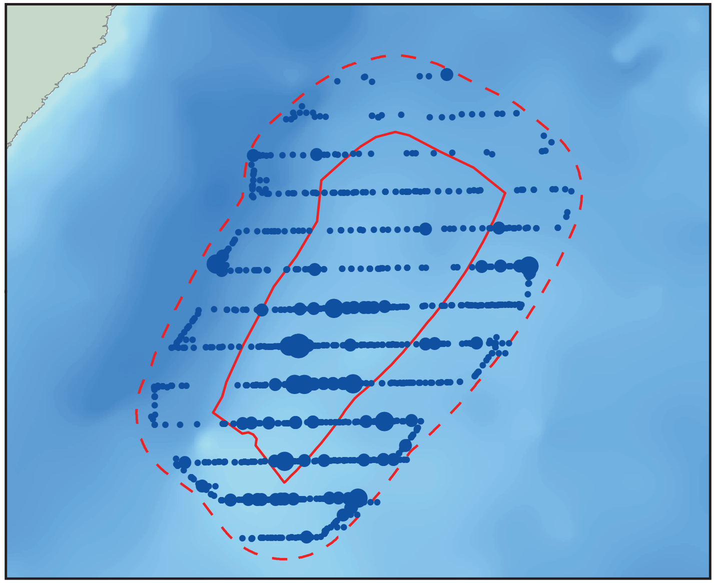


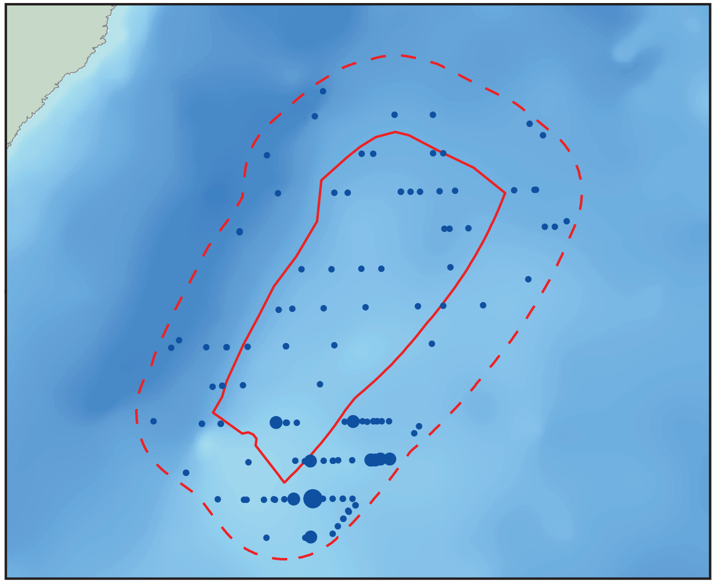
Figure 3.11.4 Average seasonal distribution (± 1 standard error) of unidentified auks recorded from the Beatrice Alpha Oil Platform between 2005 – 2008 for the Beatrice Demonstrator Project.

3.72 The RSPB surveys recorded gu illemot throughout the year (Fi gure 3.11.3), although densities were lowest over winter. The distribution of birds during the breeding season was concentrated along the Caithness coast, but also extended out to include the Smith Bank (and the Wind Farm Site). Other important areas during this period include the southern half of the Moray Firth. The importance of southern areas was further supported by the 2011 tracking study (Figure 3.11.7, Figure A4.3).

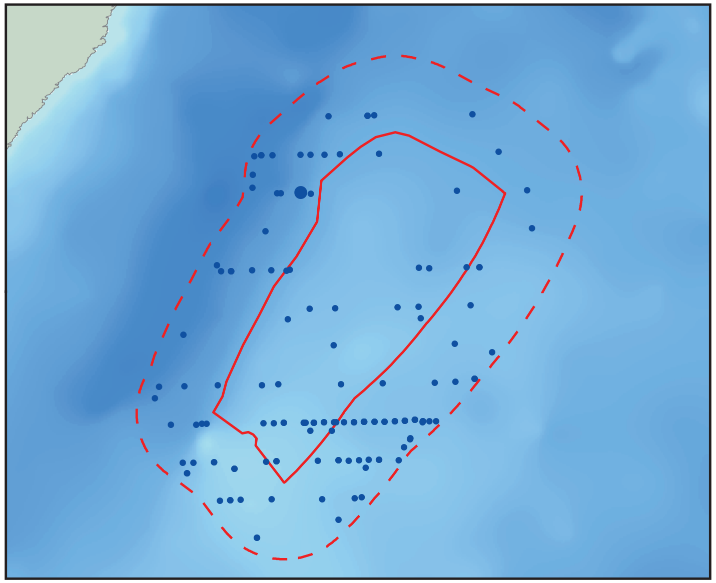
3.73 The aerial surveys, which are un able to distinguish between auk species, found similar distributions and densities in both summer (Figure 3.16.5) and winter (Figure 3.16.6).



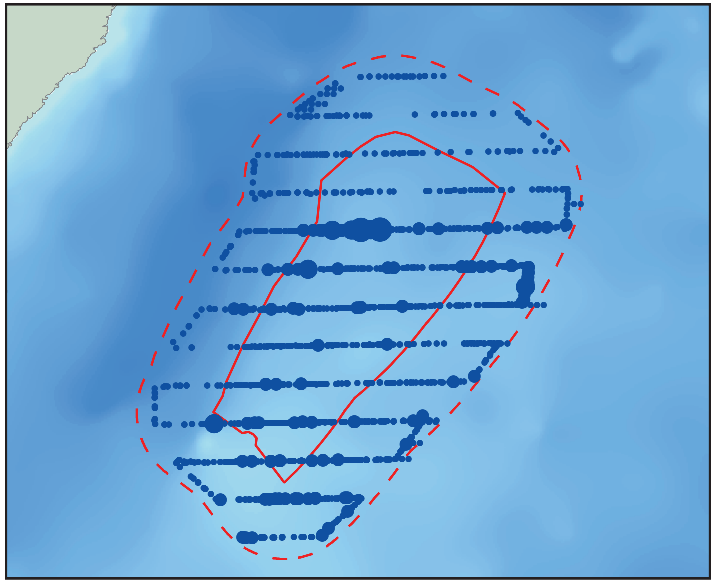
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km   0 1 2 3 4 5 Nm

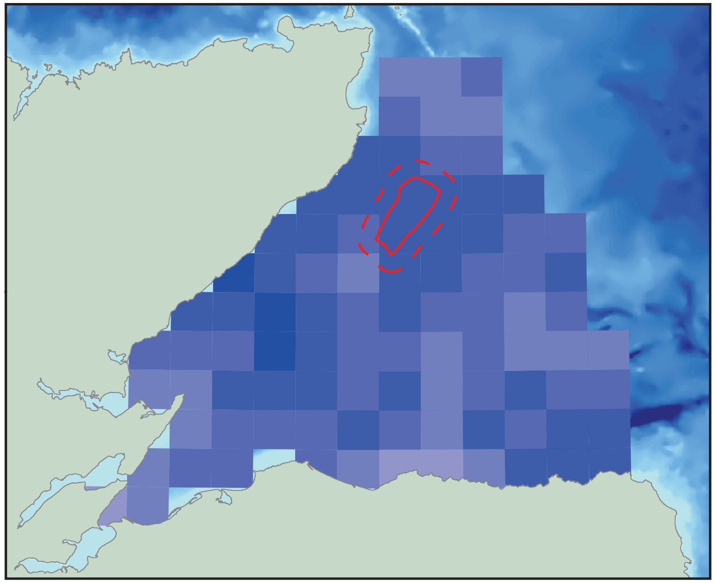
Beatrice Offshore Wind Farm

Figure 3.11.1

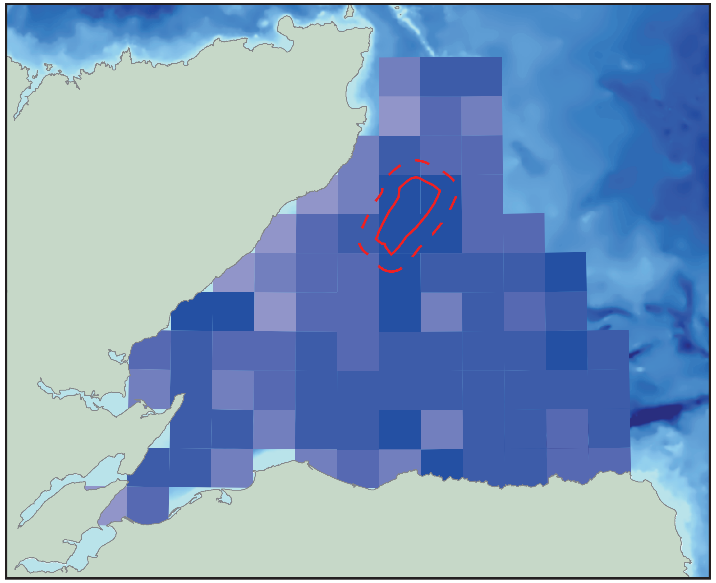
Boat based observations of Guillemot between October 2009 and July 2011

Drawn: CH	Checked: MT	Approved: MT
Date: 02/09/2011	Scale: 1:375,000	
Drawing Number: sgp6355_Beatrice_3_01_1_boatBirdObs2	Revision: 03	
Datum: WGS84	Projection: UTM Zone 30 N	

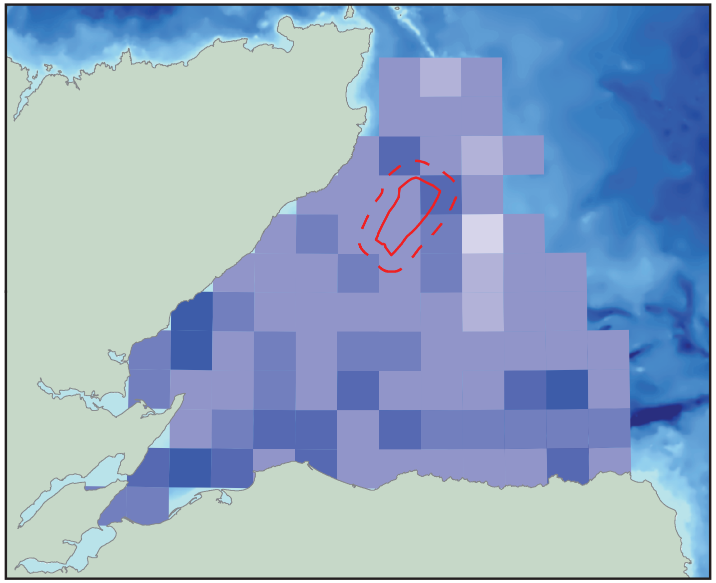
Beatrice
Offshore Windfarm Ltd



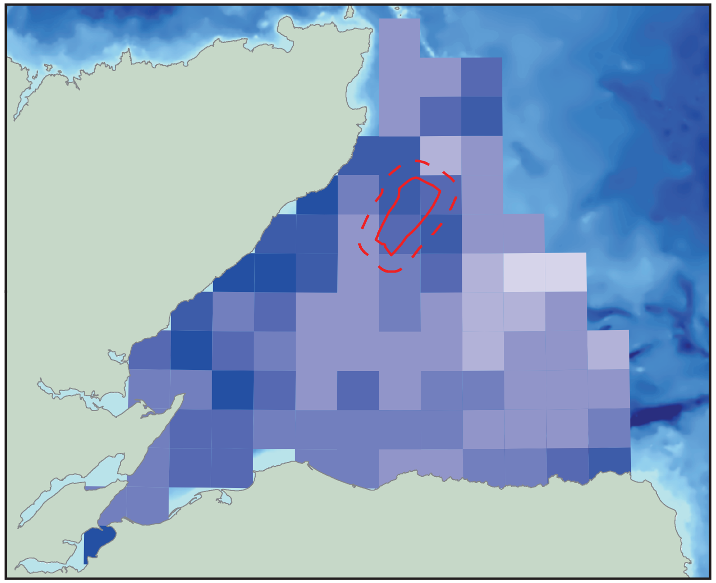
May to July



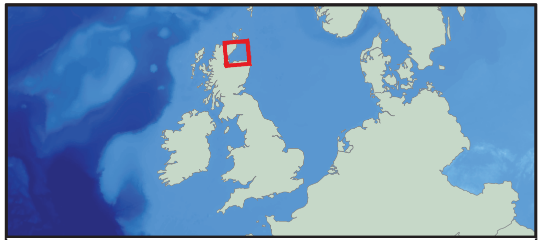
August to October



November to January



February to April



Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km

0 5 10 20 Nm

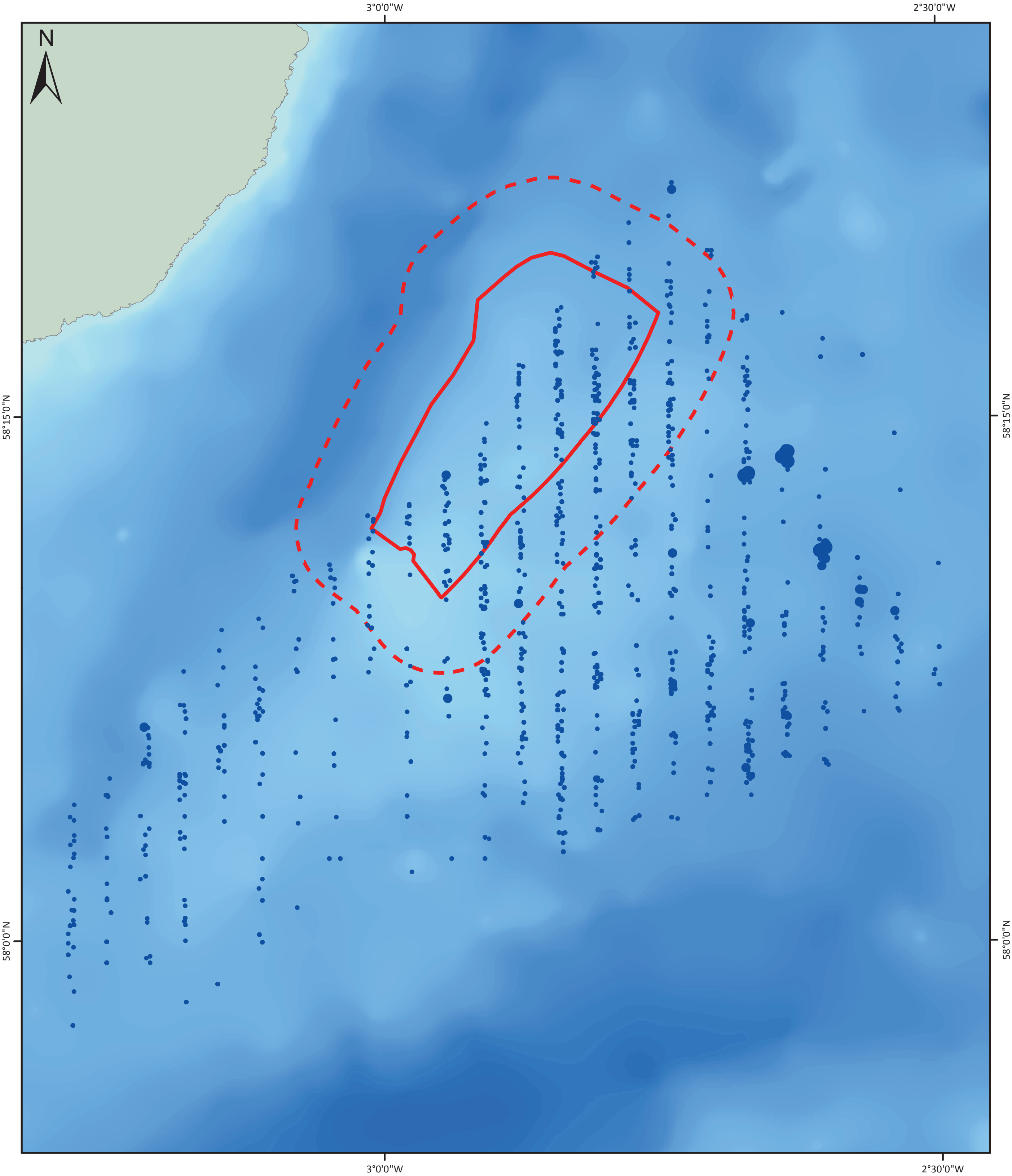
Beatrice Offshore Wind Farm

Figure 3.11.3

Mean density of Guillemot derived from boat-based observations between January 1982 and December 1983

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice
Offshore Windfarm Ltd



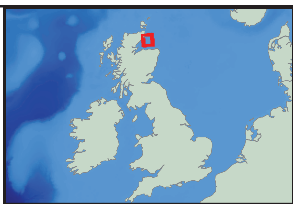
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



0 1.5 3 6 km

0 0.5 1 2 Nm

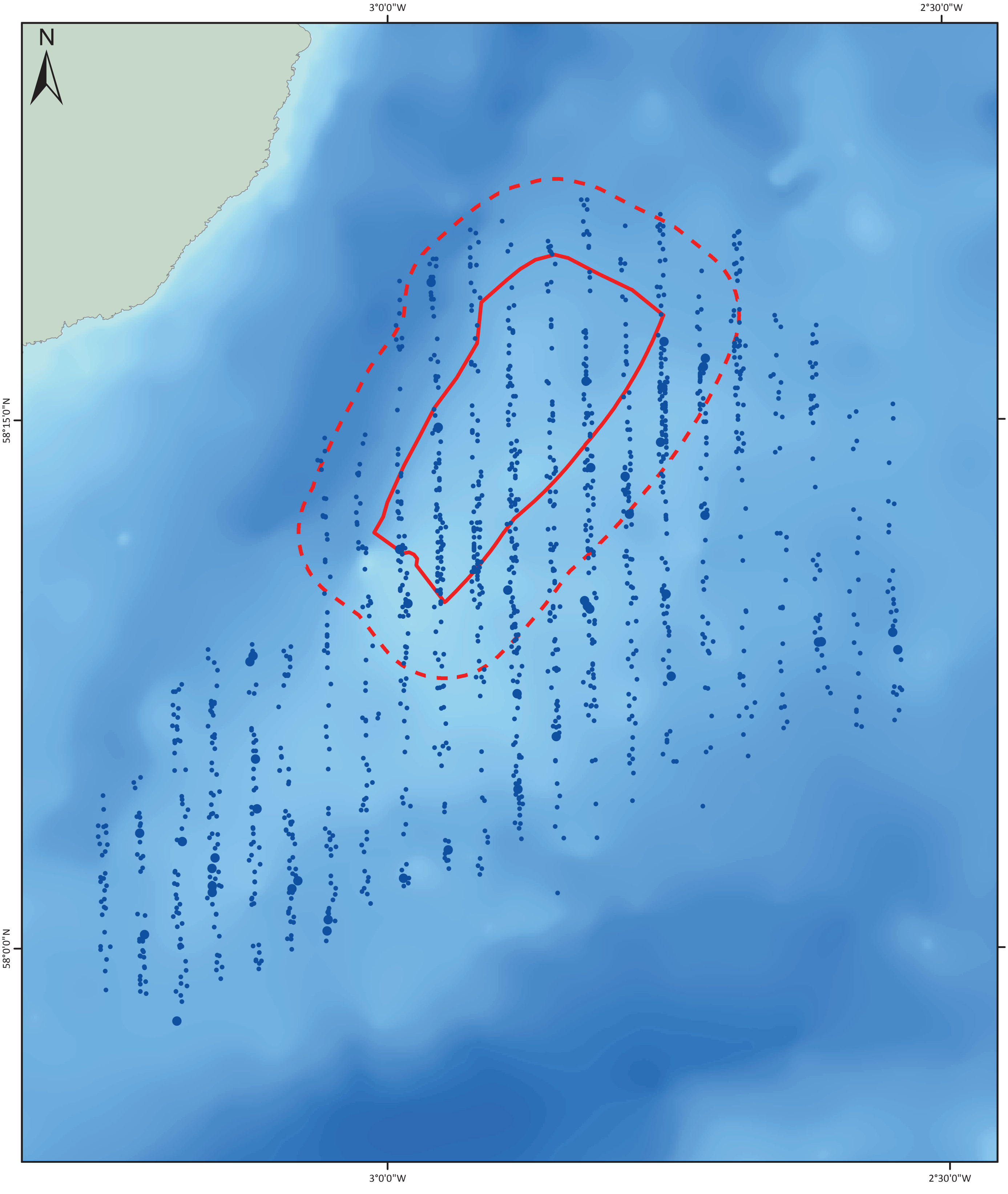
Beatrice Offshore Wind Farm

Figure 3.16.5

Aerial survey observations of unidentified auks between May and August 2009

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_5_aerial_hidefBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

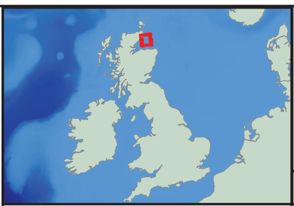


Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100



This map contains TCarta and UKCS Bathymetry, 2009.

NOT TO BE USED FOR NAVIGATION

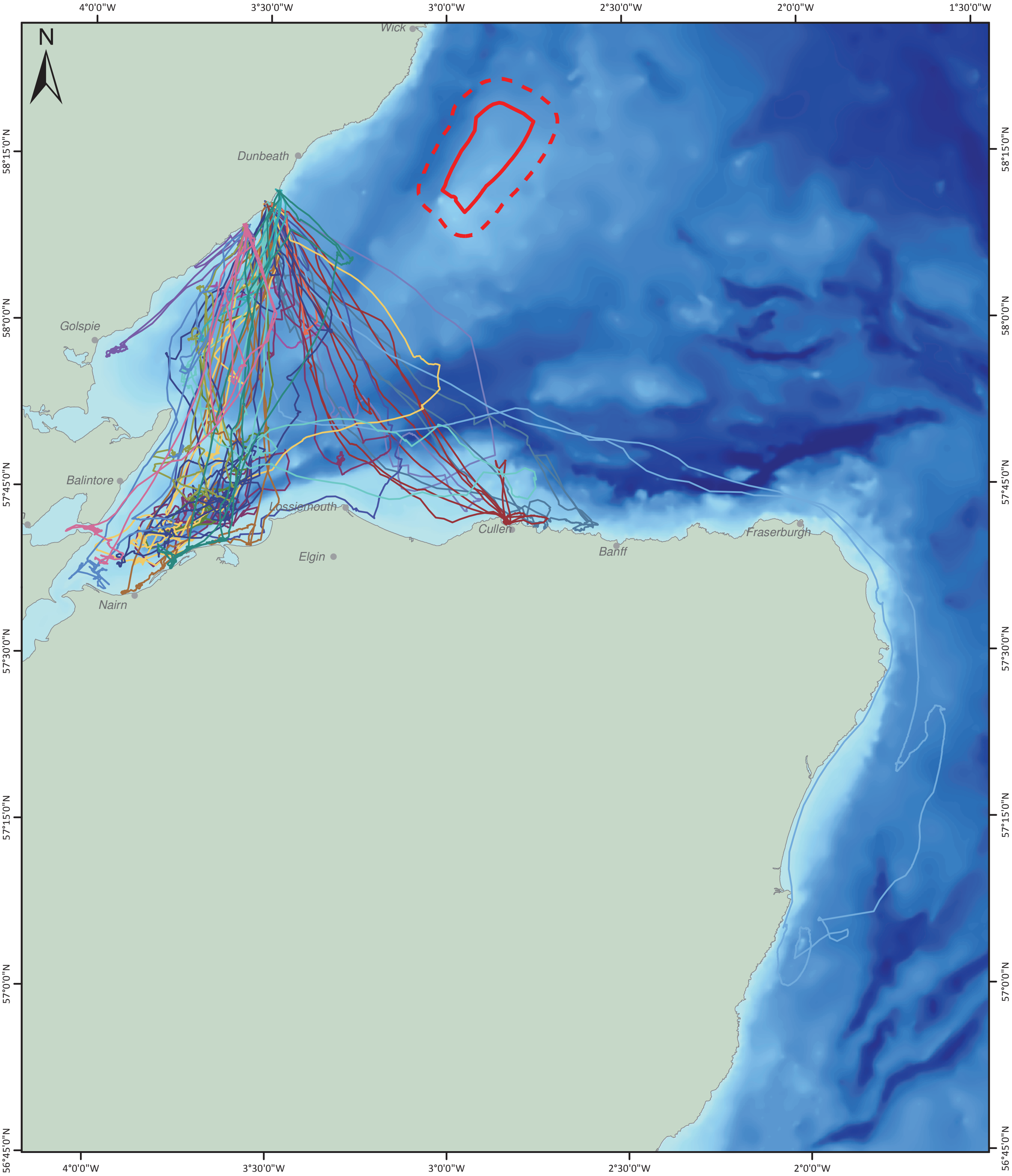
Beatrice Offshore Wind Farm

Figure 3.16.6

Aerial survey observations of unidentified auks between November 2009 and February 2010

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:275,000	
Drawing Number: sgp6355_Beatrice_3_01_6_aerial_wwtBirdObs1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

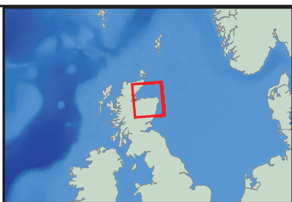


Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Different coloured lines represent individual birds



0 5 10 20 km

0 3 6 12 Nm

Beatrice Offshore Wind Farm

Figure 3.11.7

The foraging range of individual breeding Guillemot tracked by satellite telemetry during spring 2011

Drawn: CH	Checked: MT	Approved: MT	
Date: 30/08/2011	Scale: 1:865,000		
Drawing Number: sgp6355_Beatrice_3_01_7_satTracks1		Revision: 01	
Datum: WGS1984	Projection: UTM Zone 30N		

Beatrice
Offshore Windfarm Ltd

Razorbill

3.74 The European razorbill population is estimated to be between 430,000 and 760,000 breeding pairs, of which 23 % (164,000) breed in Britain (Mitchell *et al.* 2004). Approximately 139,186 of these birds breed in Scotland. There is concern that populations of razorbill in Scotland have declined since the previous survey (Seabird 2000), although this is based on monitoring at a comparatively small subset of only 17 colonies. It is thought this may represent increased competition for resources at the largest colonies (http://jncc.defra.gov.uk/page-2899). It should also be highlighted that there is no evidence that the Moray Firth colonies have matched the trend seen elsewhere in Scotland.

3.75 Estimates indicate 17,830 breeding razorbills in the East Caithness Cliffs SPA, with another 4,000 individuals in the North Caithness Cliffs SPA. Densities calculated from boat survey data gave a peak of 8.6 per km^2, which equates to an estimated peak abundance of 3,258 birds foraging in the area (Figure 3.12.2). While razorbills were recorded all year round, numbers peaked between April and July inclusive, indicative of the presence of breeding birds.

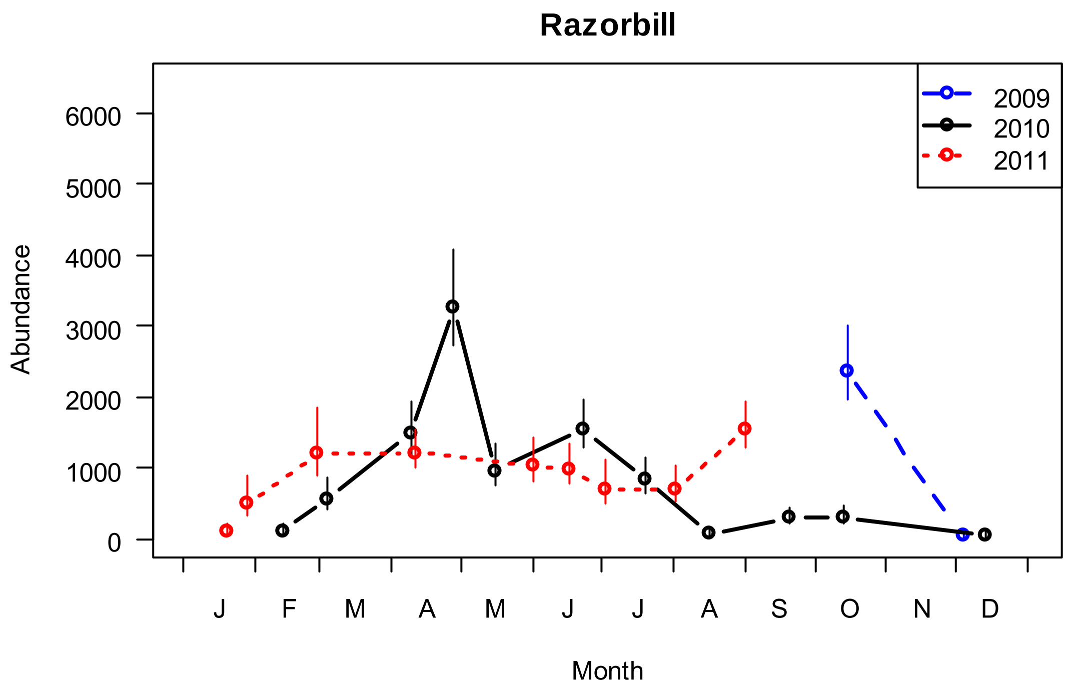
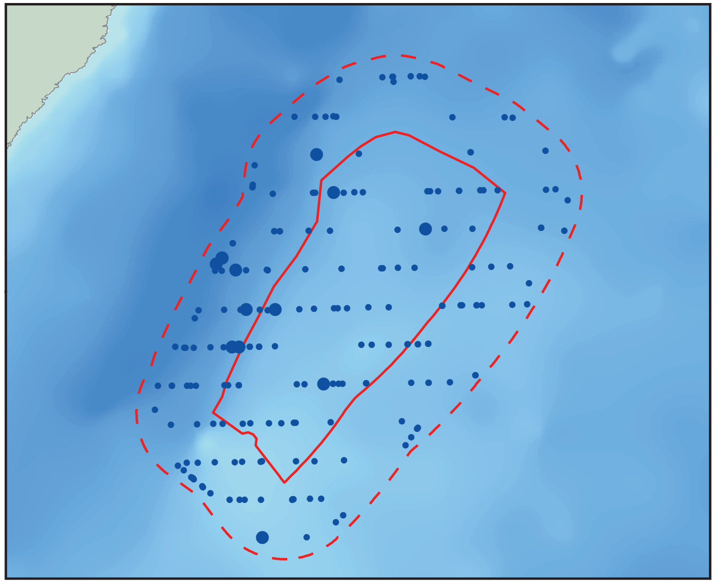


Figure 3.12.2: Razorbill seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).

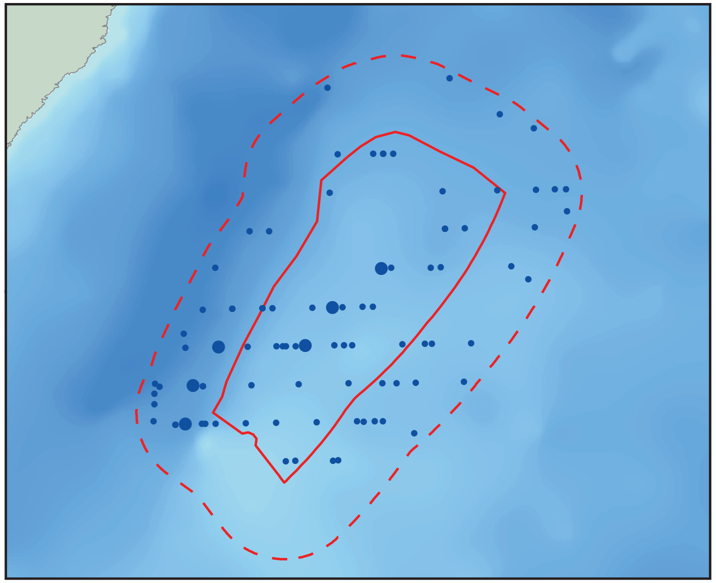
3.76 The observations of auks made for the Beatrice Demonstrator study (Figure 3.11.4) revealed a similar seasonal trend to that recorded using the boat data. The RSPB surveys recorded a year round presence within the Moray Firth, with very even densities in the breeding season followed by greater concentrations further offshore during the post-breeding moult (Figure 3.12.3).

3.77 The aerial surveys also found even distributions of auks during summer and winter, although it is worth noting that the majority of these will have been guillemot (observed ratios of the two species from boat surveys were: 83:17, guillemot to razorbill).

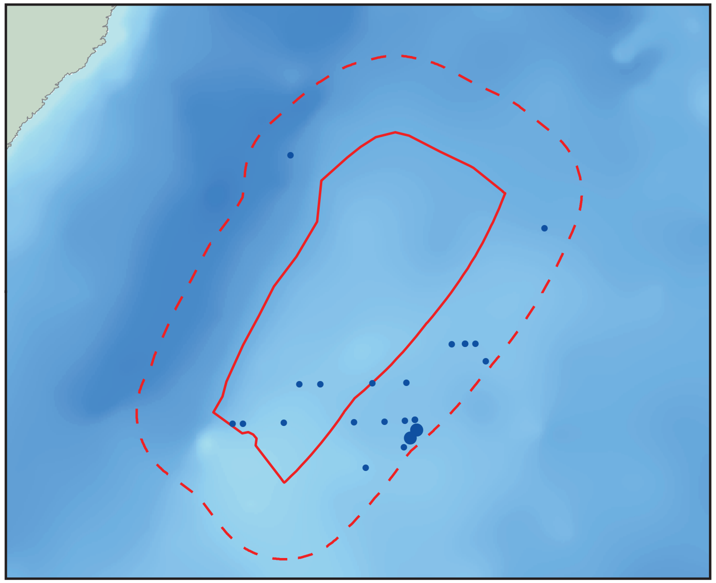
3.78 The tracking study showed that ra zorbill favour coastal waters more than guillemot, with the tagged birds all foraging within the south western area of the Moray Firth (Figure 3.12.7. Figure A4.4).



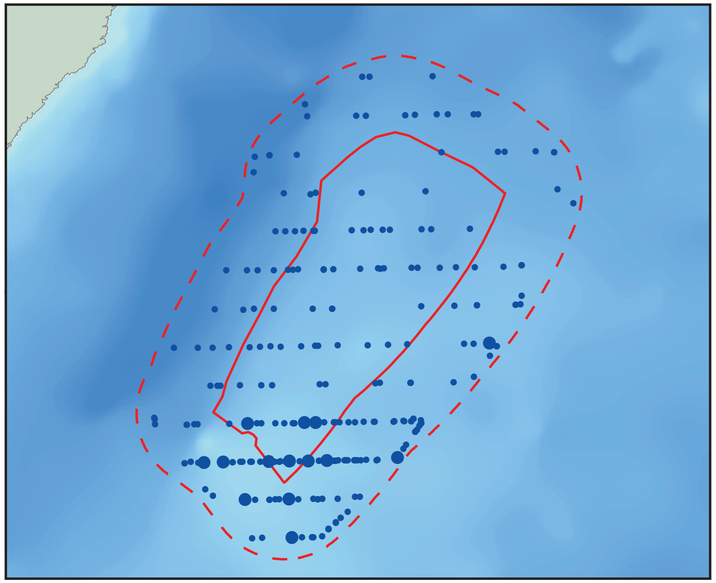
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km 0 1 2 3 4 5 Nm

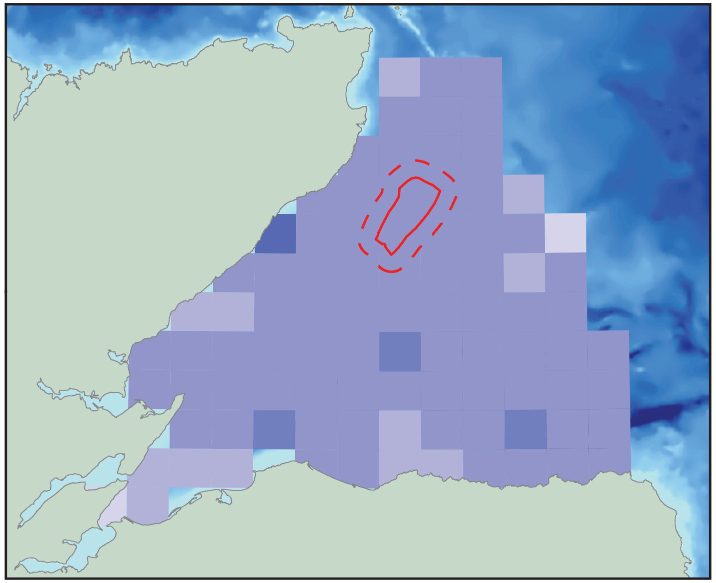
Beatrice Offshore Wind Farm

Figure 3.12.1

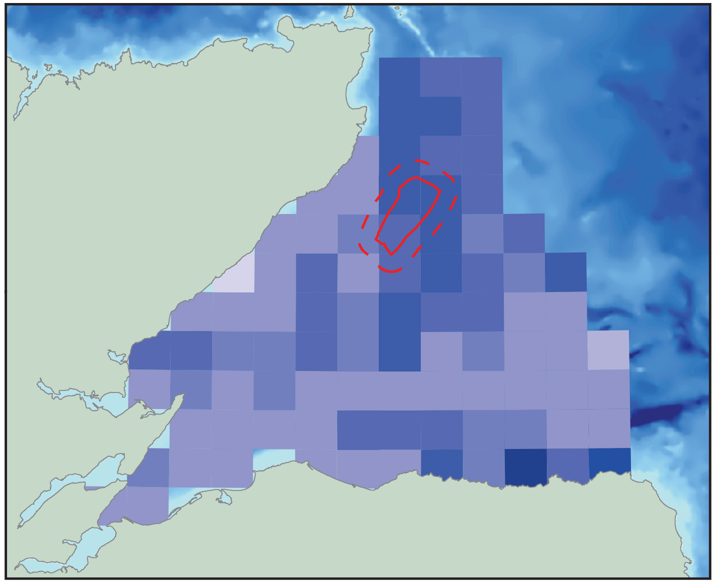
Boat based observations of Razorbill between October 2009 and July 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:375,000		
Drawing Number:	sgp6355_Beatrice_3_01_1_boatBirdObs2	Revision:	03		
Datum:	WGS84	Projection:	UTM Zone 30 N		

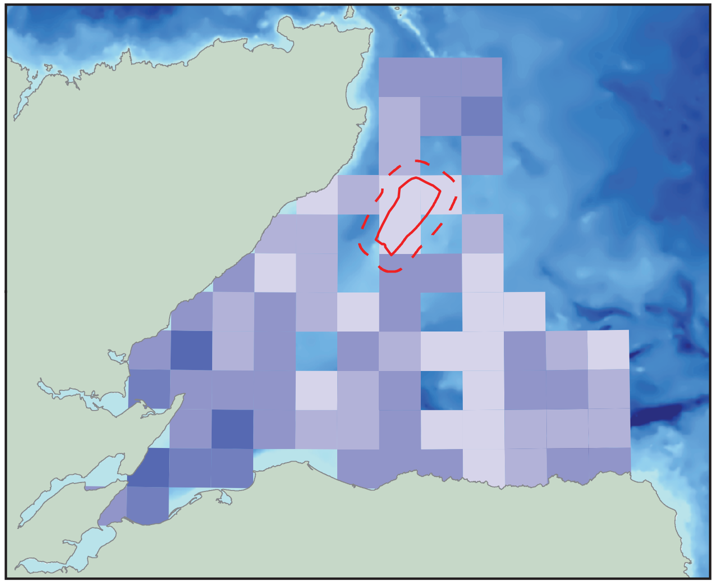
Beatrice Offshore Windfarm Ltd



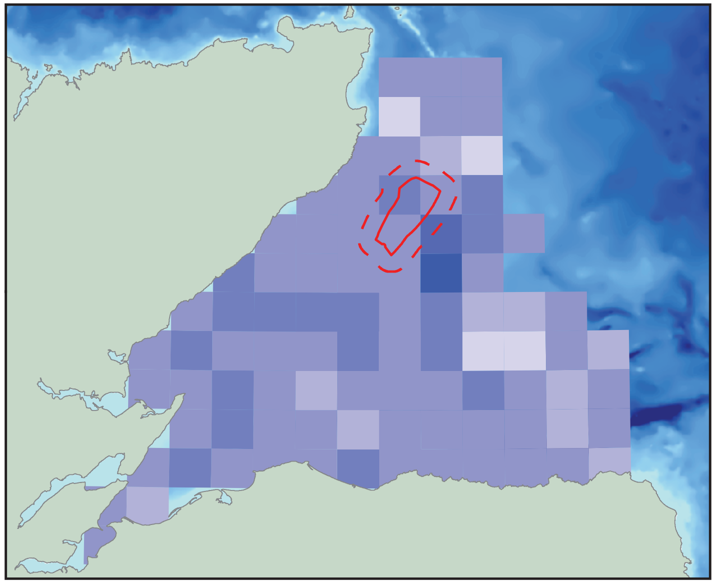
May to July



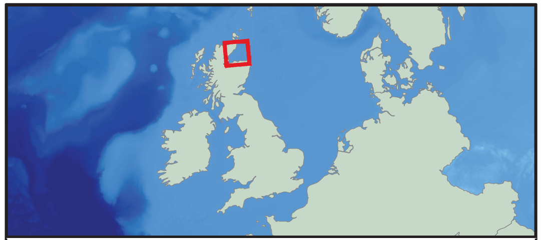
August to October



November to January



February to April



Legend

- Site boundary buffered by 4 km
- Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km   0 5 10 20 Nm

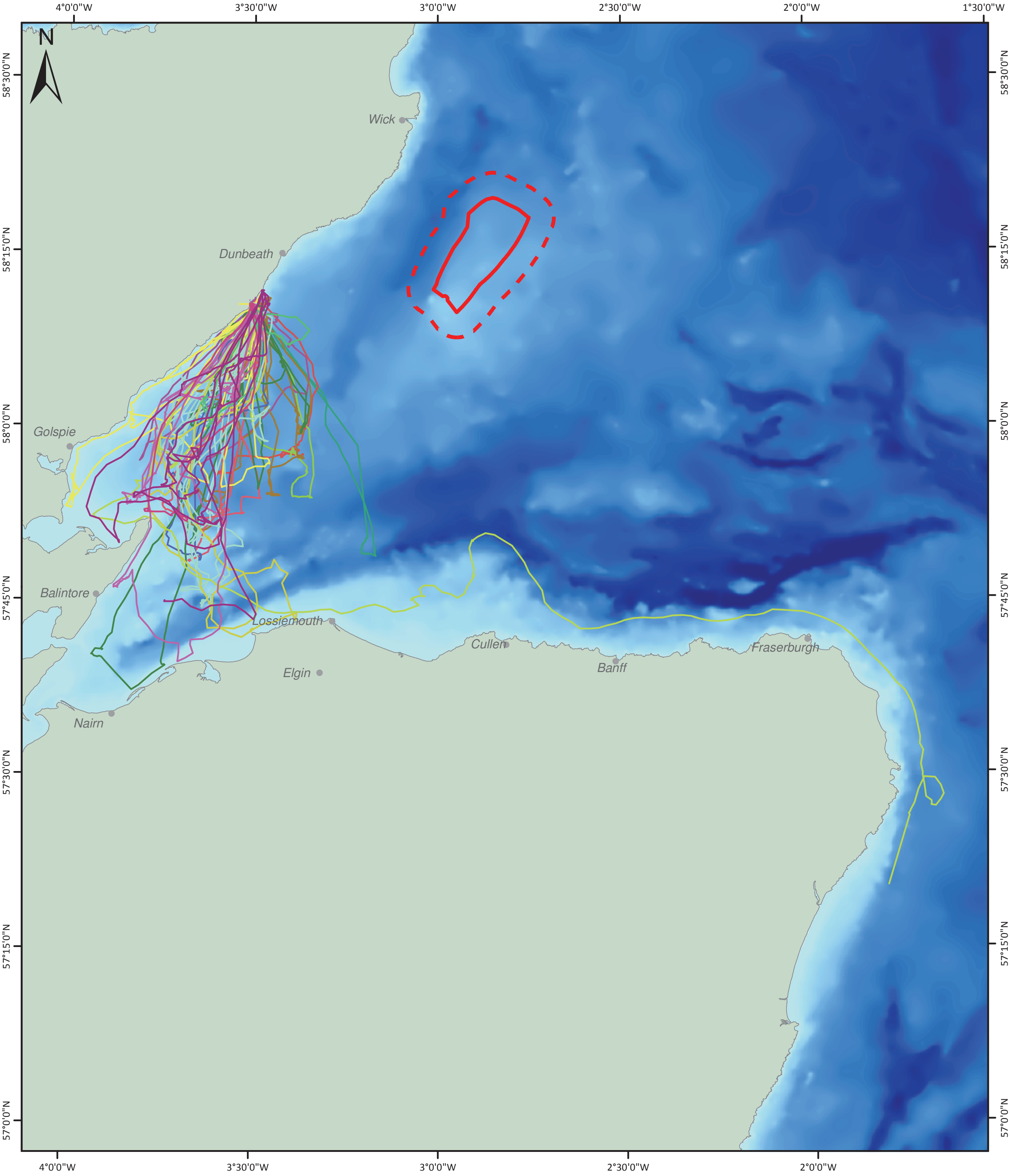
Beatrice Offshore Wind Farm

Figure 3.12.3

Mean density of Razorbill derived from boat-based observations between January 1982 and December 1983

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice
Offshore Windfarm Ltd

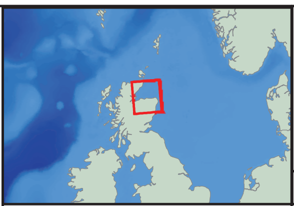


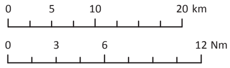
Legend

Beatrice Offshore Wind Farm Site Boundary

Site boundary buffered by 4 km

Different coloured lines represent individual birds





Beatrice Offshore Wind Farm

Figure 3.12.7

The foraging range of individual breeding Razorbill tracked by satellite telemetry during spring 2011

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:826,000	
Drawing Number: sgp6355_Beatrice_3_01_7_satTracks1		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

Atlantic Puffin

3.79 The European population of Atlantic puffins (hereafter, puffin) is thought to be between 5.7 and 7.3 million pairs, of which about 580,700 pairs nest in Britain, comprising 9.6% of the global population (Mitchell *et al.* 2004).

3.80 In Scotland an estimated 493,042 pairs breed, with between 1,750 and 1,278 pairs in the greater Caithness area (Mitchell *et al.* 2004). The Atlantic puffin is listed as a species of moderate conservation concern in the UK, due to localised populations and population declines in Europe.

3.81 Puffins have been recorded during the boat surveys between March and October inclusive with peaks in August and October (Figure 3.13.1). The estimated peak density on the survey site was 11.1 per km^2, which equated to a peak abundance of 4,192 birds (Figure 3.13.2).

3.82 The RSPB surveys found a similar seasonal difference, with much more sparsely distributed observations during winter than the breeding season (Figure 3.13.3). There is also evidence for a coastal concentration during the breeding season, before birds disperse during the post-breeding moult. This pattern is consistent with the August peak observed during the boat surveys.

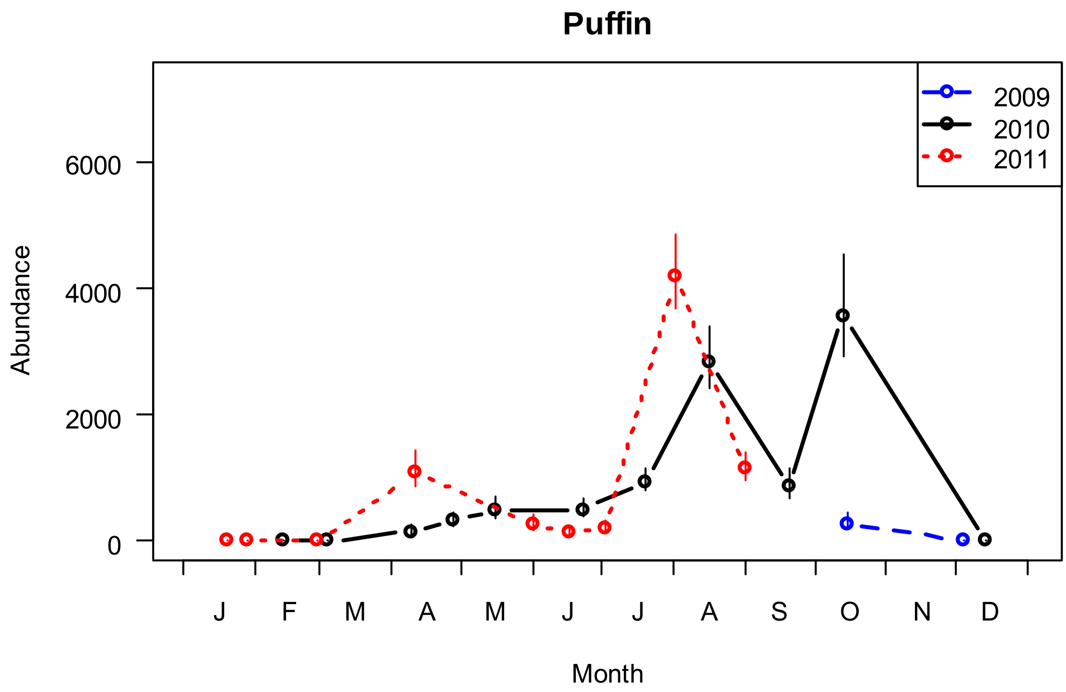
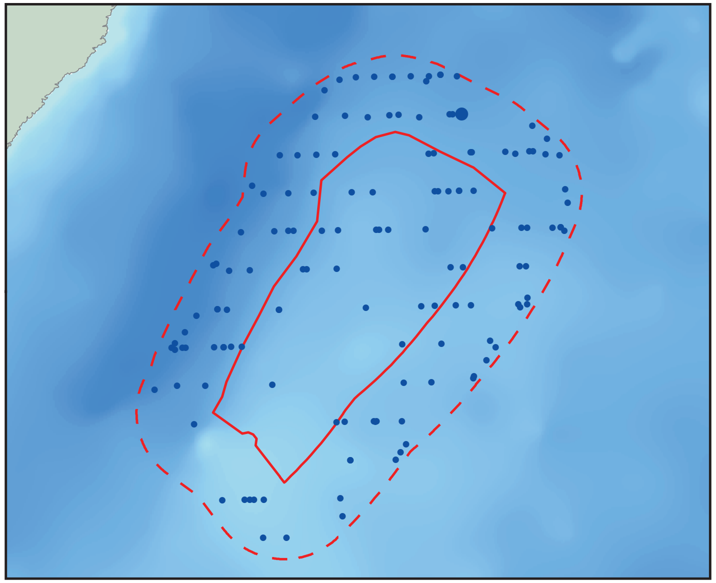
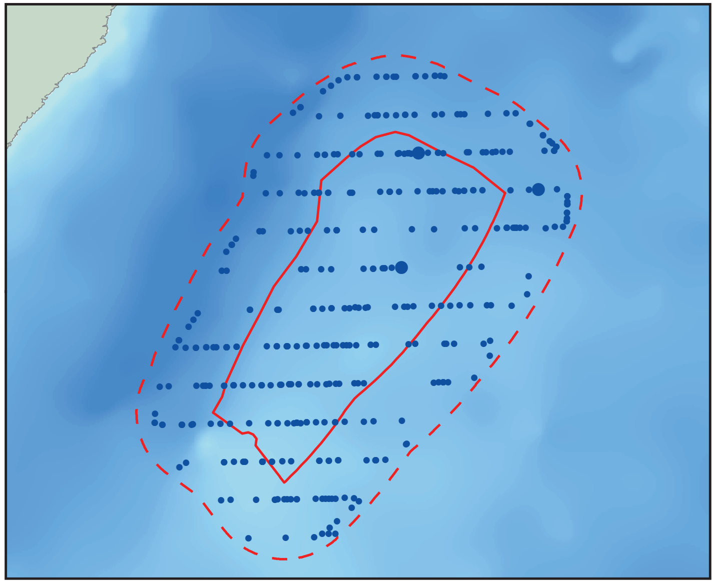


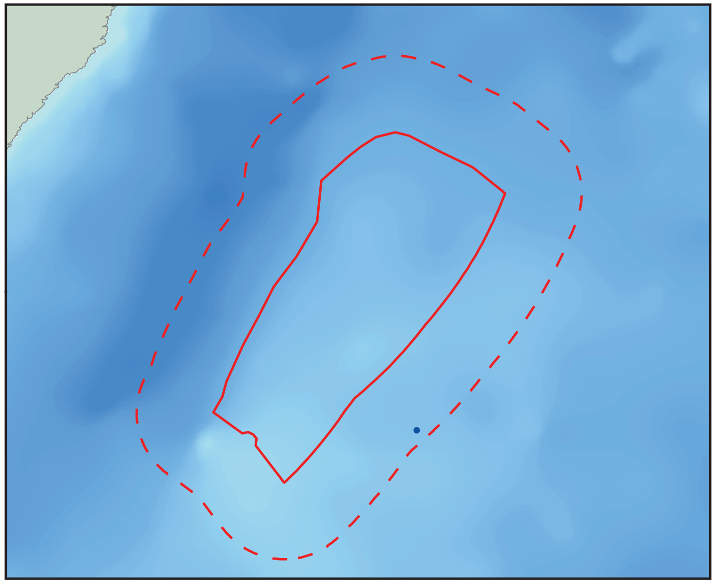
Figure 3.13.2: Puffin seasonal abundance (±1 standard error) estimated using boat survey data for the whole boat based study area (application site plus 4 km buffer).



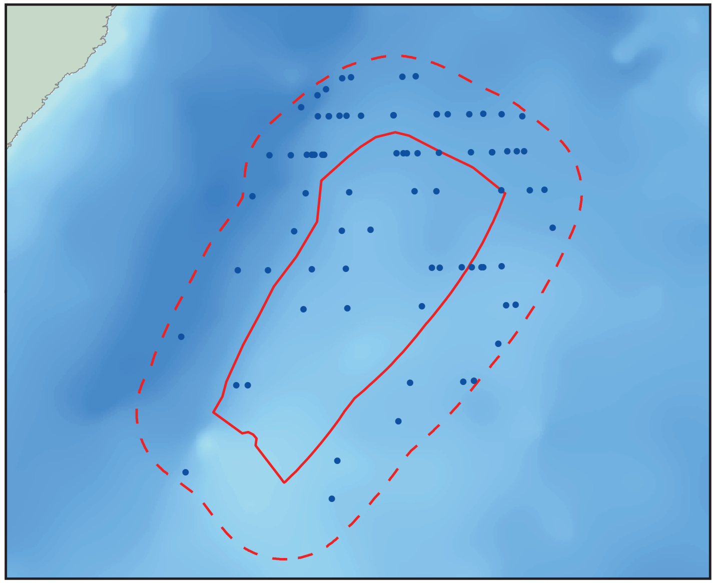
May to July



August to October



November to January



February to April

Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Number of birds

- 1 - 5
- 6 - 20
- 21 - 50
- 51 - 100
- 101 - 200

0 5 10 km 0 1 2 3 4 5 Nm

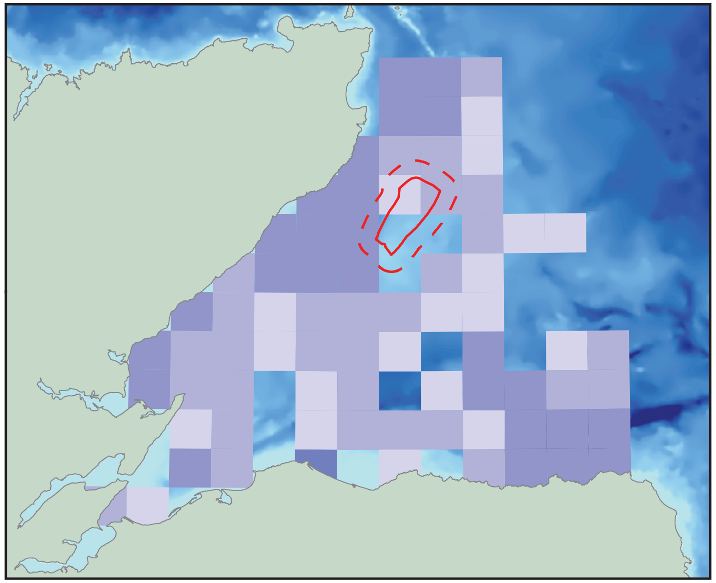
Beatrice Offshore Wind Farm

Figure 3.13.1

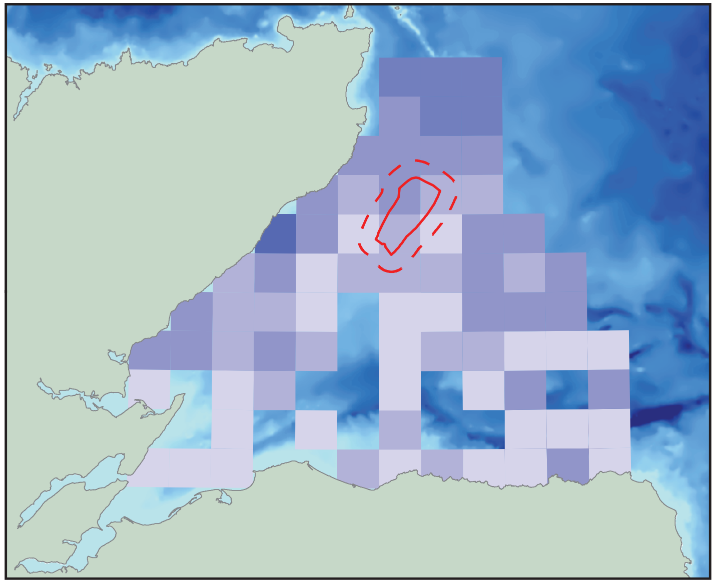
Boat based observations of Puffin between October 2009 and July 2011

Drawn: CH	Checked: MT	Approved: MT
Date: 02/09/2011	Scale: 1:375,000	
Drawing Number: sgp6355_Beatrice_3_01_1_boatBirdObs2		Revision: 03
Datum: WGS84	Projection: UTM Zone 30 N	

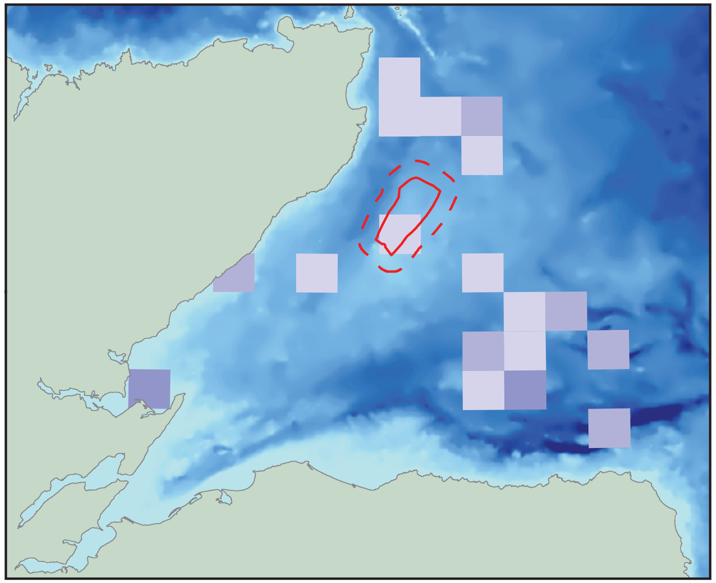
Beatrice
Offshore Windfarm Ltd



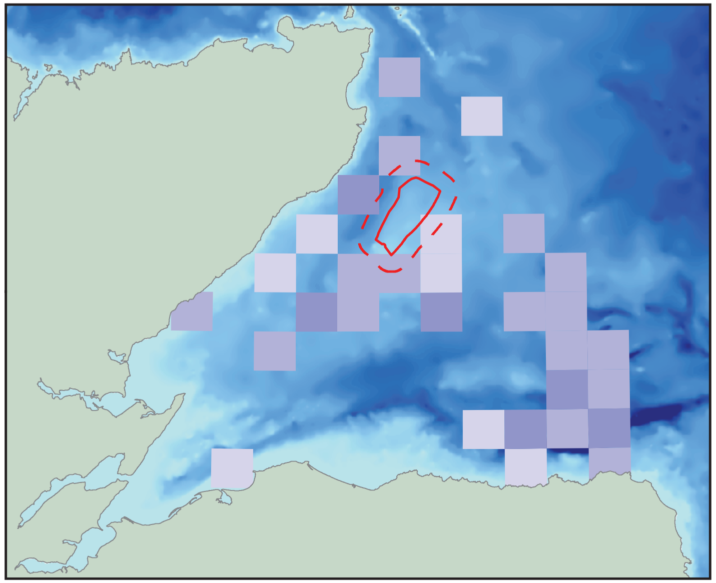
May to July



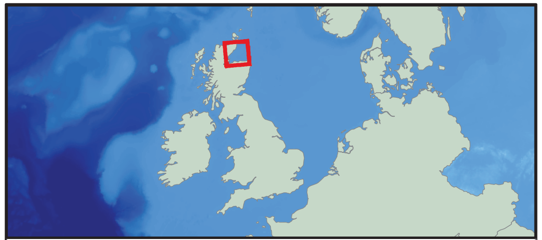
August to October



November to January



February to April



Legend

Site boundary buffered by 4 km

Beatrice Offshore Wind Farm Site Boundary

Mean density per km^2

- 0.1 - 0.5
- 0.5 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 600

0 10 20 40 km   0 5 10 20 Nm

Beatrice Offshore Wind Farm

Figure 3.13.3

Mean density of Puffin derived from boat-based observations between January 1982 and December 1983

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	02/09/2011	Scale:	1:1,700,000		
Drawing Number:	sgp6355_Beatrice_3_01_3_RSPB1			Revision:	02
Datum:	WGS84	Projection:	UTM Zone 30 N		

Beatrice
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Wildfowl Passage Species

3.83 While the East Caithness Cliffs provide the main nesting site for seabird species in the Moray Firth region, SPAs to the south of the proposed Wind Farm Site provide important wintering and stopover locations for waterfowl and waders during their spring and autumn migrations. The Loch of Strathbeg near Fraserburgh in north-east Aberdeenshire is an SPA designated for the large number of wildfowl, including whooper swans (*Cygnus cygnus*), pink-footed geese (*Anser brachyrhynchus*) and greylag geese (*Anser anser*) which use the site whilst on migration (with some birds present throughout winter).

3.84 The autumn and spring passage of geese and swans across the Moray Firth was studied in relation to the Beatrice Offshore Wind Farm and the Moray Firth Round 3 Eastern Development Zone wind farm in 2010 and 2011. The migratory route followed by individuals to and from sites in eastern Scotland and their Icelandic breeding grounds was expected to result in a proportion of them crossing the Moray Firth through the proposed Beatrice and Round three wind farm sites.

3.85 Estimates of the extent to which migratory flights crossed the Wind Farm Site were derived from the flightlines recorded by surveyors stationed at four locations around the Moray coast, over periods of eight weeks in autumn and spring. The survey data were used to generate estimates of the total number of birds which may cross the Moray Firth, taking into account the proportion of time surveyed as well as factors such as night time flight activity.

3.86 Birds were also monitored using the monthly boat surveys, with an additional surveyor present on board whose role was to scan for wildfowl flocks.

3.87 The total number of birds observed during each migration, and the estimated number generated from these are presented in Table 3.7.

Table 3.7 Recorded and extrapolated numbers of wildfowl flying through the Beatrice site during migration periods. Flights classed as probable were judged likely to cross (or have crossed) the Wind Farm Site. Flights judged as possible were judged likely to cross (or have crossed) within 2 km of the Wind Farm Site. These categories are exclusive (i.e. probable flights does not include possible flights).

Species	Recorded no. of possible flights through Beatrice			Recorded no. of probable flights through Beatrice			Extrapolated no. of possible flights through Beatrice			Extrapolated no. of probable flights through Beatrice		
	Autumn	Spring	Total	Autumn	Spring	Total	Autumn	Spring	Total	Autumn	Spring	Total
Pink-footed goose	651	2992	3643	2638	2469	4837	5227	18290	23517	21180	15093	36273
Greylag goose	128	9	138	681	49	730	1028	55	1083	5468	300	5768
Barnacle goose	3	-	3	17	-	17	24	-	24	136	-	136
Unidentified goose	0	520	520	403	19	422	0	3179	3,179	3236	116	3352
Whooper swan	13	2	15	11	-	11	104	12	116	88	-	88

3.88 It was estimated that over 36,000 pink footed geese, over 5,700 greylag geese, over 3,300 unidentified geese and fewer than 100 whooper swans probably flew across the Wind Farm Site on autumn and spring migration (combined for both periods). Collision risk modelling of these flights is presented in the impact assessment section of this report.

3.89 The pink-footed goose population which winters in the UK, breeds in Iceland and the eastern coast of Greenland (Trinder *et al*. 2005, Mitchell 2010b). Icelandic breeding greylag geese, in contrast, winter in Britain, Ireland and Norway (Mitchell 2010b). However, there are also populations of greylag geese which are resident in the UK all year round, which can lead to difficulties in determining the provenance of geese observed at certain times of year. Recent survey work for the resident greylag population in Scotland (Mitchell *et al*. 2010a) reported a population of approximately 47,000. However, these birds are generally found in more westerly locations than those traditionally used by the Icelandic population. Therefore it is considered reasonable to assume that greylag geese seen in the vicinity of the Moray Firth during the autumn and spring are members of the Icelandic breeding population. Unidentified geese sighted during the vantage point surveys are expected to be either pink-footed or greylag.

3.90 A few small flocks of barnacle geese (*Branta leucopsis*) were observed from the vantage points, however these were all taking a coastal route around the Moray Firth.

3.91 All of these goose populations are Amber listed to reflect their localised wintering range in the UK (all three species) and for pink-footed and greylag geese also for their internationally important wintering numbers in the UK (Eaton *et al.* 2009)

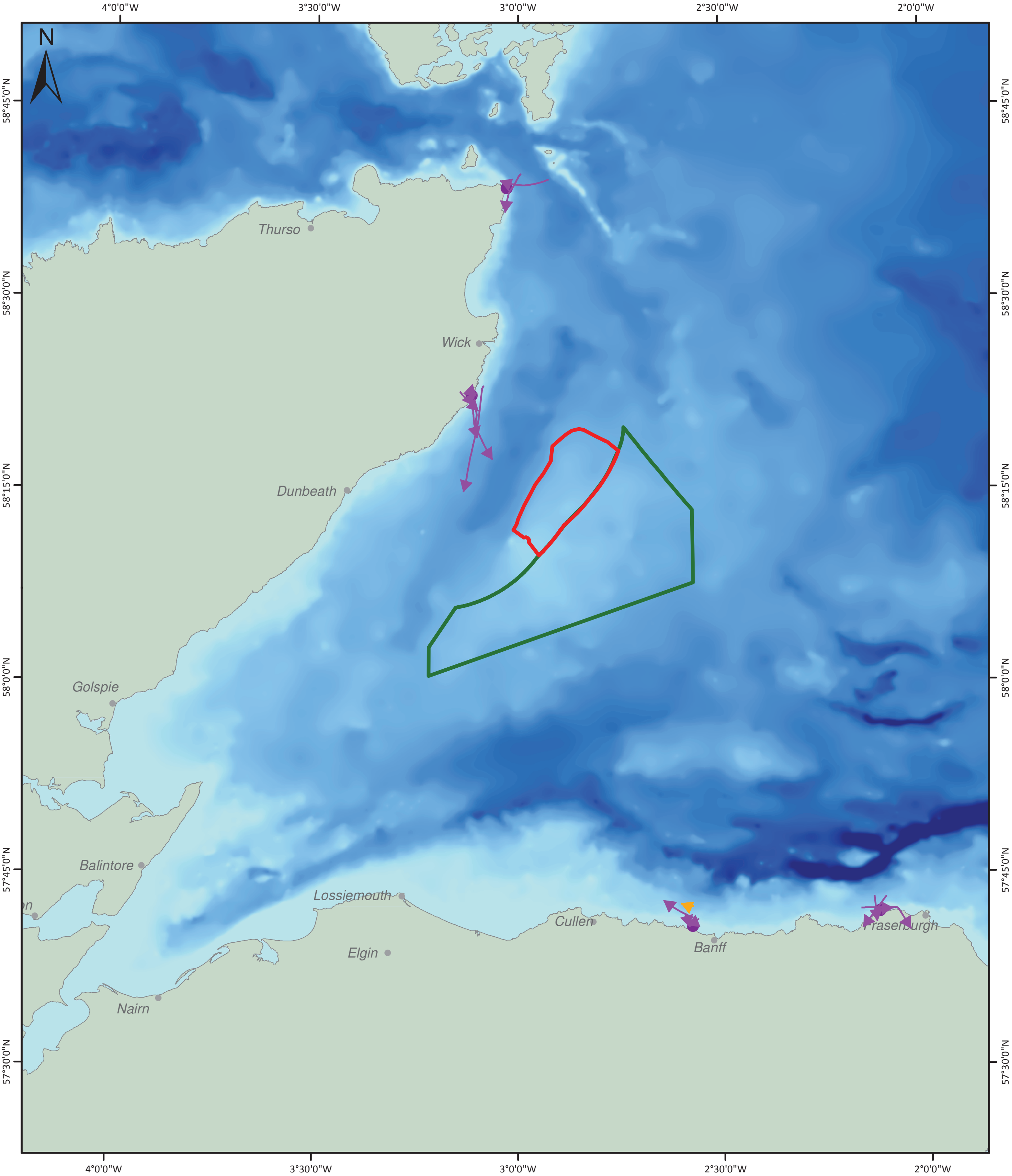
3.92 Whooper swans have a widespread breeding population in Europe, with five distinct populations recognised. The Iceland-breeding population winters almost exclusively in Ireland, with relatively small numbers wintering in the Scotland and England. Steady population increases have been noted in the British wintering population (Eaton *et al*. 2010).

3.93 Table 3.8 provides a comparison between the number of individuals of each species observed, which are estimated to have flown across the Wind Farm Site in relation to the UK population estimates.

3.94 Flightlines for each species during autumn and spring are presented in Figures 3.17.8 and 3.17.9 (swans), Figures 3.18.8 and 3.18.9 (pink-footed geese), Figures 3.19.8 and 3.19.9 (greylag geese), Figure 3.20.8 (barnacle geese) and Figures 3.20.8 and 3.20.9 (unidentified geese).

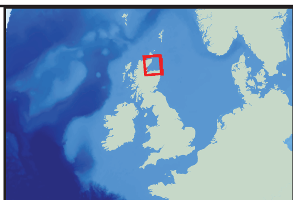
Table 3.8 Goose and swan population estimates (Mitchell 2010a, Worden *et al*. 2005) and numbers estimated to have crossed the Beatrice Offshore Wind Farm Site.

Species	Possible flights through Beatrice (extrapolated)	Probable flights through Beatrice (extrapolated)	Peak UK Wintering population	UK 1% Threshold
Pink-footed goose	23,517	36,273	364,212	3,642
Greylag goose	1,083	5,768	109,496	1,095
Barnacle goose	24	136	32,800	300
Unidentified goose	3,179	3,352	n/a	n/a
Whooper swan	116	88	16,618	166



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Moray Firth Offshore Windfarm Site Boundary
- Vantage point locations
- Whooper swan
- Unidentifed swan



0 5 10 20 km

0 2.5 5 10 Nm

This map contains TCarta and UKCS Bathymetry, 2009.

NOT TO BE USED FOR NAVIGATION

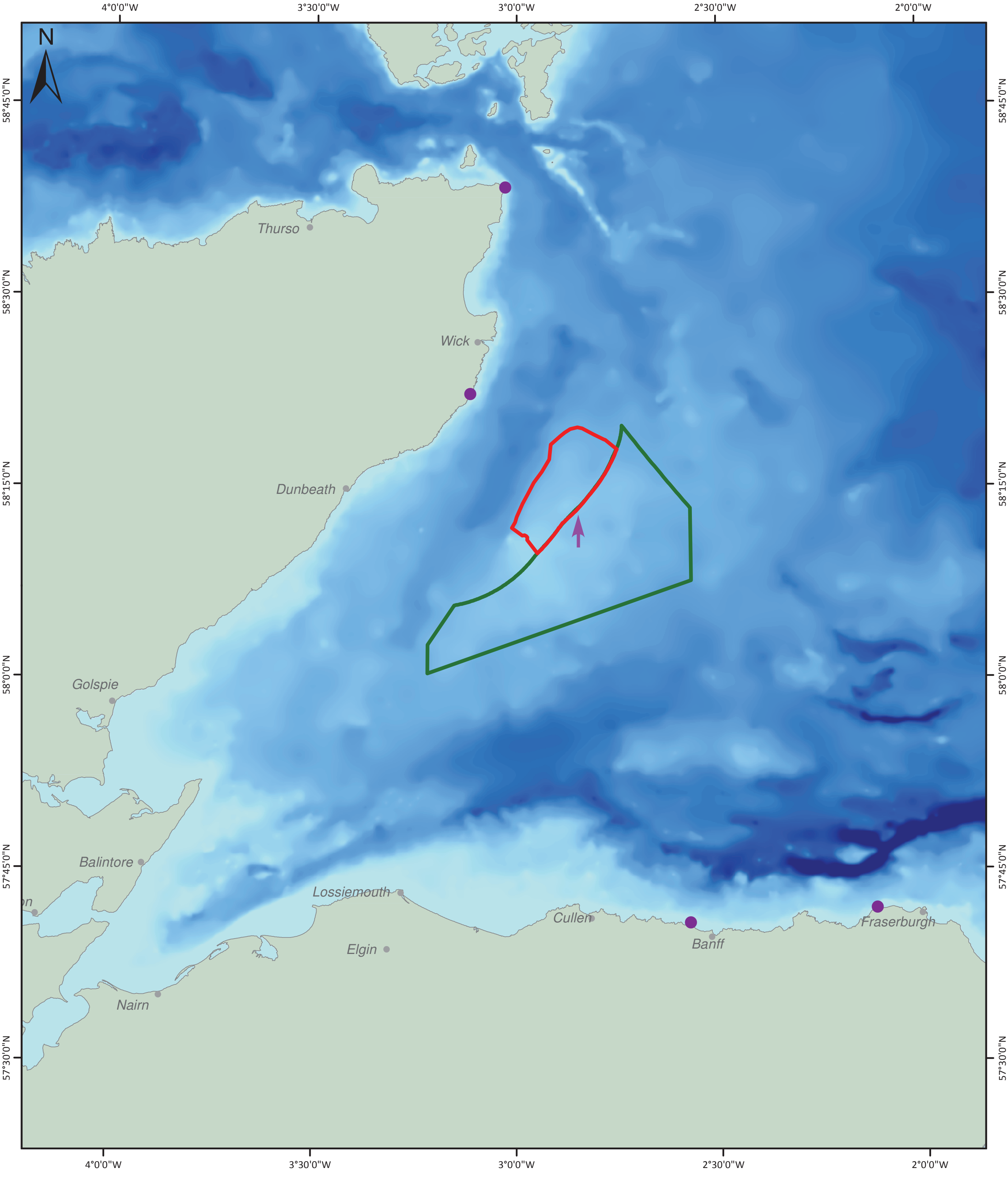
Beatrice Offshore Wind Farm

Figure 3.17.8

Observed swan flights from coastal vantage point and boat-based surveys: September to November 2010

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:750,000	
Drawing Number: SGP6355_Beatrice_3_17_8_autumn10Flights_swans		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Moray Firth Offshore Windfarm Site Boundary
- Vantage point locations
- Whooper swan

0 5 10 20 km

0 2.5 5 10 Nm

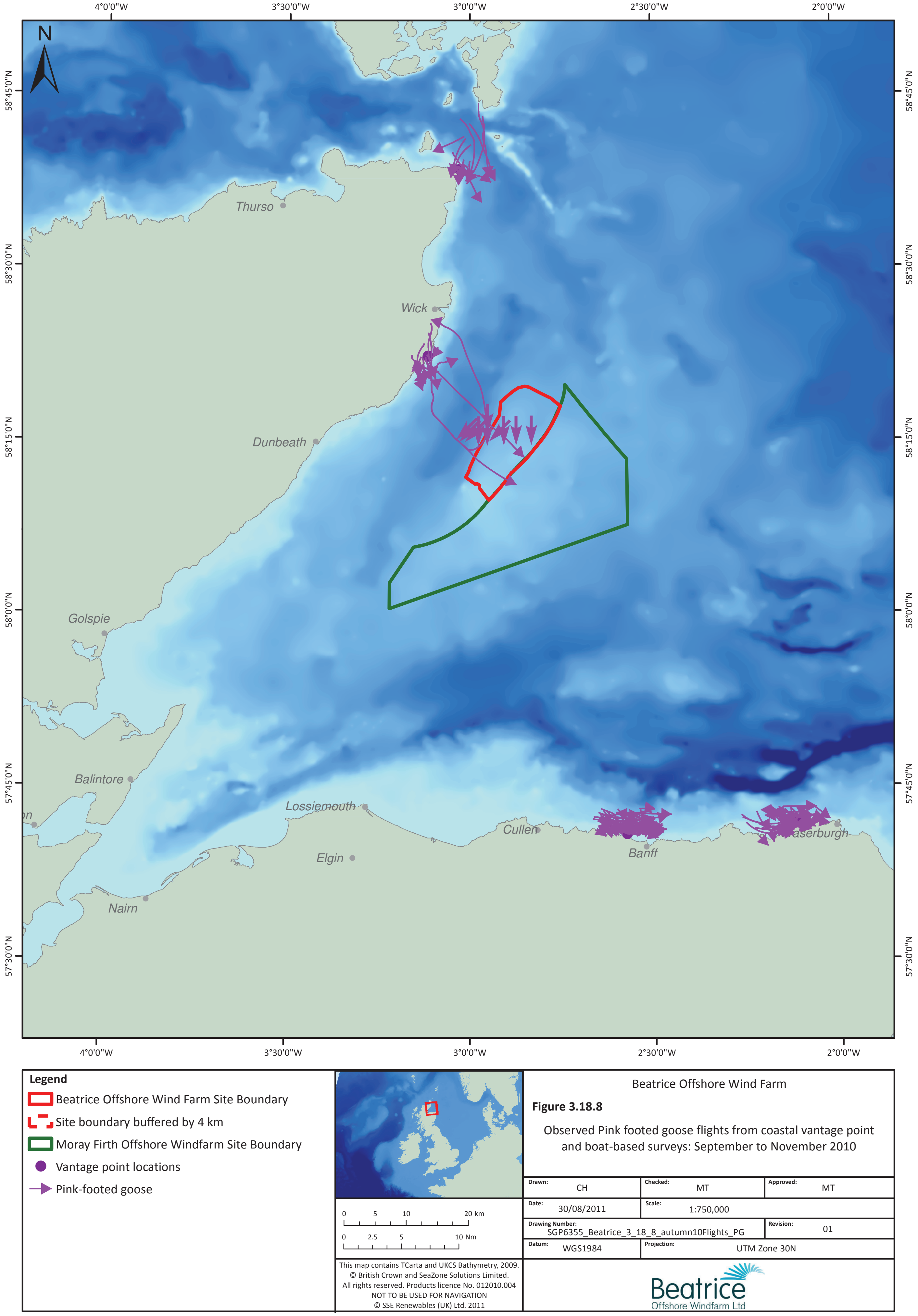
Beatrice Offshore Wind Farm

Figure 3.17.9

Observed Whooper swan flights from coastal vantage point and boat-based surveys: March to May 2011

Drawn:	CH	Checked:	MT	Approved:	MT
Date:	30/08/2011	Scale:	1:750,000		
Drawing Number:	SGP6355_Beatrice_3_17_9_spring11Flights_WS			Revision:	01
Datum:	WGS1984	Projection:	UTM Zone 30N		

Beatrice
Offshore Windfarm Ltd



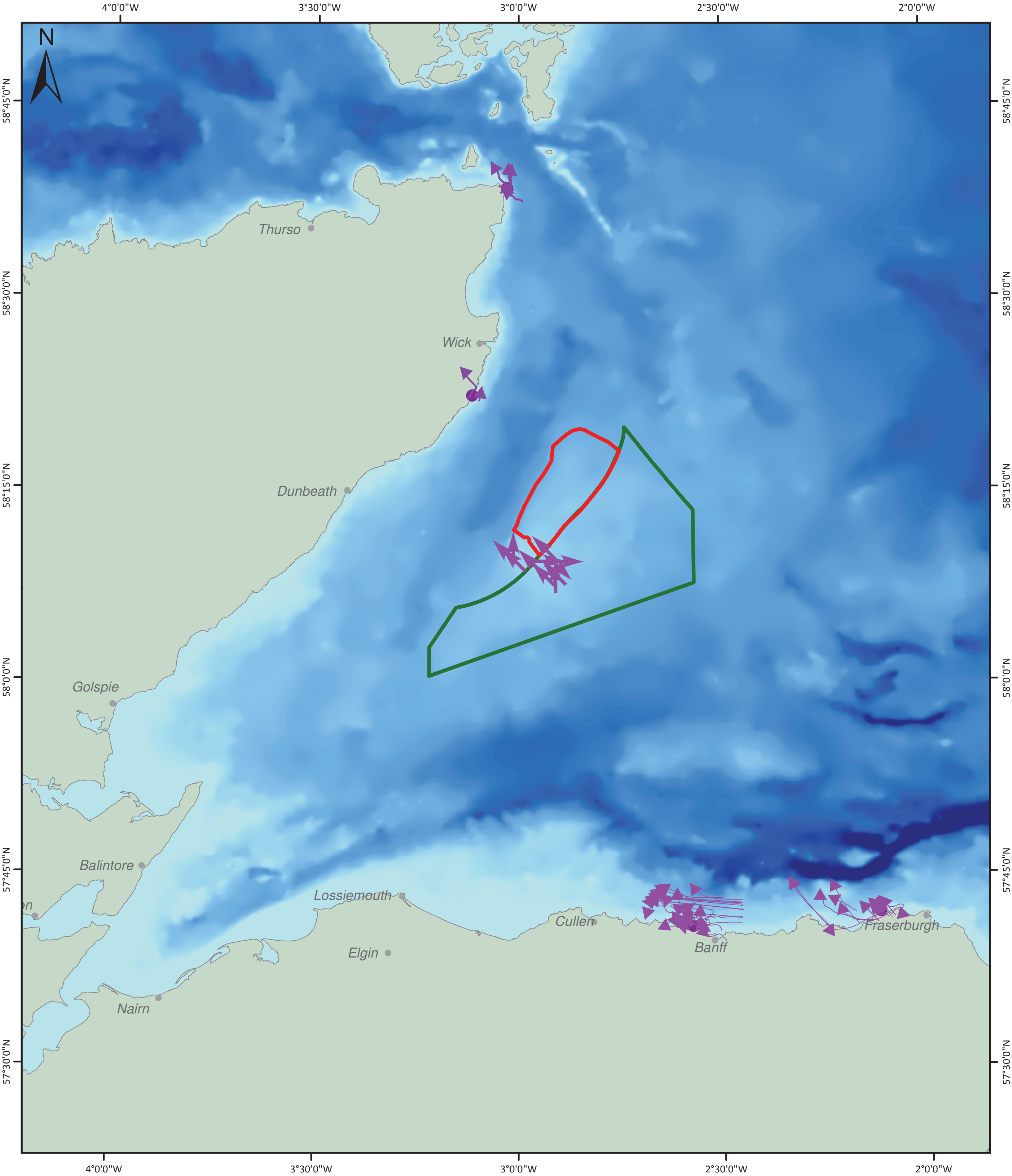
Beatrice Offshore Wind Farm

Figure 3.18.8

Observed Pink footed goose flights from coastal vantage point and boat-based surveys: September to November 2010

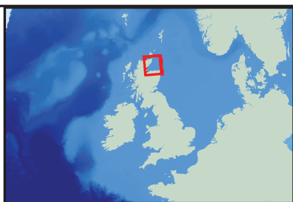
Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:750,000	
Drawing Number: SGP6355_Beatrice_3_18_8_autumn10Flights_PG		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Moray Firth Offshore Windfarm Site Boundary
- Vantage point locations
- Pink-footed goose



0 5 10 20 km

0 2.5 5 10 Nm

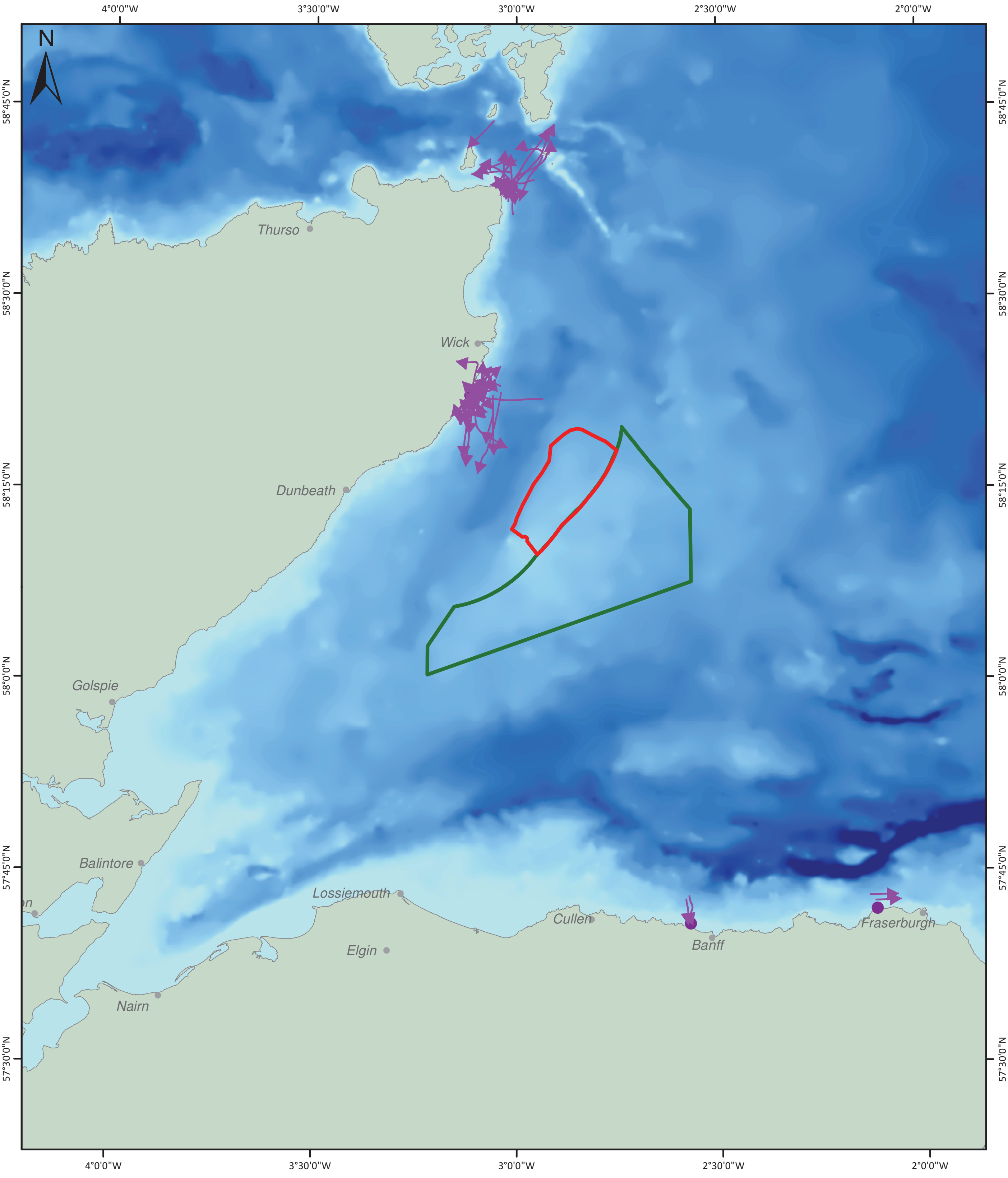
Beatrice Offshore Wind Farm

Figure 3.18.9

Observed Pink-footed goose flights from coastal vantage point and boat-based surveys: March to May 2011

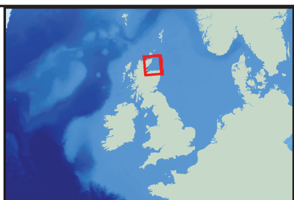
Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:750,000	
Drawing Number: SGP6355_Beatrice_3_18_9_spring11Flights_PG		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Moray Firth Offshore Windfarm Site Boundary
- Vantage point locations
- Greylag goose



0 5 10 20 km

0 2.5 5 10 Nm

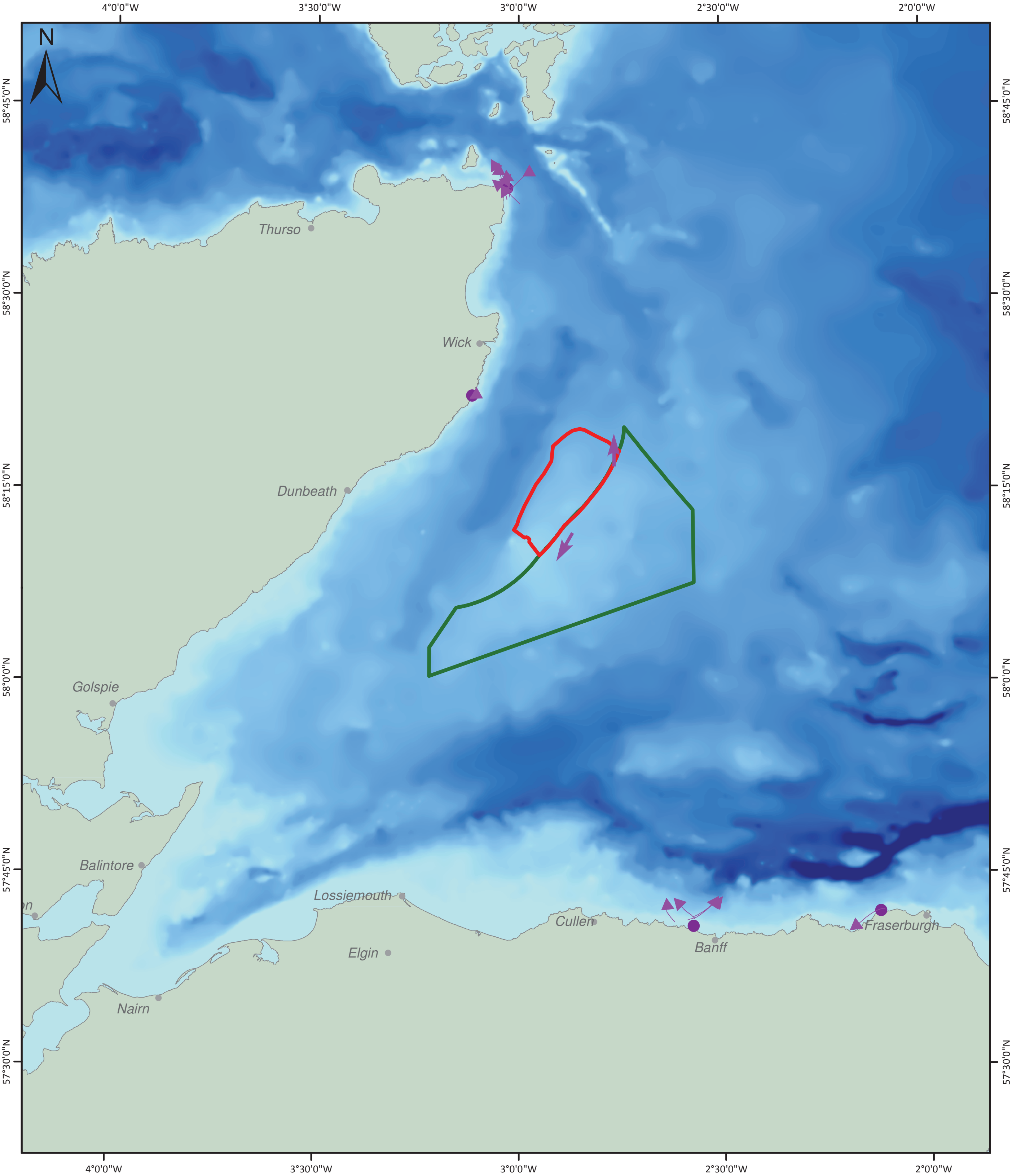
Beatrice Offshore Wind Farm

Figure 3.19.8

Observed Greylag goose flights from coastal vantage point and boat-based surveys: September to November 2010

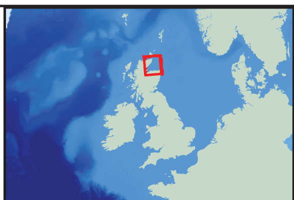
Drawn:	CH	Checked:	MT	Approved:	MT
Date:	30/08/2011	Scale:	1:750,000		
Drawing Number:	SGP6355_Beatrice_3_19_8_autumn10Flights_GJ			Revision:	01
Datum:	WGS1984	Projection:	UTM Zone 30N		

Beatrice
Offshore Windfarm Ltd



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Moray Firth Offshore Windfarm Site Boundary
- Vantage point locations
- Greylag goose



0 5 10 20 km

0 2.5 5 10 Nm

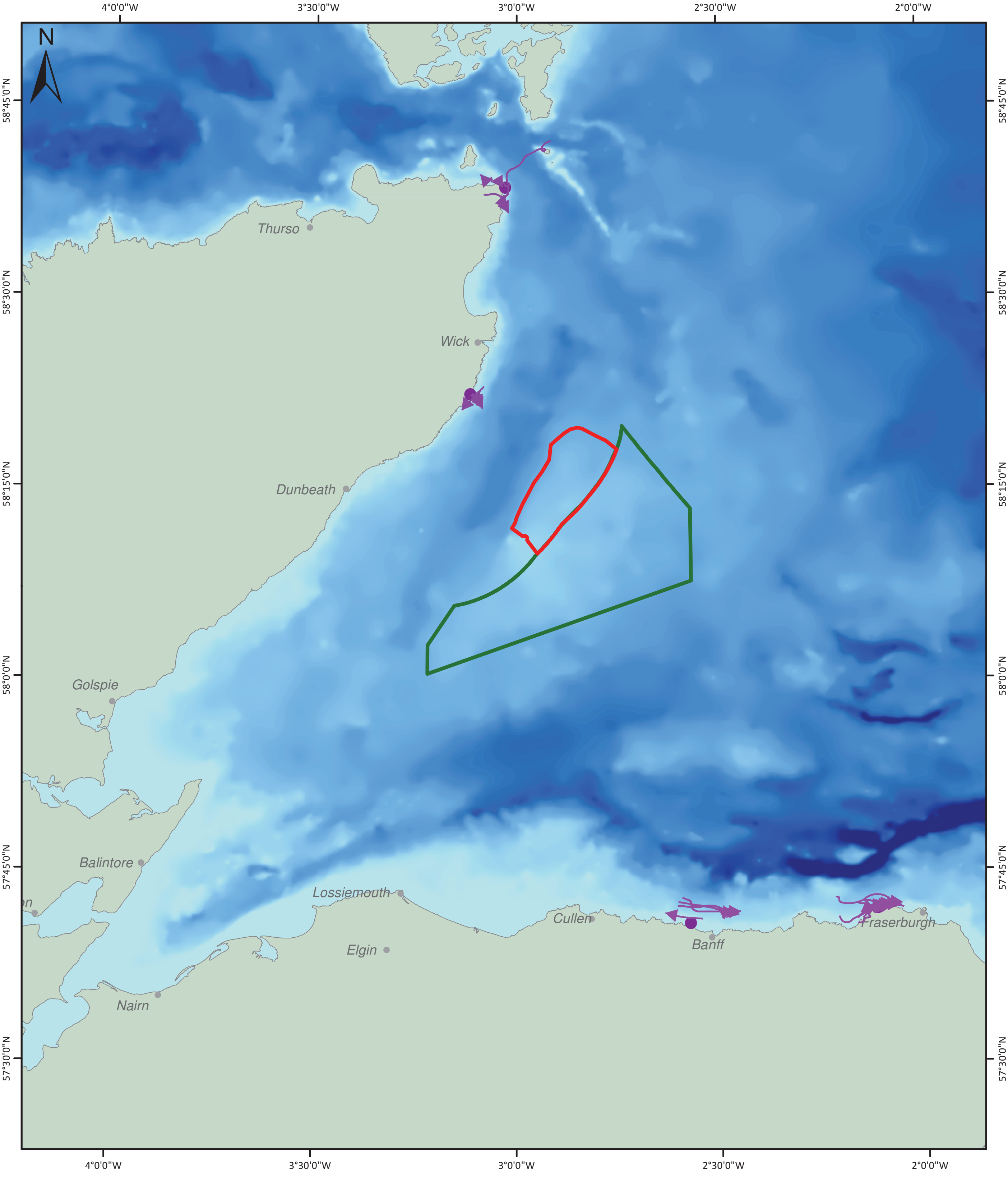
Beatrice Offshore Wind Farm

Figure 3.19.9

Observed Greylag goose flights from coastal vantage point and boat-based surveys: March to May 2011

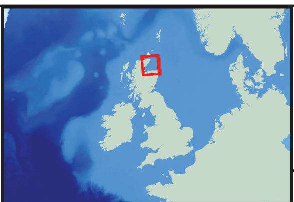
Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:750,000	
Drawing Number: SGP6355_Beatrice_3_19_9_spring11Flights_GJ		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Moray Firth Offshore Windfarm Site Boundary
- Vantage point locations
- Barnacle goose



0 5 10 20 km

0 2.5 5 10 Nm

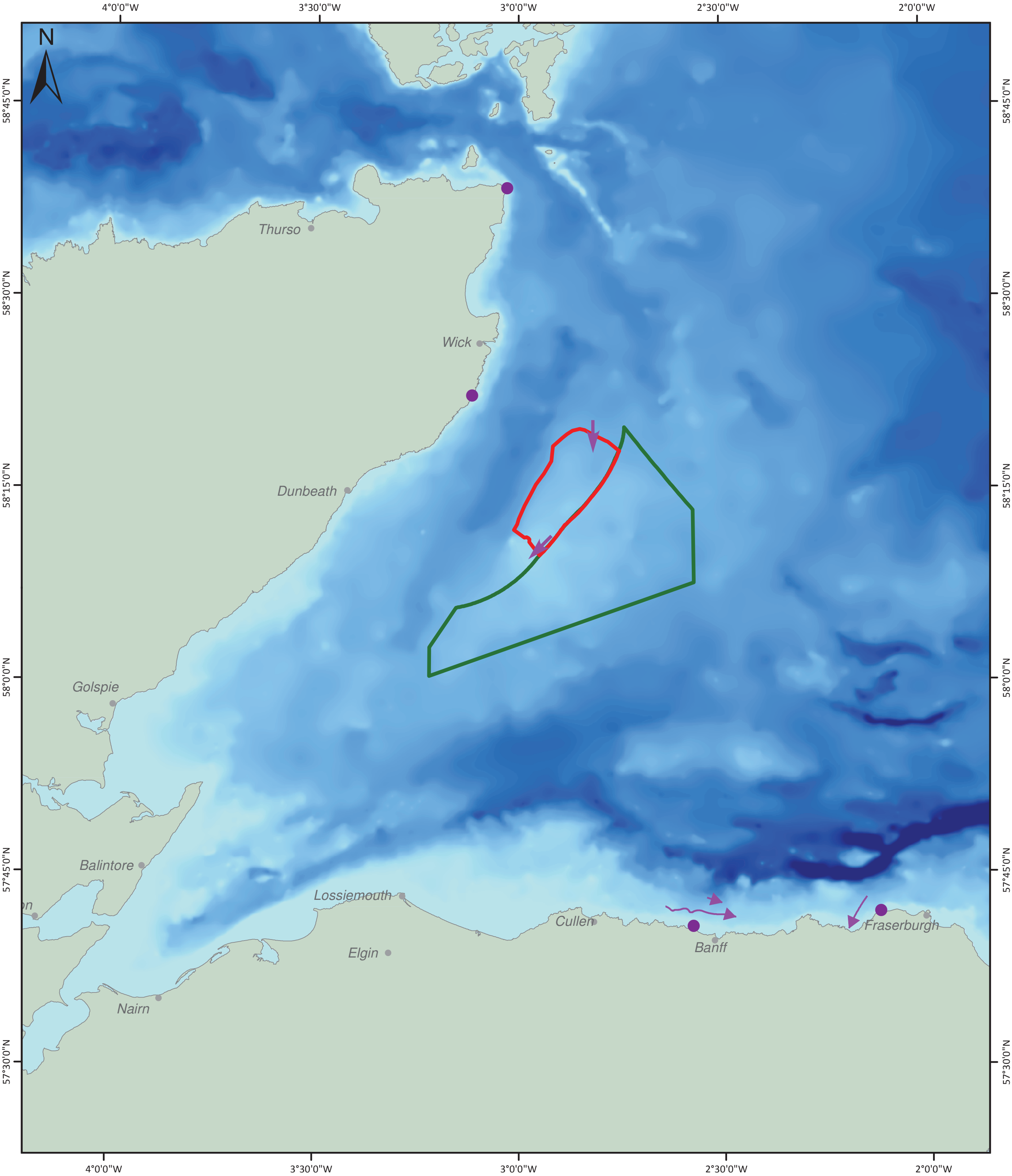
Beatrice Offshore Wind Farm

Figure 3.20.8

Observed Barnacle goose flights from coastal vantage point and boat-based surveys: September to November 2010

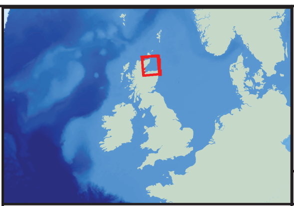
Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:750,000	
Drawing Number: SGP6355_Beatrice_3_20_8_autumn10Flights_BY		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Moray Firth Offshore Windfarm Site Boundary
- Vantage point locations
- Unidentified goose flights



0 5 10 20 km

0 2.5 5 10 Nm

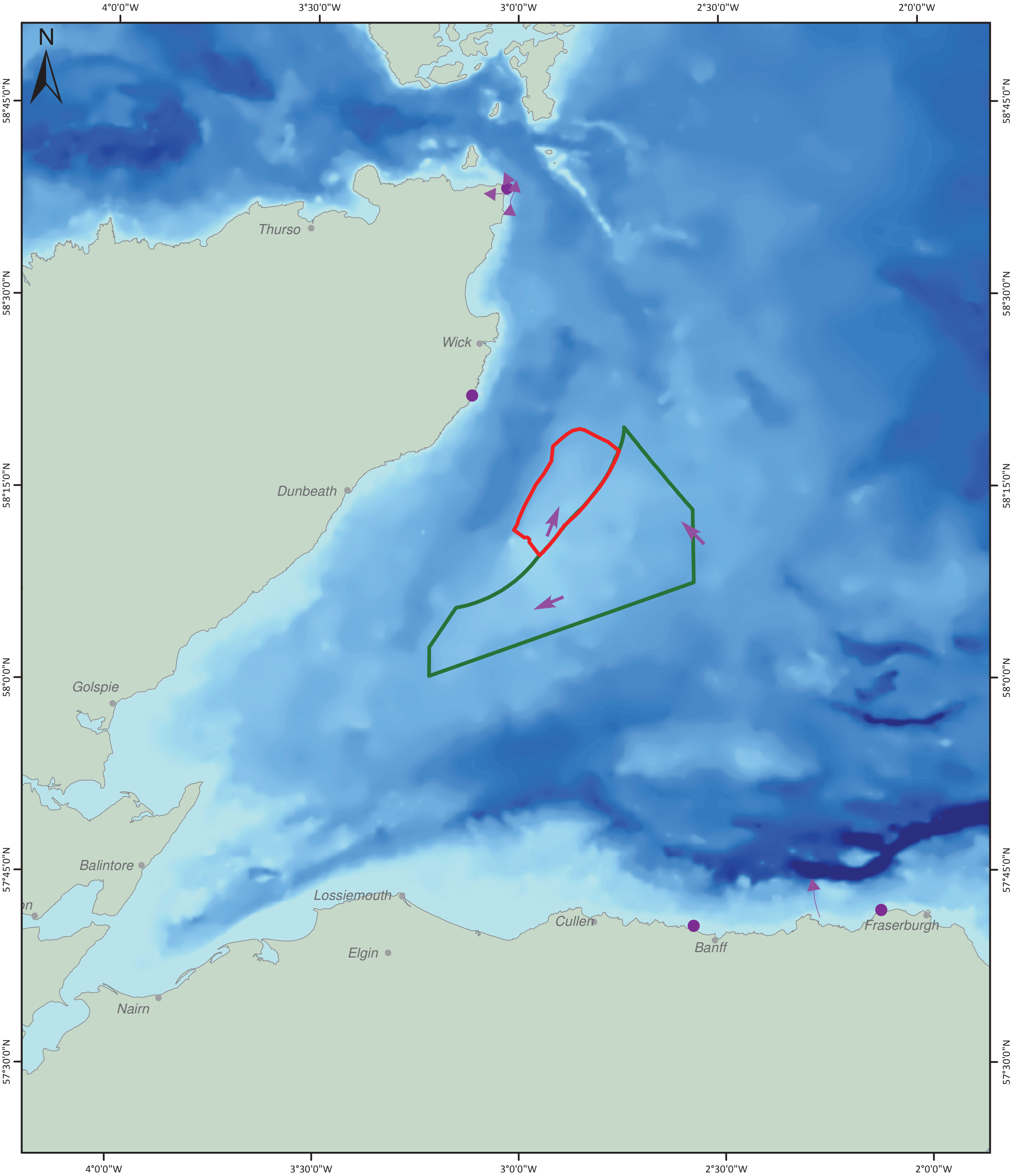
Beatrice Offshore Wind Farm

Figure 3.21.8

Observed unidentified goose flights from coastal vantage point and boat-based surveys: September to November 2010

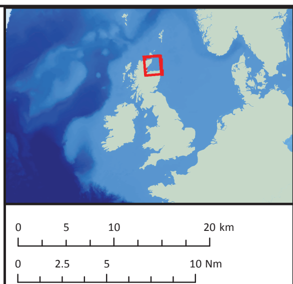
Drawn:	CH	Checked:	MT	Approved:	MT
Date:	30/08/2011	Scale:	1:750,000		
Drawing Number:	SGP6355_Beatrice_3_21_8_autumn10Flights_UO			Revision:	01
Datum:	WGS1984	Projection:	UTM Zone 30N		

Beatrice
Offshore Windfarm Ltd



Legend

- Beatrice Offshore Wind Farm Site Boundary
- Site boundary buffered by 4 km
- Moray Firth Offshore Windfarm Site Boundary
- Vantage point locations
- Unidentified goose



Beatrice Offshore Wind Farm

Figure 3.21.9

Observed unidentified goose flights from coastal vantage point and boat-based surveys: March to May 2011

Drawn: CH	Checked: MT	Approved: MT
Date: 30/08/2011	Scale: 1:750,000	
Drawing Number: SGP6355_Beatrice_3_21_9_spring11Flights_UO		Revision: 01
Datum: WGS1984	Projection: UTM Zone 30N	

Beatrice
Offshore Windfarm Ltd

Other non-seabird passage species

3.95 Few non-seabird species were recorded during the boat-based surveys, either in transect or in snapshot, with only single records of a grey phalarope and an unidentified passerine (Table 3.5). There were some incidental records of wader, duck and passerine species recorded outside of transect (Table 3.6), which are likely to indicate the presence of birds on migration.

3.96 Passage duck, wader and passerine migrants may pass through the Beatrice site once or twice a year as they travel between breeding and wintering grounds. As witnessed during baseline surveys, these species may only be recorded in small numbers by boat and aerial surveys which sample only a small part of the migratory period. However, it is possible that numbers passing through the site throughout this period may be much larger and potentially constitute important parts of SPA populations. Many wader species for example migrate along flyways (Davidson *et al*. 1995), so wind turbines positioned within these areas could pose a risk of collision or result in barrier effects. The boat-based surveys and migration surveys were conducted during daylight hours only and would therefore not record any large scale nocturnal migratory movements, should these have taken place.

3.97 The risk of wind farms to migratory birds in general is not altogether straightforward: while species that migrate at night or during low light conditions may be at increased risk from collisions with turbines, the majority of nocturnal bird migration usually occurs at altitudes considerably higher than potential collision height. In addition, birds usually initiate their migrations under clear conditions and quickly climb to high altitudes, minimising the risk of collision. Although periods of poor visibility may increase risk through changes in bird behaviour, flight activity may also be reduced, especially at night, thereby balancing risks.

3.98 Passerine land-falls can be associated with poor weather, but they also occur when conditions are ideal for migration, indicating that in these instances, bird may fly at high altitudes until shortly before coming into land (Wright *et al*. in prep.). Migration patterns of passerines are largely unknown over the marine environment as these small individuals are difficult to detect and often migrate at night and during conditions of poor visibility, and even when using radar or thermal imaging, identification is not possible to species level. Although migrating passerines may fly higher than turbine height (Blew *et al*. 2008; Newton 2010), they have been observed flying at altitudes at which they would be vulnerable to collision in several studies (e.g. Desholm 2005), especially at night and in poor visibility. There is also evidence that passerines are attracted to, and killed by collision with, offshore structures (especially those that are lit) under poor climatic conditions (Percival 2001; Blew *et al*. 2008; Newton 2010).

3.99 A review of the empirical evidence available on offshore wind farms and migratory behaviour is presented below.

Evidence of migratory behaviour in relation to offshore wind farms

3.100 Terrestrial species typically migrate over the sea at high altitudes and so they will be at little risk of collision with turbines (e.g. Blew *et al*. 2008, Krijgsveld *et al*. 2005). Post-construction monitoring at the Egmond aan Zee Offshore Wind Farm showed that waders migrating through the area generally flew above rotor height and did not show avoidance reactions. Those birds that flew at rotor height showed some deflection in their flight paths, but often entered the wind farm, often at a location where a turbine was standing still (Krijgsveld *et al*. 2010). Both eiders and scoters have been shown to detect and avoid offshore turbines at night in both the Netherlands (Winkelman 1995) and at offshore towers at Tuno Knob in Denmark (Tulp *et al*. 1999).

3.101 Extensive post-construction monitoring radar surveys have been conducted at Horns Rev and Nysted offshore wind farms in Denmark between 1999-2005. Seaducks are common in these locations, and the results have shown that birds may show macro avoidance responses up to 5 km from the turbines, and that overall, 71-86 % and 78 % (at Horns Rev and Nysted respectively) of all bird flocks heading for the wind farms at 1.5 - 2.0 km distance avoided flying between turbine rows (Petersen *et al*. 2006). A large number of the birds which were recorded entering the wind farm were represented by gulls and terns which did not show as much of an avoidance reaction as other species (chiefly comprising common scoter and eider). Consequently, with the exception of gulls and terns, avoidance behaviour may be even more pronounced than the 78 – 80 % estimated

3.102 Changes in flight direction tended to occur closer to the wind farm by night than day at both sites, but avoidance rates remained high in darkness, when it was also shown birds tended to fly higher. There was considerable movement of birds along the periphery of both wind farms, as birds preferentially flew around, rather than between the turbines.

3.103 Radar studies have also revealed that many birds entering a wind farm re-orientate to fly down the middle of rows, equidistant between turbines, further minimising collision risk. Waterbirds (mostly eider) reduced their flight altitude within the wind farm, flying more often below rotor height than they did outside the wind farm.

3.104 Using radar studies, Desholm and Kahlert (2005) reported that the percentage of seaduck and geese flocks entering the Nysted wind farm area decreased by 78 % between pre-construction and initial operation. At night, 13.8 % of flocks entered the area of the operating turbines, but only 6.5 % of those flew closer than 50 m to turbines. During the day, over the same period, these figures were 4.5 % and 12.3 %, respectively. This means that only 0.9 % of the night migrants and 0.6 % of the day migrants flew close enough to the turbines to be at risk of colliding with the turbines. Migrating flocks were slightly more prone to enter the wind farm but counteracted the higher risk of collision in the dark by increasing their distance from individual turbines and flying in the corridors between turbines.

3.105 Christensen *et al*. (2004) combined the use of radar, and visual observations during the daytime, to provide species-specific information on bird movements and orientations as well as data on flight altitude at Horns Rev Wind Farm during spring and autumn migration. Bird movement intensity was highest at night. Only a small percentage of bird tracks entered the wind farm (14 - 22 %). The majority of tracks either changed their orientation and passed around the wind farm with most changing course between 400 - 1,000 m from the wind farm. These distances may represent the general extent to which flying birds avoid such structures. Analyses showed that adjustment of the flight direction (in respect of the turbine rows) was more accurate during the day than at night, which may relate to a more precise recognition of individual turbines by the birds during the hours of daylight. Complete avoidance of the wind farm was also shown by 28 common scoters and 70 divers approaching the wind farm, which contrasted with other species such as gulls that were regularly found within the wind farm.

Non-seabird SPA species – assessment of migratory routes

3.106 The Moray Firth is the most northerly estuary in Europe to hold internationally important concentrations of birds in winter. It is also an important migration staging area in autumn and spring (Swann and Etheridge, 1996), and therefore it is possible that as part of the wider area, the Wind Farm Site may form part of a migratory corridor for some non-seabird species. Migration routes and the numbers of birds migrating across sites may vary from year-to-year depending on environmental conditions (Newton 2010).

3.107 However, this section considers the likely most sensitive ornithological receptors (qualifying species of SPAs around the Moray Firth) and assesses the likelihood of an overlap of the wind farm with a regular migration path. Based on SPAs in the vicinity of the Beatrice site (Table 3.1), the following qualifying non-seabird species may be sensitive receptors, due to the possibility of their presence within the Wind Farm Site during migration periods:

- redshank (Moray and Nairn Coast SPA, Inner Moray Firth SPA)
- wigeon (Dornoch Firth and Loch Fleet SPA)
- bar-tailed godwit (Dornoch Firth and Loch Fleet SPA, Inner Moray Firth SPA, Cromarty Firth SPA)
- red-breasted merganser (Inner Moray Firth SPA)
- teal (Loch of Strathbeg SPA); and
- goldeneye (Loch of Strathbeg SPA).

3.108 Most SPAs relevant to these species are within the inner Moray Firth, with the exception of the Loch of Strathbeg SPA which is near the north-easternmost point of the Aberdeenshire coast (Figure 3.0). The species are present during the winter months only and so an attempt has been made to determine whether the Beatrice site is likely to lie within an important migratory route for individuals travelling from breeding grounds, based on known activity and ringing recoveries (e.g. Wernham *et al*. 2002).

Wigeon

3.109 Wigeon is an abundant and widespread passage migrant and winter visitor to Scotland. From 1996-2001 winter WeBS counts noted an average peak of 58,250 birds at over 500 sites. In the early 2000s the winter population in Scotland was 76,000-96,000 birds with peak numbers in late autumn (Forrester *et al*. 2007).

3.110 Wigeon breed in the high latitudes across northern Europe, from Iceland across northern Britain and Scandinavia. The species is highly migratory, overwintering across the whole European temperate zone (Wernham *et al*. 2002). Ringing recoveries of UK wintering birds show that individuals originate from a large area. Recoveries are mainly from Fennoscandia and Russia, as well as Denmark and the Baltic Sea. Winter recoveries of Icelandic breeding birds have shown that the majority head to Scotland and Ireland. In spring the majority of recoveries have been from inland countries south of the Baltic Sea, suggesting that spring migration is more southerly than in autumn. There is substantial movement of wigeon in Britain throughout winter, with Icelandic birds moving south and continental birds moving west.

3.111 Precise migration routes of Wigeon over the seas around the UK are not known, but as they are widespread around Britain and Ireland in winter, their migration routes probably take birds across most parts of UK waters (Wright *et al*. in prep.). It is therefore unlikely that the Beatrice site constitutes part of a particularly important migratory corridor for the species in relation to the flyway population or any SPA population.

Teal

3.112 Teal occurs commonly across much of Scotland as a winter visitor and passage migrant from northern Europe. Wintering numbers are estimated to be approximately 37,500 individuals. However numbers could range from 22,500 to 125,000 due to limitations in survey coverage for this species (Forrester *et al*. 2007).

3.113 Teal migrate to Britain from Iceland and from northern Europe, especially around the Baltic and Russia (Wernham *et al*. 2002). Autumn migration occurs over a long period from late June until at least November, depending on weather conditions. Spring migration also occurs over a long periods, with birds departing from Britain between late February and May. Some birds also migrate via the UK on passage towards wintering sites further south in Europe (Wright *et al*. in prep.).

3.114 Ringing recoveries suggest that Teal migrate over almost all parts of UK waters, although based on the eastern location on the nearest SPA (Loch of Strathbeg), birds from continental Europe are unlikely to pass via the Beatrice site to overwinter there. Although it is possible that some birds from the Icelandic breeding population (which numbers a few hundred pairs) may pass within the Moray Firth area, there is no evidence to suggest that the Loch of Strathbeg SPA is a particularly important wintering site for this population, with Wernham *et al*. (2002) indicating ringing recoveries of Icelandic birds across Britain and Ireland during winter.

Goldeneye

3.115 Goldeneye is widely distributed outside of the breeding season, with large wintering numbers arriving from more northerly breeding areas. WeBS counts since the late 1990s suggest the minimum wintering population in Scotland to be between 10,000 and 12,000 birds (Forrester *et al*. 2007). WeBS data indicate that the majority of birds arrive at UK wintering sites between October and December, with departures between March and May (Holt *et al*. 2011).

3.116 Migration routes across UK waters are not well understood, but ringing recoveries suggest that UK birds come exclusively from the Scandinavian breeding population, and so the main migration route is likely to be across the North Sea. The passage across however likely comprises a wide corridor, with Wernham *et al*. (2002) indicating ringing recoveries of Scandinavian birds the length of Britain, but particularly along the east coast. With the closest SPA comprising the Loch of Strathbeg, it is unlikely that birds of Scandinavian origin will migrate via the Beatrice site en route to the SPA, although some may migrate to the Inner Moray Firth, which holds relatively small numbers (five year peak mean count of 153 individuals, Holt *et al*. 2011).

Red-breasted merganser

3.117 Red-breasted Merganser is a widespread and relatively common breeding species in Scotland, although in winter the resident, and relatively sedentary British birds are joined by immigrants, including a major proportion of the Icelandic breeding population, and probably from populations that breed in central Europe (across the North Sea) to the east coast of Britain (Wernham *et al*. 2002). It is however considered unlikely that birds will cross the Wind Farm Site on migration from Iceland or within Britain.

Redshank

3.118 Ringing studies have shown that redshanks from Iceland are found wintering in the Moray Firth (Swann and Etheridge 1996). Not all birds arrive directly, with many appearing to 'overshoot' to estuaries further south and then move north to arrive in the Moray Firth later in the winter. There are also a number of records of birds that have bred in Scotland. Both Icelandic and Scottish birds use the firth during autumn migration, and in April it is an important staging site for Icelandic birds.

3.119 Some of the redshank that breed in the UK leave the country during the non-breeding season, but a large proportion remain in the UK. Redshank from Icelandic and UK populations may cross UK waters to France or coastal areas around the North Sea, mainly during peak migration times (Wernham *et al*. 2002).

3.120 Although a large proportion of the Icelandic population migrates across UK waters, it is unlikely that birds from there will pass via the Beatrice site to reach wintering grounds. Most migration between sites within the UK is likely to occur along the coastline, and so the Beatrice site is not expected to constitute part of an important migratory corridor for the species.

Bar-tailed godwit

3.121 Ringing studies have shown that bar-tailed godwits from northern Scandinavia and Russia are found wintering in the Moray Firth (Swann & Etheridge 1996). Adults from this population arrive from the end of July and commence their moult, although evidence shows that some birds moult in continental Europe (Germany and Denmark) or England (The Wash) before their arrival. Some birds also continue southwards towards France to overwinter. Spring return starts in March and six birds caught and plumage-dyed in January-March in the Moray Firth were sighted in southern Norway during April and May (Swann & Etheridge 1996).

3.122 Bar-tailed godwit migration routes are therefore likely to take place across the North Sea, although with large numbers staging at sites in and around the Wadden Sea in spring, this suggests that migration routes are probably concentrated on paths to this area from key wintering sites. Although some birds may pass directly from Scandinavia towards the Moray Firth area, it is unlikely that the Beatrice site is part of an important route for the species, compared to the overall flyway population.

4 IMPACT ASSESSMENT

Introduction

4.1 The magnitudes of any potential impacts resulting from the proposed wind farm were considered in relation to the construction and decommissioning phases, and the operational phase. Within these sub-sections, the potential impacts, both direct and indirect, on birds were considered under the following categories:

- Disturbance and/or displacement of birds from areas used for feeding, roosting, resting, moulting or passage, including as barriers to movement;
- Mortality as a result of collision with turbine blades;
- Barrier effects, and
- Indirect effects to habitats and prey.

4.2 The level of significance of the impact in each case was also evaluated in the context of empirical information, in particular survey data collected for this assessment, and from other relevant sources of bird data and also information collected for constructed wind farms.

Construction and Decommissioning Impacts

4.3 Potential effects associated with the construction and decommissioning of the wind farm include:

- Disturbance / displacement due to increased boat traffic;
- Disturbance / displacement due to construction activities; and
- Indirect impacts of pile-driving or installation of gravity bases upon local habitat conditions and prey stocks.

4.4 During these phases impacts will be temporary and extend over comparatively small areas. Impacts would include those due to the presence and movement of vessels on site and as a result of particular construction activities. Therefore it is possible that birds may re-distribute around the Wind Farm Site, making use of non-impacted areas during periods construction activity. These impacts are considered in more detail below.

Potential disturbance due to increased boat traffic

4.5 For each sensitive receptor species, the impact of disturbance from increased boat traffic was evaluated on the basis of:

- Knowledge of the sensitivity of each bird species from prior studies;
- The magnitude of disturbance that is expected to take place; and
- Information on the likely vulnerability of a species to disturbance from boat traffic was taken from Garthe and Hüppop (2004).

4.6 Fulmar, sooty shearwater, European storm petrel, gannet, Arctic skua, great skua, kittiwake, great black-backed gull, herring gull and Arctic tern are highly mobile foragers, which spend significant proportions of time in flight, rapidly covering large sea areas in search of prey.

Therefore the impact of site specific vessel activity is predicted to be small and of no significance for these species and no further action beyond the adoption of best practice will be required (Table 4.1).

4.7 Guillemot, razorbill and puffin were classed as being of medium sensitivity to disturbance from vessel activity by Garthe and Hüppop (2004), which, combined with a high species sensitivity (due to their inclusion in nearby seabird SPAs), suggests that localised impacts may result. Auks often show a degree of disturbance by vessel activity either by flushing from the water surface or diving when a vessel approaches. The distance of displacement tends to be very small however, and given the available suitable habitat within the Moray Firth such disturbance is very unlikely to result in a negative impact. The potential impacts for these species were therefore classed as of minor significance (Table 4.1).

4.8 While shag are considered to be moderately vulnerable to disturbance due to boat traffic, the low numbers recorded on site led to an impact prediction of minor significance (Table 4.1).

Table 4.1 Analysis of the combination of species' sensitivity with vulnerability to disturbance from boat traffic according to Garthe and Hüppop (2004) and the significance of any impact

Species	Sensitivity	Vulnerability to boat traffic	Theoretical significance of impact	Rationale for predicted significance of impact	Predicted significance of impact
Fulmar	High	Low	Negligible	Attracted to boat traffic	Negligible
Sooty shearwater	Medium	Low	Negligible	Not habitat limited	Negligible
European storm-petrel	Medium	Low	Negligible	Not habitat limited	Negligible
Gannet	High	Low	Negligible	Mostly ignore vessels, show occasional attraction	Minor
European shag	High	Medium	Moderate	Not habitat limited. Not present on site in large numbers.	Minor
Arctic skua	Medium	Low	Negligible	Not habitat limited	Negligible
Great skua	Medium	Low	Minor	Not habitat limited	Minor
Kittiwake	High	Low	Negligible	Not habitat limited	Negligible
Great black-backed gull	High	Low	Minor	Not habitat limited	Minor
Herring gull	High	Low	Moderate	Not habitat limited	Minor
Arctic tern	Medium	Low	Negligible	Not significantly disturbed by vessels; not habitat limited at local scale	Negligible
Guillemot	High	Medium	Moderate	Not significantly disturbed by vessels; not habitat limited at local scale	Minor
Razorbill	High	Medium	Moderate	Not significantly disturbed by vessels; not habitat limited at local scale	Minor
Puffin	High	Low	Moderate	Not significantly disturbed by vessels; not habitat limited at local scale	Minor

Potential disturbance due to construction activity

4.9 Construction and decommissioning works are likely to involve noisy and potentially disturbing works such as pile driving. Turbine foundation options currently under consideration include pin piles, gravity bases or suction bases. Of these, any piling operation will be expected to generate the greatest source of direct disturbance to birds, through vessel activity and above sea noise. Thus, in line with the Rochdale Envelope approach, consideration for construction impacts will focus on the direct disturbance and potential indirect impacts on birds, predicted to occur from piling operations.

4.10 As a worst case scenario such activity could result in the complete avoidance of the surrounding area out to a given range by all the individuals of one or more species for the duration of activity. However, a lack of specific information on the response of many species to noise, in particular the type, duration and severity of the impact and the speed at which birds may habituate, makes it extremely difficult to predict the level to which different species may be affected. Susceptibility to disturbance and its consequences may depend on:

- The foraging strategy of the birds involved, i.e. aerial, swimming or surface diving foragers (Table 4.2);
- Whether the birds present in the site are actively feeding or simply loafing or rafting, with the relative proportions of these activities likely to vary depending on the season;
- The period and duration of occupancy of the site and the reasons behind it (e.g. whether birds are engaged in another activity other than feeding such as resting or undergoing moult; and
- The origin of the birds involved (i.e. whether they are breeding birds or temporary migrants).

4.11 Each of these factors has, therefore, been taken into account when assessing the potential impact of construction activities on any given species (Table 4.3). One study which has reported on construction impacts (Leopold and Camphuysen 2007), noted that the only birds seen to be present around the Egmond aan Zee wind farm in the Netherlands at the times of (observed) pile driving were gulls (mainly lesser black-backed and herring gulls) and terns (mainly sandwich and common terns). These birds were mainly seen flying by (i.e. in the air where they were not subjected to underwater noise). They concluded that there was little, if any effect of pile driving on the presence of gulls in the area.

4.12 In contrast to impacts on birds, Leopold and Camphuysen (2007) reported marked effects on the behaviour, or presence of mackerel during pile driving, strongly suggesting that there could be measurable indirect effects of underwater noise on the local distribution and abundance of (underwater) seabirds. The fact that seabirds were not reported as being affected was due to a combination of factors, most importantly the general absence at this site of birds that spend a lot of time diving under water such as auks.

Table 4.2 Principal prey items and feeding strategy of the sensitive receptors at Beatrice Offshore Wind Farm Site, as documented in the general literature (Snow and Perrins 1998).

Species	Principal prey type at sea
Fulmar	Omnivorous – fish, crustaceans, squid, discards, jellyfish and molluscs. Follows boats.
Puffin	Marine fish (particularly sandeels, clupeids and gadids).
Kittiwake	Small fish – especially clupeids and sandeels, invertebrates and discards taken by dipping to the surface and head-immersion. Follows boats.
European storm-petrel	Mainly surface crustaceans, small fish, medusae and cephalopods. Sometimes follows boats.
Gannet	Fish – especially clupeids, gadoids, sandeel, mackerel and discards captured by deep plunge diving.
Razorbill	Small fish (particularly sandeel and clupeids), many invertebrates also taken in winter.
Guillemot	Fish – especially clupeids and sandeels, but also benthic species, and some invertebrates taken by diving up to ~60 m.
Sooty shearwater	Mainly cephalopods, crustaceans and fish. Feeds largely from surface or by short, shallow dives, often close inshore during day.
Arctic skua	Specialist food pirate (kleptoparasite) of terns, small gulls and auks – diet probably thus mainly sandeels and clupeids in the Moray Firth.
Herring gull	Omnivorous, taking wide variety of foods. Predator, scavenger and food-pirate.
Great black-backed gull	Omnivorous, taking wide variety of foods. Voracious predator, scavenger and food-pirate.
Arctic tern	Small fish and invertebrates taken by dipping to the surface and shallow plunge diving – highly opportunistic.
Great skua	Food pirate (kleptoparasite) and predator of gulls, terns and auks, small fish at surface.
European shag	Marine fish (particularly sandeels, clupeids and gadids).

4.13 Very little is known about how diving birds may respond directly to underwater noise. As species which have hearing adapted primarily for use in air, it is expected that hearing sensitivity underwater will generally be low, in comparison to that for marine mammals, for example. In addition, standard practices such as soft start procedures, would be expected to minimise any major direct noise impacts.

4.14 Consequently, it seems likely that for some species, the impact of construction activity (especially pile driving) would occur indirectly through impacts upon the distribution of prey species. High intensity sounds within the water column are known to have a highly significant and potentially lethal effect on certain fish species (e.g. Caltrans 2001, Thomsen *et al.* 2006, RPS 2011). It is possible therefore that pile driving could influence the abundance and distribution of some prey species during construction, and potentially beyond the period of construction if fish populations are significantly affected.

4.15 The assessment of noise impacts on sandeels, which constitute a major resource for many of the seabirds foraging within the Wind Farm Site, reported that this species is considered to be at risk of impacts due to underwater noise of minor significance (see Fish Ecology Section of the Beatrice Offshore Wind Farm ES). This assessment is based on the fact that sandeels lack a swim bladder, the presence of which is considered to be a major determinant of the magnitude of effect which underwater noise has on fish species. Their low sensitivity to noise, in combination with the fact that pile driving will occur within comparatively localized areas across the Wind Farm Site at any one time (no more than two locations at any one time)will limit the extent of impacts. Therefore indirect impacts on seabirds mediated through effects on sandeels are considered to be of negligible significance.

4.16 Large numbers of guillemots, and lower numbers of razorbills were recorded in the boat based study area during the breeding season, with considerable foraging activity throughout this period. Pile driving operations may cause fish to re-distribute away from the sources of disturbance, with the birds responding by simply moving with the shoals. The temporary displacement of fish from the immediate area may be of little consequence to birds if they are able to locate suitable habitat nearby and re-populate the affected area once piling has ceased. Whilst this seems likely for many wide ranging pelagic species, the extent and duration of displacement is hard to predict due to a lack of detailed study of fish movements.

4.17 The various seabird surveys conducted across the Moray Firth have revealed that much of the region provides foraging opportunities for guillemots and razorbills (e.g. RSPB 1984). Furthermore, the tracking study conducted during the 2011 breeding season highlighted the importance of south western areas of the Moray Firth for foraging. Individuals which nest at more northerly locations than those selected for the tagging study might be expected to forage within the Wind Farm Site, due to their greater proximity to it. However, it is notable that the birds tagged undertook foraging trips to destinations much farther away from their nest sites than the Wind Farm Site (Figures 3.1.7, 3.7.7, 3.11.7, 3.12.7). Thus, it appears that the south western area of the Moray Firth provided foraging opportunities which were favoured over those available on the Wind Farm Site. It is therefore plausible that any short term displacement caused during the construction of the wind farm will constitute a small impact of minor significance on auks (Table 4.3).

4.18 Puffin were not recorded on site in large numbers during the breeding season, however their diving habits could potentially cause them to be impacted by construction activities. Consequently the significance of impacts on puffin was also classed as minor.

4.19 Opportunistic scavenging species such as gulls and fulmar (Table 4.2) may benefit from foraging opportunities created by construction works. Great black-backed gull, for example, frequently associate with vessels and human activity such as fishing (Mitchell *et al.* 2004). Individuals of this species may exploit novel foraging opportunities created by the presence of vessels or noise disturbance, bringing potential prey (dead or alive) to the surface. As such, the magnitude of construction related impacts on these species, and others with similar foraging habits (e.g. herring gull, kittiwake and fulmar), which also forage opportunistically, were assessed as small and either of minor, or no, significance (Table 4.3).

4.20 Whilst gannet have been recorded feeding within the Wind Farm Site, this has been in low numbers, and this species is known to have an extremely flexible foraging strategy (Table 4.2). This species is known to associate with human activity at sea, aggregating around fishing vessels in order to take advantage of discards. There is potential therefore that individuals may take advantage of any fish disorientated by construction activity. In relation to direct impacts, gannet are considered unlikely to respond adversely to noise and other construction activity. Overall, therefore construction impacts on gannet were considered to be of minor significance (Table 4.3).

4.21 As kleptoparasites of other species, Arctic skua and great skua (Table 4.2) are not expected to be directly affected by impacts on fish and loss of foraging areas as a result of the construction process, but may be indirectly impacted by the way in which species they parasitise (e.g. auks and kittiwake) respond. Since, their foraging strategies tend to cause them to focus their efforts on seabird breeding colonies, this lends further support to the prediction of minimal direct impacts due to construction. Both skua species would be expected to exhibit flexible responses to shifts in the distribution of other species by moving into areas that are more profitable. Thus the predicted impact on these species is considered to be of negligible significance (Table 4.3).

4.22 Sooty shearwater are not reliant on fish (Table 4.2), reducing the possible impact of any indirect effects on fish. Moreover, sooty shearwater only occurs in the Moray Firth during a limited period during Autumn migration. Thus, individuals are only likely to be within the site for very short periods limiting the time over which any theoretical impact could occur. Consequently the predicted indirect impact upon sooty shearwater is most appropriately judged to be of negligible significance (Table 4.3).

4.23 No other seabird species were considered to make use of the Wind Farm Site in ways which would lead them to be impacted during construction or decommissioning. Thus the significance of impacts due to construction for all the remaining sensitive receptors was classed as of negligible significance.

Table 4.3 Analysis of the combination of species' sensitivity with possible vulnerability to direct and indirect disturbance from construction noise and the resulting significance of any impact

Species	Sensitivity	Vulnerability to construction activity (e.g. noise) and habitat flexibility	Theoretical significance of impact	Rationale for predicted significance of impact	Predicted significance of impact
Fulmar	High	Negligible	Negligible	Flexible and wide ranging foraging behaviour	Negligible
Sooty shearwater	Medium	Negligible	Negligible	Unlikely to respond to noise	Negligible
European storm-petrel	Medium	Low	Negligible	Unlikely to respond to noise	Negligible
Gannet	High	Low	Minor	Unlikely to respond to noise	Minor
European shag	High	Medium	Negligible	Not habitat limited. Not present on site in large numbers.	Negligible
Arctic skua	Medium	Negligible	Negligible	Flexible foraging pattern	Negligible
Great skua	Medium	Low	Negligible	Flexible foraging pattern	Negligible
Kittiwake	High	Low	Negligible	Unlikely to respond to noise	Negligible
Great black-backed gull	High	Low	Minor	Unlikely to respond to noise	Minor
Herring gull	High	Low	Minor	Unlikely to respond to noise	Minor
Arctic tern	Medium	Low	Negligible	Not habitat limited. Not present on site in large numbers.	Negligible
Guillemot	High	Medium	Minor	Possible short range displacement	Minor
Razorbill	High	Medium	Minor	Possible short range displacement	Minor
Puffin	High	Medium	Minor	Possible short range displacement	Minor

Operational Impacts

4.24 The potential operational impacts of offshore wind farms on birds are:

- Disturbance due to maintenance activity;
- Avoidance of turbines resulting in displacement from some or all of the site;
- Barrier effects limiting or preventing free movement;

- Direct collision of birds with turbines; and
- Indirect effects on distribution of prey and foraging habitat.

Disturbance due to Maintenance Activity

4.25 Disturbance of birds resulting from maintenance activity around turbines is likely to be similar in scope to that discussed in relation to boat traffic during the construction phase (see Table 4.1). However, as vessel traffic during maintenance events will be lower than during construction, the associated impacts are also reduced.

Displacement from the Wind Farm Site

4.26 Displacement is defined here as the prevention of individuals from a seabird species from undertaking their normal behaviour within areas previously utilised, due to the presence of a novel stimulus. For the purposes of this assessment, the novel stimulus is considered to be the wind turbines (and associated structures) but does not include the wind farm related vessel traffic (e.g. maintenance vessels).

4.27 To explore the potential impacts of displacement on seabirds foraging on the site, a mechanistic approach was used. The proposed model relates a species' turbine avoidance distance to radial areas around each turbine, and from this generates an estimate of the percentage of the Wind Farm Site from which individuals of each seabird species would be excluded. Birds thus excluded from the site are assumed to be unable to successfully reproduce.

4.28 The species of primary concern with regards to the potential impacts of displacement on their populations were those for which the Wind Farm Site appeared to be of importance for foraging during the breeding season. Estimates of seasonal abundance during the breeding season, derived from the boat data, indicated that fulmar, kittiwake, guillemot and razorbill were the species most at risk of population impacts due to displacement. While great skua have a breeding season peak abundance on the Wind Farm Site, this species' habitat flexibility and feeding habits lead to it being regarded as at low probability of impact due to displacement.

4.29 Species with peak abundances recorded in months outside the breeding season were not considered at significant risk, since observations made at these times were expected to reflect passage movements and ad hoc site use rather than selection of the boat based study area for foraging. Birds are much less constrained in terms of foraging locations than during the breeding season and consequently the impact of any potential displacement in terms of energetic costs will be considerably smaller. In addition impacts will be distributed amongst much larger populations outside the breeding season

4.30 The turbine option with the highest number of turbines and the closest spacing was considered to represent the worst case scenario for displacement. This scenario was 277, 3.6 MW turbines placed at 642 m intervals (both orientations). Table 4.4 provides estimates of the predicted displacement percentages for this turbine option in relation to bird avoidance distances.

Table 4.4. Seabird avoidance distances and associated predicted displacement percentages for the worst case wind farm scenario based on 3.6 MW turbines.

Radial avoidance distance	Displacement percentage
50	2
100	7.6
200	30.5
300	68.6
400	100

Fulmar

4.31 The peak abundance of fulmar recorded on the Wind Farm Site during the breeding season was 1,026. Including a buffer area around the Wind Farm Site boundary to account for a 400 m maximum avoidance distance from perimeter turbines, added an extra 9.05 km^2. At a maximum density of 7.82 per km2, this increased the peak population at risk of displacement to 1,096 individuals.

4.32 The breeding population of the East Caithness Cliffs SPA is currently estimated to be 28,400 individuals (SNH 2008a). If it is assumed that all of the fulmars recorded during the boat surveys were breeding birds from this population, the estimated percentage of the population which would be affected by the wind farm would be 3.6 %.

4.33 However, fulmar forage over large distances, with a mean maximum range of 311 km (Langston 2010). It is therefore probable that birds observed on the Wind Farm Site include individuals from other breeding colonies. Including breeding colonies within 300 km of the Wind Farm Site increases the size of the potential population from which birds have been seen on site to over 600,000 (Mitchell *et al.* 2004), although it is unlikely that all of these breeding individuals would forage within the Moray Firth. A more conservative estimate of foraging range from which to identify breeding colonies to include in this assessment is the mean range (69 km, Langston 2010). Applying this distance reduces the potential population to those along the Moray Firth coast, North Caithness Cliffs and southern Orkney (Troup, Pennan and Lions Head, East Caithness Cliffs, North Caithness Cliffs, Copinsay and Hoy). Summing the most recent estimates from the SPAs within this range gives 139,676 individuals (Tables 3.1 and 3.2). Using this estimate for the effective population size reduces the percentage of SPA individuals which could be displaced by the wind farm to 0.7 %.

4.34 A population model was developed for fulmar, using published demographic data (Dunnet and Ollason 1978, Maclean *et al.* 2007). Birds first breed at the age of nine (Ollason and Dunnet and Ollason 1978), and little is known about their movements prior to this age. Breeding adult annual survival has been estimated as 0.971 (Dunnet *et al.* 1979). However, very few birds ringed as fledglings return to breed at their natal colonies (approx. 10 %, Dunnet and Ollason 1978), making estimation of pre-breeding survival difficult. Dunnet and Ollason (1978) used indirect methods to derive an annual pre-breeder survival rate of between 0.88 and 0.93 (the average, 0.9, was used here). Dunnet and Ollason (1979) also provide an estimate of the mean number of fledged young per pair of 0.34.

4.35 A two stage population model (A.F) was developed form these data, with compound age classes for pre-breeding birds (0 – 9 years) and breeding birds (9 + years):

$$A.F = \begin{bmatrix} 0 & 0.165 \\ 0.387 & 0.971 \end{bmatrix}$$

4.36 Pre-breeding age survival was calculated as a product of the nine annual estimates of 0.9 to give a fledging to nine years old survival rate of 0.387 (row two, column one). Reproduction was calculated as the product of adult survival (to incorporate the fact that only birds which survive from one year to the next can breed) and the number of fledglings per individual (0.34 divided by two). Adult breeders have an annual survival rate of 0.971. In this format, the model is density independent and includes no environmental or demographic stochasticity (i.e. variations due to weather and chance). However, for the displacement assessment these additional components were considered to provide unnecessary complexity for little benefit.

4.37 Two initial population sizes were used for the assessment of potential displacement impacts. The first was restricted to the East Caithness Cliffs SPA population (28,400) and the second to birds breeding at SPAs within the mean maximum foraging range of 69 km of this species from the Wind Farm Site (139,676).

4.38 To determine the impact of displacement of breeding birds on these two populations from the site, the population model was used to predict the population growth rate resulting when between 0 % and 100 % of the birds estimated to be making use of the Wind Farm Site (1,096), were prevented from breeding (Table 4.5).

Table 4.5. Population growth rate of the East Caithness Cliffs SPA fulmar population and the wider SPA populations within 69 km of the Wind Farm Site resulting from reductions in the breeding output of birds foraging on the Wind Farm Site due to displacement, based on 3.6 MW turbines separated by 642 m.

Radial avoidance distance (m)	Displacement (%)	Population growth rate (%)	
		East Caithness Cliffs SPA population	Wider SPA population (within 69 km of application site)
0	0	3.29	3.29
50	2	3.29	3.29
100	7.6	3.28	3.29
200	30.5	3.2	3.28
300	68.6	3.2	3.27
400	100	3.15	3.26

4.39 The baseline annual population growth rate predicted by the model was 3.29 %. The magnitude of reduction in the population growth rate of the East Caithness Cliffs SPA population, resulting from between 2 % and 100 % of the estimated application site foraging population failing to breed was small (Table 4.5). Even if all of the 1,096 birds estimated to be using the site failed to breed, the reduction in the population growth rate was only 0.14 %. Over the period of a 25 year simulation this approximated to a difference in the East Caithness Cliffs breeding population size of 2,100 (baseline population size: 49,990 compared with 100 % displaced birds failing to breed: 47,890).

4.40 Thus, even with a scenario with all birds using the site in the breeding season being excluded from their foraging grounds and failing to breed, with the effect limited to just the East Caithness population, the overall impact on the population was found to be small.

4.41 Garthe and Hüppop (2004) estimated that fulmar had a very low wind farm sensitivity score, with very low sensitivity to disturbance by ship and helicopter traffic and high habitat use flexibility. This implies that fulmar will exhibit short avoidance distances in relation to turbines, with consequent predictions of low displacement percentages.

4.42 Fulmar are also considered to be flexible in their choice of foraging location. Site specific evidence for this can be derived from the results of the tracking study undertaken during the 2011 breeding season (Votier *et al*. 2011). Twenty individuals had satellite tags fitted, and the geographic distribution of tracks obtained extended beyond the Wind Farm Site (Figure 3.1.7), and indeed beyond the Moray Firth region (taken here as a line connecting Peterhead to Duncansby Head).

4.43 It is therefore concluded that fulmar populations within range of the Wind Farm Site will experience low levels of impact as a result of displacement due to the presence of the turbines. Even if the effects are restricted to just the East Caithness population, the impact is predicted to be small. Outside the breeding season much lower numbers were recorded during the boat surveys. While this species remains present at low densities throughout much of the year, the effective range at this time of year is such that the impacts of displacement on the passage and wintering population of the region is also not considered to constitute a significant impact.

Guillemot

4.44 Garthe and Hüppop (2004) estimated guillemot to have a low overall wind farm sensitivity score, although their sensitivity to ship and helicopter traffic and their habitat flexibility scores were both moderate. The peak abundance of this species on site has been recorded during the breeding season (peak abundance in April 2010, application site estimated abundance: 6,928). This species was therefore considered at potential risk of population impacts during the breeding season due to displacement effects. Adding on birds which would be displaced from the perimeter turbines, using a maximum avoidance distance of 400 m, and the peak estimated density of 52.83 per km^2, increased the number of birds at risk of displacement to 7,406.

4.45 The number of individual guillemots recorded in with the East Caithness Cliffs SPA is currently estimated to be almost 160,000 individuals (SNH 2008a). This will include both breeding birds and immature individuals associating with the breeding colonies. Harris (1989) recommends a correction factor of 0.67 to convert total counts to the number of breeding pairs (or 1.34 to estimate the number of breeding individuals). Applying this correction yields an expected number of breeding individuals of 214,400. If it is assumed that all the guillemot recorded during the boat surveys were breeding birds from this population, the estimated percentage of the population which would be affected by the wind farm would be 3.4 %. However, prior to their first breeding attempts, immature guillemot are found in association with breeding colonies (Snow and Perrins 1998), and these non-breeding birds will also have been recorded during the boat surveys. These chiefly comprise immature birds which have not reached breeding age (age at first breeding has been taken here as a minimum of four years old). Typically, birds up to the age of two are thought to remain at sea all year round, but from two they begin to associate with breeding colonies during the breeding season. Simple population modelling was used to estimate the proportion of the population made up of these two to four year old non-breeding birds, as described below.

4.46 Demographic rates for guillemot were taken from published long-term studies of survival and reproduction for the Isle of May and Skomer populations (Crespin *et al.* 2006a, Crespin *et al.* 2006b, Votier *et al.* 2008). From these data the following population matrix (A.GU), describing annual change in the population, was derived:

$$A.GU = \begin{bmatrix} 0 & 0 & 0 & 0.32 \\ 0.7 & 0.7 & 0 & 0 \\ 0 & 0.27 & 0.86 & 0 \\ 0 & 0 & 0.18 & 0.9 \end{bmatrix}$$

4.47 This model has four stages, juveniles, immatures, adult non-breeders and adult breeders and incorporates both sexes in a post-breeding census format. The value in the first row, fourth column (0.32) is a product of the breeding adult survival rate (fourth row, fourth column, 0.9) and the number of young fledged per individual (0.715/2). Survival from fledging to age two can only be estimated as a composite, over both years since young guillemot do not begin returning to breeding colonies (and hence present leg rings for re-sighting analysis) until the beginning of their third year. Hence the first two survival estimates (row two, column one and row two, column two, 0.7) were derived as the square-root of the composite two year rate ($0.497^{0.5}$). Recruitment from immature to non-breeder occurs at a rate of 0.39, hence survival and transition to immature (row threes, column two) occurs at a rate of 0.27 (0.7*0.39). The non-breeder survival rate (row three, column three) was 0.86, while recruitment of non-breeders to breeders from among this stage occurs at a rate of 0.21, giving a recruitment rate (row four, column three) of 0.18 (0.21 * 0.86). Adult breeders have an annual survival rate of 0.9. In this format, the model is density independent and includes no environmental or demographic stochasticity (i.e. variations due to weather and chance). However, for the displacement assessment these additional components were considered to provide unnecessary complexity for little benefit.

4.48 Using this model it was possible to estimate the stable age distribution. This is the predicted average number within each of the four age classes. The percentage of the population in each age class was: 11 %, 22 %, 31 % and 36 % for ages one to four respectively. If it is assumed that one and two year olds are not present in the Moray Firth during the breeding season in appreciable numbers, but that, due to their presence in the breeding colonies, three year olds are present in the above proportion, this indicates there may be 185,000 three year old guillemots present, in addition to the 214,400 breeding birds.

4.49 Therefore, an overall population of almost 400,000 individual guillemots are predicted to be present in the Moray Firth and associating with the East Caithness Cliffs breeding colonies. While a proportion of the birds seen in the wind farm study area are expected to be immature birds, thereby reducing the impact of displacement on the breeding population, a precautionary approach was adopted here, with all displaced individuals assumed to be breeding birds.

4.50 To determine the impact on the SPA population of displacement of these breeding birds from the site, the population model was used to estimate the population growth rate which resulted when between 0 % and 100 % of the above number of birds (7,406), multiplied by the range of displacement percentages in Table 4.4, were prevented from breeding (Table 4.6).

Table 4.6. East Caithness Cliffs SPA guillemot predicted population growth rate with percentage reductions in the breeding output of birds foraging on the Wind Farm Site, resulting from range of displacement values, based on 3.6 MW turbines separated by 642 m.

Radial avoidance distance (m)	Displacement (%)	Population growth rate (%)
0	0	5.68
50	2	5.68
100	7.6	5.68
200	30.5	5.66
300	68.6	5.64
400	100	5.61

4.51 The baseline annual population growth rate predicted by the model was 5.7 %. The reductions in the population growth rate resulting from between 2 % and 100 % of the Wind Farm Site foraging population failing to breed were small: even if 100 % of the 7,406 birds estimated to be using the site failed to breed, the reduction in the population growth rate was only 0.07 %.

4.52 Thus, even with a scenario with all birds using the site in the breeding season being excluded from their foraging grounds and failing to breed, the overall impact on the population was found to be of no significance. Thus, displacement of guillemot is not considered to constitute a significant impact on the East Caithness Cliffs SPA population.

Kittiwake

4.53 The peak abundance of this species on site has been recorded during the breeding season (peak abundance in May 2010, Wind Farm site estimated abundance: 496). Since this species appears to use the Wind Farm Site during the breeding season, it was considered at potential risk of population impacts during the breeding season due to displacement effects. Adding on birds which would be displaced from the perimeter turbines, using a maximum avoidance distance of 400 m, and the peak estimated density of 5.88 per km ^{2}, increased the number of birds at risk of displacement to 530.

4.54 The breeding population of the East Caithness Cliffs SPA is currently estimated to be almost 80,820 individuals (SNH 2008a). If it is assumed that all of the kittiwakes recorded during the boat surveys were breeding birds from this population, the estimated percentage of the population which would be affected by the wind farm would be 1 %. However, prior to their first breeding attempts, immature kittiwakes are typically found in association with breeding colonies (Wooller and Coulson 1977), and these non-breeding birds will also have been recorded during the boat surveys. These chiefly comprise immature birds which have not reached breeding age (age at first breeding has been taken here as four years old). In their study, no birds younger than two were observed at the colonies, but from two they begin to associate with breeding colonies during the breeding season (Wooller and Coulson 1977). These individuals are found at the fringes of colonies and are not included in the SPA population estimates (which are based on Apparently Occupied Nests, AON). The proportion of the birds associated with the breeding colonies made up of these pre-breeders is not reported. However, in other seabirds it has been found to be in the region of 40 %. As a conservative estimate a ratio of 30 : 70 pre-breeder to breeder was applied to the SPA populations to generate an estimate of the potential number of kittiwake which could be present in the Moray Firth. Thus, the estimated total number of adult kittiwake associated with the East Caithness Cliffs SPA was 115,457 (80,820 divided by 0.7).

4.55 Demographic rates for kittiwake were taken from a study on the Isle of May (Frederiksen *et al.* 2005). These rates gave a population growth rate of 0.964, signifying negative population growth. However, the East Caithness Cliffs population have not shared this negative growth. This population increased between 1985-88 and 1998-2002 at an annual rate of 4.5 % (Mitchell *et al*. 2004). Therefore the productivity rate was adjusted to achieve this rate of growth under the baseline scenario of no displacement. This step has little impact on the final outcome of the analysis since this is based on change in the population growth rate. From these data the following population matrix (A.KI), describing annual change in the population, was derived:

$$A.KI = \begin{bmatrix} 0 & 0.582 \\ 0.264 & 0.896 \end{bmatrix}$$

4.56 This model has two stages, pre-breeders aged from fledging to four years old and breeding adults aged four and up, and incorporates both sexes in a post-breeding census format. The value in the first row, second column (0.582) is a product of the breeding adult survival rate (second row, second column, 0.896) and the number of young fledged per individual (1.3/2). Survival from fledging to age four can only be estimated as a composite over all years, since insufficient young birds return to breeding colonies at this age for reliable estimation. The rate used here was identified as that which yielded the target population growth rate when combined in the model with the known rates. Thus an annual rate of 0.72 was derived, which multiplied by itself four times gave the value in the model (0.264). Adult breeders have an annual survival rate of 0.896. In this format, the model is density independent and includes no environmental or demographic stochasticity (i.e. variations due to weather and chance were omitted). However, for the displacement assessment these additional components were considered to provide unnecessary complexity for little benefit.

4.57 The initial total population size for simulations was the estimated overall population of 115,457 predicted to be present in the Moray Firth and associating with the East Caithness Cliffs breeding colonies. While a proportion of the birds seen in the wind farm study area are expected to be immature birds, thereby reducing the impact of displacement on the breeding population, a precautionary approach was adopted here, with all displaced individuals assumed to be breeding birds.

4.58 To determine the impact on the SPA population of displacement of these breeding birds from the site, the population model was used to estimate the population growth rate which resulted when between 0 % and 100 % of the above number of birds (530), multiplied by the range of displacement percentages in Table 4.4, were prevented from breeding (Table 4.7).

Table 4.7. East Caithness Cliffs SPA kittiwake predicted population growth rate with percentage reductions in the breeding output of birds foraging on the Wind Farm Site, resulting from range of displacement values, based on 3.6 MW turbines separated by 642 m.

Radial avoidance distance (m)	Displacement (%)	Population growth rate (%)
0	0	4.35
50	2	4.35
100	7.6	4.35
200	30.5	4.34
300	68.6	4.33
400	100	4.32

4.59 The baseline annual population growth rate predicted by the model was 4.35 %. The magnitude of reductions in the population growth rate resulting from between 2 % and 100 % of the Wind Farm Site foraging population failing to breed were small: even if 100 % of the 530 birds estimated to be using the site failed to breed the reduction in the population growth rate was only 0.04 %.

4.60 Thus, even with a scenario of all birds which would choose to use the site in the breeding season being excluded from their foraging grounds and failing to breed, the overall impact on the population was found to be of no significance. Thus, potential displacement of kittiwake was not considered to constitute a significant impact on the East Caithness Cliffs SPA population.

Razorbill

4.61 The peak abundance of this species on site recorded during the breeding season was 537 (June 2010). This species was therefore considered at potential risk of population impacts during the breeding season due to displacement effects. Adding on birds which would be displaced from the perimeter turbines, using a maximum avoidance distance of 400 m, and the peak estimated density of 4.1 per km^2, increased the number of birds at risk of displacement to 574.

4.62 The breeding population of the East Caithness Cliffs SPA is currently estimated to be almost 17,830 individuals (SNH 2008a). This will include both breeding birds and immature individuals associating with the breeding colonies. Harris (1989) recommends a correction factor of 0.67 to convert total counts to the number of breeding pairs (or 1.34 to estimate the number of breeding individuals). Applying this correction yields an expected number of breeding individuals of 23,892. If it is assumed that all of the razorbills recorded during the boat surveys were breeding birds from this population (based on the mean maximum foraging range of 31 km, www.seabird.wikispaces.com), the estimated percentage of the population which would be affected by the wind farm would be 2.4 %. However, prior to their first breeding attempts, immature razorbill are found in association with breeding colonies (Lloyd and Perrins 1977), and these non-breeding birds will also have been recorded during the boat surveys. These chiefly comprise immature birds which have not reached breeding age (age at first breeding has been taken here as five years old). Very few birds younger than two were observed at the colonies, but from this age they begin to associate with breeding colonies during the breeding season

(Lloyd and Perrins 1977). Razorbills share many of the same demographic traits as guillemot, but have been less well studied. Thus, there was a lack of data from which to estimate the proportion of non-breeding immature birds present at the colonies. Thus the estimated ratio of pre-breeding age to breeding age birds for guillemot derived above (0.31:0.36) was applied to the razorbill. Thus, the total number of adult razorbill estimated to be associated with the East Caithness Cliffs SPA was 44,244 (23,892 divided by 0.54). While a proportion of the birds seen in the wind farm study area are expected to be immature birds, thereby reducing the impact of displacement on the breeding population, a precautionary approach was adopted here, with all displaced individuals assumed to be breeding birds.

4.63 Demographic rates for razorbill were taken from published studies of survival and reproduction from several locations (Lloyd and Perrins 1977, Chapdelaine 1997, Harris *et al.* 2000, Mavor *et al.* 2006). From these data the following population matrix (A.RA), describing annual change in the population, was derived:

$$\text{A.RA} = \begin{bmatrix} 0 & 0.329 \\ 0.38 & 0.9 \end{bmatrix}$$

4.64 This model has two stages, pre-breeders aged from fledging to five years old and breeding adults aged five and up, and incorporates both sexes in a post-breeding census format. The value in the first row, second column (0.329) is a product of the breeding adult survival rate (second row, second column, 0.9) and the number of young fledged per individual (0.73/2). Survival from fledging to age five can only be estimated as a composite, over all years since insufficient young birds return to breeding colonies at this age for reliable estimation. Chapdelaine (1997) derived an estimate for pre-breeder survival, based on the population growth and adult demographic data, of 0.38. This is the rate at which birds are estimated to survive from fledging to breeding age. Adult breeders have an annual survival rate of 0.9. In this format, the model is density independent and includes no environmental or demographic stochasticity (i.e. variations due to weather and chance were omitted). However, for the displacement assessment these additional components were considered to provide unnecessary complexity for little benefit.

4.65 To determine the impact on the SPA population of displacement of these breeding birds from the site, the population model was used to estimate the population growth rate which resulted when between 0 % and 100 % of the above number of birds (574), multiplied by the range of displacement percentages in Table 4.4, were prevented from breeding (Table 4.8).

Table 4.8. East Caithness Cliffs SPA razorbill predicted population growth rate with percentage reductions in the breeding output of birds foraging on the Wind Farm Site, resulting from range of displacement values, based on 3.6 MW turbines separated by 642 m.

Radial avoidance distance (m)	Displacement (%)	Population growth rate (%)
0	0	2.21
50	2	2.21
100	7.6	2.20
200	30.5	2.16

Table 4.8. East Caithness Cliffs SPA razorbill predicted population growth rate with percentage reductions in the breeding output of birds foraging on the Wind Farm Site, resulting from range of displacement values, based on 3.6 MW turbines separated by 642 m.		
300	68.6	2.09
400	100	2.04

4.66 The baseline annual population growth rate predicted by the model was 2.21 %. The magnitude of reductions in the population growth rate resulting from between 2 % and 100 % of the Wind Farm Site foraging population failing to breed were small: even if 100 % of the 574 birds estimated to be using the site failed to breed the reduction in the population growth rate was only 0.17 %.

4.67 Thus, even with a scenario of all birds which would choose to use the site in the breeding season being excluded from their foraging grounds and failing to breed, the overall impact on the population was found to be of no significance. Thus, potential displacement of razorbill was not considered to constitute a significant impact on the East Caithness Cliffs SPA population.

Barrier Effects Resulting from the Presence of the Wind Farm

4.68 Previous studies of existing offshore wind farms have revealed that some bird species actively avoid wind farms by not flying in close proximity to them (Pettersson 2005, Petersen *et al.* 2006). Large wind farms may thus represent barriers to movement for some bird species including migrating wildfowl, which tend to move in large flocks along linear flight lines. A review of a number of wind farm sites indicated that wildfowl begin to take avoiding action from wind farms at between 100 – 3,000 m, with avoidance distances increasing on the darkest nights (Drewitt and Langston 2006). Avoidance in this way does however reduce collision risk. For example, at Nysted, data suggest that <1 % of the migrant wildfowl migrate close enough to the turbines to be at any risk of collision (Desholm and Kahlert 2005). Overall, 71-86 % at Horns Rev, and 78% at Nysted, of all bird flocks heading for the wind farm at 1.5 - 2.0 km distance avoided entering into the wind farm between the turbine rows (Petersen *et al.* 2006). There was considerable movement of birds along the periphery of both wind farms, as birds preferentially flew around rather than between the turbines. Such avoidance was calculated to add an additional period of flight equivalent to an extra 0.5 - 0.7 % on normal migration costs of Eiders migrating through Nysted. Changes in flight direction tended to occur closer to the wind farm by night than day at both sites, but avoidance rates remained high in darkness, when it was also shown birds tend to fly higher.

4.69 Flight deviation as a result of any potential barrier effect caused by the presence of a wind farm may increase journey distance, and therefore represent an energetic cost to each individual (Masden *et al.* 2010). For each individual, the cost of this deviation increases in proportion to the frequency of passages across the site. Thus, breeding birds making multiple trips will suffer some energetic costs if they avoid travelling through wind farms even if these are relatively low compared to other stochastic variables, such as weather conditions. Species that move through the site on a single occasion during migration are unlikely to bear a measurable cost in most cases, particularly as deviation may begin from a large distance away. Pettersson (2005) showed that increased distance experienced by migratory waterfowl represented only 0.2 – 0.4% of the total migration distance from the breeding grounds to wintering areas and vice versa. Whilst this represented a likely increase in energy expenditure, it is of a negligible magnitude (Speakman *et al*. 2009). For species predominately on passage, such as sooty shearwater, European storm petrel and (at certain times of year) gannet, the impact of barrier effects could potentially consist of one movement through or around the site area, increasing to two if the species also takes the same route through the area during its return migration in the spring (this description equally applies to migrating wildfowl). Therefore the impact of a barrier effect would only be of low significance. However, individuals of some species such as fulmar, kittiwake, guillemot, puffin, razorbill and herring gull have the potential to make repeat movements through the site or occupy the site for a longer period than takes to simply cross it, meaning there is the potential for a greater magnitude of impact.

Table 4.9 The potential significance of a barrier effect for the different sensitive species, taking into account the status of the individuals of a species in the area and their prospective use of the site

Species	Sensitivity	Status in area	Use of site	Theoretical significance of impact	Rationale for predicted significance of impact	Predicted significance of impact
Fulmar	High	Breeding population and passage	Potential repeat movements, peaking in breeding season	Minor	Not expected to be affected	Negligible
Sooty shearwater	Medium	Passage	Autumn passage	Minor	Not expected to be affected	Negligible
European storm-petrel	Medium	Passage	Passage	Minor	Not expected to be affected	Negligible
Gannet	High	Small breeding population and passage	Some breeding usage plus passage	Minor	Not expected to be affected	Negligible
European shag	High	Occasional breeding and wintering	Year round low intensity, peaking in winter	Negligible	-	Negligible
Arctic skua	Medium	Small breeding population and passage	Low numbers of breeding, passage	Minor	Not expected to be affected	Negligible
Great skua	Medium	Small breeding population and passage	Low numbers of breeding, passage	Minor	Not expected to be affected	Negligible
Kittiwake	High	Breeding population	Potential repeat movements, peaking in breeding season	Moderate	No population level affect expected	Minor
Great black-backed gull	High	Small breeding population and passage	Mainly wintering and passage	Moderate	Possible winter impacts	Minor
Herring gull	High	Small breeding population and passage	Mainly wintering and passage	Moderate	Possible winter impacts	Minor
Arctic tern	Medium	Small breeding population	Small number breeding	Minor	Not expected to be affected	Negligible
Guillemot	High	Resident	Potential repeat movements, peaking in breeding season	Moderate	No population level effect expected	Minor
Razorbill	High	Resident	Potential repeat movements, peaking in breeding season	Moderate	No population level effect expected	Minor
Puffin	High	Resident	Low numbers breeding, post-breeding moult	Minor	No population level effect expected	Minor

4.70 Fulmar originating from nearby SPAs and sites along the north Caithness coast and northern isles have the potential to pass through the site on passage, with the additional potential for repeat movements into the site by a smaller number of breeding adults. Fulmar, however are a wide-ranging species and it is considered highly unlikely that any barrier effect could have a population level impact, even if a few individuals were slightly affected. Sooty shearwater and European storm petrel are only present in the Moray Firth as passage species. Any diversion around the wind farm will therefore represent small additional distances, therefore, barrier effects for these species are assessed to be not significant (Table 4.9).

4.71 Evidence in the literature suggests that gulls are not sensitive to barrier effects. Surveys of gulls and terns undertaken at operational wind farms in Flanders, revealed no evidence for barrier effects during their local foraging flights in the breeding season, with large numbers of birds passing the turbines at close distance (Everaert 2006). Gulls from the breeding colony at the Port of Zeebrugge (West Dam) daily undertook thousands of foraging flights between the colony and the sea. Most gulls flew between the turbines, and although some reaction behaviours were recorded, birds only performed a very small change of course and continued through the wind farm (Everaert 2006). This behaviour was also recorded at Blyth Harbour (Lawrence *et al*. 2007). Gulls showed no apparent barrier effects at operational wind farms, with regular flights between closely-spaced turbines (c.200-300 m) recorded.

4.72 Kittiwake is present throughout the breeding season but, as discussed above, there is no evidence at present that this species is subject to barrier effects, therefore a minor significance was assessed for kittiwake.

4.73 Great black-backed gulls and herring gulls which breed and over winter in the North Sea in the area of the Wind Farm Site could conceivably make repeated movements through the site. Reasonable numbers of these species were seen within the Wind Farm Site and buffer. However, as discussed above, gulls are not considered to be particularly sensitive to the presence of turbines. Therefore, the impact of barrier effects were assessed as minor for these species..

4.74 As well as being an autumn migrant through the site, gannet from breeding colonies have the potential to make repeat movements into the site during the breeding period. Preliminary studies have indicated that the majority of gannets avoided flying into the Egmond aan Zee wind farm (Fijn *et al*. 2011). In addition, given the flexibility of habitat use and the large distances travelled by this species when foraging (Hamer *et al.* 2000) any barrier effect of the Wind Farm was assessed as not significant within the context of the broader sea area (Table 4.9).

4.75 Guillemot, razorbill and puffin were recorded on the Wind Farm Site in high numbers. There is little evidence on which to base the extent to which these species may be subject to barrier effects during the breeding season as no existing offshore wind farms have been located near to auk breeding colonies. However, post-construction monitoring of the North Hoyle offshore wind farm, which lies in an area where auks are recorded outside the breeding season, has found no evidence for displacement (NWP 2008), which is strongly indicative that the wind farm is not acting as a barrier to movement. It seems plausible that avoidance of the Wind Farm Site would be more pronounced outside the breeding season, since the birds will be expected to be less constrained by site selection when they are not provisioning young. These species are therefore considered unlikely to demonstrate barrier effects and the significance of any impact was assessed as minor at worst.

Direct Collision of Birds with turbines

4.76 Birds may collide with wind turbines and associated structures and this is almost certain to result in death of the individual. Most studies have found evidence of low levels of avian mortality associated with operational wind farms, as birds are able to take avoiding action (Drewitt and Langston 2006). The actual risk of collision depends on a number of factors including the location of a wind farm, the bird species using the area, weather conditions and the size and design of the wind farm including the number and size of turbines and use of lighting.

4.77 The effect of an individual loss on a population is influenced by several characteristics of the affected population, notably its size, density, recruitment rate (additions to the population through reproduction and immigration) and background mortality rate (the natural rate of losses due to death and emigration). In general, the effect of an individual lost from the population will be greater for species that are relatively long-lived and reproduce at a low rate. Most seabird species fall into this category. Conversely, the effect will often be much less for relatively shorter-lived species with higher reproductive rates, including some smaller gulls. Species that habitually fly at night or during low light conditions at dawn and dusk may also be at increased risk from collisions, although seaducks such as eiders and scoters have been shown to detect and avoid offshore turbines at night in both the Netherlands (Winkelman 1995) and at offshore towers at Tuno Knob in Denmark (Tulp *et al*. 1999)..

4.78 It should be noted that operational disturbance/displacement and collision risk effects are mutually exclusive in a spatial sense, i.e. a bird that avoids the wind farm area cannot be at risk of collision with the turbine rotors at the same time. However, they are not mutually exclusive in a temporal sense; a bird may initially avoid the wind farm, but habituate to it, and would then be at risk of collision. In addition, birds may generally avoid wind farms, but during periods of poor visibility may fly closer to turbines before taking avoiding action.

4.79 In general, effects of increased mortality on populations due to collisions with turbines are considered to be long-term (i.e. throughout the operational wind farm's lifespan). One simplifying assumption of collision risk modelling is that collision rates do not decrease in response to losses from the population. In reality, effects may change over time due to the interplay of many factors (e.g. habituation to the presence of turbines, changes in fishing activities, climate change impacts on prey species, etc.). The modelling therefore predicts collisions on the basis of maintenance of current conditions.

Collision Risk Modelling

4.80 This section presents the parameter estimates inputted in to the CRM and the results of the modelling process. Data for this modelling were derived from the boat surveys in combination with published metrics (e.g. wingspan, flight speed) for each species and also recent guidance on flight height distributions and avoidance rates (SOSS-02). For the purposes of assessing collision mortality two approaches were used. The first followed the recommended methods in MacLean *et al.* (2009) for offshore wind farms (hereafter referred to as Band 2007). This method uses the mean number of birds in flight at any time during a particular month, taken from snapshot counts within the Wind Farm Site during boat-based surveys (the full methodology is described in the Methodology Section). The second used a refinement of this method developed by Band (2011) as part of the Crown Estate's Strategic Ornithological Support Services (SOSS) work stream. This method is still currently in review and therefore has not been officially adopted for offshore wind farm assessments. However, it is anticipated that this approach will become the industry standard and therefore it has been included here.

Species selection for CRM

4.81 Not all species observed on the Wind Farm Site are likely to be affected to any significant extent by increases in mortality from collisions, either due to low numbers of flights recorded within the Wind Farm Site, or behaviour that indicates that the species is not susceptible to collisions. Therefore survey data and information on species' ecology were used to screen which species will be included in CRM.

4.82 Initial selection was based on the list of species of principal concern to determine which species warranted consideration for CRM. This was based on three aspects: (i) the total number of birds in flight recorded in snapshot within the Wind Farm Site each year; (ii) the proportion of birds recorded flying at potential collision height (PCH; 20 m – 150 m); and (iii) the sensitivity of a species to collision, based on flight manoeuvrability, altitude and proportion of time flying risk ratings in Garthe and Hüppop (2004), and recommended avoidance rates in Maclean *et al*. (2009).

4.83 Based on these criteria (Table 4.10), the following eight species were included in collision risk modelling: Arctic skua, Arctic tern, fulmar, great black-backed gull, gannet, herring gull, kittiwake and great skua. At the request of SNH common guillemot and razorbill were added to this list.

Table 4.10: Percentage of flights recorded at Potential Collision Height (PCH) during 2010 boat surveys. Shaded rows indicate species for which collision risk modelling was undertaken. Note that the guillemot and razorbill counts include unidentified auks and the great black-backed gull and herring gull counts include unidentified large gulls. Birds were added to each species in proportion to positively identified birds.

Species	Percentage at potential collision height (20 – 150 m)		Total number of individuals recorded during snapshots on wind farm site (all heights)	Species Sensitivity to collisions (Garthe and Hüppop 2004)
	From boat surveys	SOSS-02		
Fulmar	0.5	1	242	Low
Sooty shearwater	0	0	1	Low
Gannet	18.7	14	32	Medium
Shag	7	12	1	Low
Arctic skua	8.6	10	4	Medium
Great skua	7.1	4	9	Medium
Kittiwake	13.3	13	55	Medium
Great black-backed gull	36.2	28	38	Medium
Herring gull	34.7	24	81	High
Arctic tern	10.9	25	5	Low
Guillemot	0.2	1.5	356	Low
Razorbill	0.1	4	51	Low
Puffin	0	0	5	Low

4.84 The species selected for CRM were those considered to be at greatest potential risk. This was based on an assessment of their vulnerability to collisions (Garthe and Hüppop 2004). No other species occurred in sufficient numbers to warrant CRM.

4.85 Although the total number of birds recorded in snapshots were very low for Arctic skua, arctic tern, and great skua, these species were encountered in relatively few months, and therefore additional mortality rates may be significant during these brief periods. Hence their inclusion in the list.

4.86 The percentage of birds at potential collision height (PCH) used in the modelling was derived from the boat surveys of the Wind Farm Site and buffer. However, since estimating collision mortality is a largely multiplicative process, mortality estimates calculated using the site specific PCH can be simply converted into those estimated using the SOSS PCH estimates as follows:

SOSS based PCH mortality = Site PCH based mortality × (SOSS PCH / site PCH)

4.87 Outputs from the modelling are presented as annual totals and also for just the breeding season (based on species specific periods, Snow and Perrins 1998).

4.88 Collision risk modelling for wildfowl was undertaken in a separate exercise, using data collected during the migration surveys in Autumn 2010 and Spring 2011.

4.89 Data on possible and probable wildfowl flights through Beatrice were gathered in autumn 2010 and spring 2011 from boat-based and vantage point surveys. From these recorded flights, total numbers of seasonal flights were extrapolated for each species (Table 4.11). To generate an annual estimate of numbers flying through the Wind Farm Site the total from each study period were combined.

4.90 Observations of wildfowl, made during the boat surveys were used to estimate flying height proportions. Due to the limited number of observations, data were summed across species to achieve reasonable estimates of the relative percentages of flights in each height band. Individual species of geese displayed similar patterns of height band distribution, which supported the method of summing species counts. No height band data was gathered for whooper swans during these surveys, so the collision risk calculations assumed 100 % of swans fly in the 20 - 200 m height band.

Table 4.11 Number of possible and probable flights by target waterfowl species in each height band.

Species	Possible flights		Probable flights		% birds in height band [2]			Extrapolated number in rotor height band (possible)	Extrapolated number in rotor height band (probable)
	Recorded	Extrapolated	Recorded	Extrapolated	0-20m	20-200m	200+m		
Pink-footed goose	3643	23517	4837	36273	1	91	8	21401	33008
Greylag goose	138	1083	730	5768				986	5249
Barnacle goose	3	24	17	136				22	124
Unidentified goose	520	3,179	422	3352				2893	3050
Whooper swan [1]	15	116	11	88	No data			116	88

1 No swans seen in height band observations

2 Numbers in these columns represent a worst-case scenario where all birds fly at rotor-swept height

4.91 Estimated numbers of waterfowl flying through the rotor-swept area (the 20 – 200 m height band) were used to calculate estimated mortality from turbine collisions. The sum of the possible and probable mortality predicts maximum collision mortality for each target species. The maximum collision mortality was also calculated for the average wind farm span of operation (25 years). The 1 % British population threshold for each target species is included for scale. As these are passage species, no regional population exists.

CRM Input Parameters

4.92 Morphological data for the CRM are provided in Table 2.11. The results of the boat-based surveys were used to estimate an overall instantaneous 'snapshot' density of birds in flight, for each species of interest within the wind farm area.

4.93 The worst case turbine layout scenario for collisions was 277, 3.6 MW turbines, as this gave the greatest amount of rotor swept airspace. This scenario was therefore used here to generate the most conservative mortality estimates. The alternative turbines under consideration (up to 7 MW in size) both generate lower mortality estimates.

4.94 Avoidance of turbines by birds can occur across a range of distances. There are few data with which to empirically estimate avoidance for seabird species, thus published guidance values have been used in this assessment. Current SNH guidance (SNH 2010) recommends a precautionary avoidance rate of 98 % unless further refinement permits another rate to be used. However, a recent review of offshore wind farm bird studies (Cook *et al.* 2011) has recommended that a minimum of 99 % is appropriate, and for many species should be higher still. Consideration of the rates of avoidance presented in Cook *et al.* (2011) indicates that for all the seabird species assessed here a lower rate of 99 % is appropriate (Appendix 3).

4.95 The results from four different collision risk models are provided (Tables 4.12, to 4.15). These used the previous CRM (Band 2007) and the revised version (Band 2011).

Table 4.12 Annual collision mortality estimated using the Band (2007) model, flight height proportions recorded on the Wind Farm Site.

Species	Avoidance rate (%)				
	0	98	99	99.5	99.9
Fulmar	1987	40	20	10	2
Gannet	8863	177	89	44	9
Arctic skua	399	8	4	2	0
Great skua	841	17	8	4	1
Kittiwake	9989	200	100	50	10
Great black-backed gull	23100	462	231	116	23
Herring gull	40943	819	409	205	41
Arctic tern	527	11	5	3	1
Common guillemot	1044	21	10	5	1
Razorbill	53	1	1	0	0

Table 4.13 Breeding season collision mortality estimated using the Band (2007) model, flight height proportions recorded on the Wind Farm Site.

Species	Avoidance rate (%)				
	0	98	99	99.5	99.9
Fulmar	799	16	8	4 1	
Gannet	3267	65	33	16	3
Arctic skua	399	8	4	2	0
Great skua	841	17	8	4	1
Kittiwake	4477	90	45	22	4
Great black-backed gull	4264	85	43	21	4
Herring gull	2024	40	20	10	2
Arctic tern	527	11	5	3	1
Common guillemot	723	14	7	4	1
Razorbill	23	0	0	0	0

Table 4.14 Annual collision mortality estimated using the Band (2011) model, flight height proportions recorded on the Wind Farm Site.

Species	Avoidance rate (%)				
	0	98	99	99.5	99.9
Fulmar	2675	53	27	13	3
Gannet	13249	265	132	66	13
Arctic skua	558	11	6	3	1
Great skua	1254	25	13	6	1
Kittiwake	13166	263	132	66	13

Table 4.14 Annual collision mortality estimated using the Band (2011) model, flight height proportions recorded on the Wind Farm Site.

	Avoidance rate (%)				
Great black-backed gull	30186	604	302	151	30
Herring gull	49353	987	494	247	49
Arctic tern	805	16	8	4	1
Common guillemot	1339	27	13	7	1
Razorbill	62	1	1	0 0	

Table 4.15 Breeding season collision mortality estimated using the Band (2011) model, flight height proportions recorded on the Wind Farm Site.

Species	Avoidance rate (%)				
	0	98	99	99.5	99.9
Fulmar	1114	22	11	6	1
Gannet	5357	107	54	27	5
Arctic skua	558	11	6	3 1	
Great skua	1254	25	13	6	1
Kittiwake	6200	124	62	31	6
Great black-backed gull	6154	123	62	31	6
Herring gull	2927	59	29	15	3
Arctic tern	805	16	8	4 1	
Common guillemot	970	19	10	5	1
Razorbill	33	1	0	0 0	

4.96 In the following species accounts, the smallest population against which potential impacts are considered is derived from the nearest reported breeding colonies. For fulmar, kittiwake, great black-backed gull and herring gull this is the East Caithness SPA, for gannet this is the Troup, Pennan and Lions Head SPA, for Arctic skua this is the inland Caithness sites and for great skua this is the Orkney colonies on Hoy and South Walls. The Arctic terns seen on site are not considered to have been breeding birds since their mean maximum foraging range (12 km) is considerably less than the nearest reported breeding colonies (40 km). Thus the smallest population considered here is drawn from the Moray Firth coasts, north Caithness and Orkney.

Fulmar

4.97 Across the two CRM, the range of predicted annual collision mortality rates was from 20 to 27 fulmar per year (Tables 4.13 to 4.16). Using the higher value, this equates to a predicted increase in the local population's background mortality rate of 0.09% (from 1.4% to 1.49%, Table 4.16).

4.98 Survey data indicate that while this species is present on the Wind Farm Site all year round, numbers peak during the breeding season. This indicates that the Wind Farm Site is used by breeding birds within the region. With over 14,000 breeding pairs, colonies within the East Caithness SPA probably account for the majority of birds seen during boat surveys during the breeding season. Collision mortality for May to September inclusive accounts for 46.2 % of the annual total. This represents an increase in the SPA population's mortality rate of approximately 0.04 %. This level of increase would have no discernible impact on the population. During the remainder of the year any mortality due to collisions would be distributed through a considerably larger population and thus impacts at this scale are predicted to be of no significance.

4.99 Overall, therefore no significant impact is expected on fulmar as a result of collisions.

Table 4.16 Predicted significance of collision mortality of fulmar at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on the highest annual collision risk estimates from boat-based surveys in 2010.

Parameters	East Caithness Cliffs SPA[2]	Breeding birds within range[1,2]	East coast potential passage[2]	Great Britain (breeding)[4]	Britain & Ireland (breeding)[2]	Europe (breeding)[5]	North Sea (Winter)[6]
Estimated population (individuals)	28,404	143,434	659,884	997,528	1,075,982	7,200,000	1,872,000
Number of birds lost per annum[7]	398	2,008	9,238	13,965	15,064	100,800	26,208
% additional mortality	0.09	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Magnitude	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Significance	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

[1] 69 km mean maximum foraging range based on Langston (2010)
[2] Mitchell *et al.* (2004). Seabird populations of Britain and Ireland
[4] Baker *et al.* (2006). Populations estimates of birds in Great Britain and the United Kingdom
[5] BirdLife International 2004
[6] Skov *et al.* (1995). Important Bird Areas for seabirds in the North Sea
[7] The number of birds lost per annum under normal conditions in each population based on an annual survival rate of 98.6% is shown.

Gannet

4.100 The predicted annual collision mortality for gannet was between 89 and 132 individuals (Tables 4.12 to 4.15). This equates to a predicted maximum increase in the regional population's background mortality rate of 0.19% (from 6 % to 6.19 %, Table 4.17). Birds seen on the site during the breeding season (May to September inc.) could have been breeding individuals, which, due to the long distances this species travels on foraging trips, could be drawn from a large population of over 60,000. Birds seen during October and November are expected to represent passage movements through the region, which further increases the effective population size under consideration.

4.101 Overall therefore, the predicted level of gannet mortality is expected to have a negligible impact on both the breeding population within range of the Wind Farm Site and the passage population which passes through the Moray Firth during the post-breeding period. This therefore is of no significance.

Table 4.17 Predicted significance of collision mortality of gannet at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on mean annual collision risk estimates from boat-based surveys in 2010.

Parameters	Orkney & Shetland SPAs[1] & Troup, Pennan and Lions Head*	Breeding birds within range[2,3]	Britain & Ireland (breeding)[4]	Britain & Ireland (all birds)[5]	Europe (breeding)[4]	Europe (all birds)[5]
Estimated population (individuals)	66,630	181,210	521,214	679,659	619,188	928,782
Number of birds lost per annum[6]	3,998	10,872	31,273	40,780	37,151	55,727
% additional mortality	0.17	0.06	0.02	0.02	0.01	<0.01
Magnitude	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Significance	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

[1] Fair Isle 2,332; Hermaness, Saxa Vord and Valla Field 32,800; Noss 13,720; Sule Skerry and Sule Stack 11,800
[2] 308 km mean maximum foraging range based on Langston (2010)
[3] Mitchell *et al.* (2004). Seabird populations of Britain and Ireland
[4] BirdLife International 2004
[5] Breeding population scaled by 1.5 (Wetlands International, 2006) to accommodate the non-breeding sub-adults
[6] The number of birds lost per annum under normal conditions in each population based on an annual survival rate of 94% is shown.
* Troup Pennan and Lions Head SPA data are included even though gannet are not named on the SPA citation as this gannet colony has expanded considerably in recent years.

Arctic skua

4.102 The annual predicted collision mortality estimates for Arctic skua ranged between 4 and 6 across the two modelling methods (Tables 4.12 to 4.15). Using the highest of these, this equates to a predicted increase in background mortality of breeding birds within range of the Wind Farm Site of 4 % (from 16 % to 20 %, Table 4.18). However, during the breeding season this species obtains food predominantly through kleptoparasitism, and consequently breeding birds tend to remain close (< 2 km) to the breeding colonies of their hosts (webref: BirdLife International

Foraging range database, http://seabird.wikispaces.com/Arctic+Skua, checked 18/08/2011). Individuals observed at greater distances from shore (during boat surveys) are therefore considered unlikely to be members of the local breeding population. The timing of the observations (arctic skua were only recorded in snapshots in May and August) also suggests passage movements of birds to and from breeding sites further north. Therefore the mortality estimates should be considered with respect to the regional population, or potentially the whole Great Britain breeding population, almost all of which breeds at sites north of the Wind Farm Site. The regional population has undergone declines since the last comprehensive seabird census (Seabird 2000), and the regional population was estimated to have fallen from 1,582 to 1,044 in 2010. Using this population the increase in background mortality which would result from the predicted level of collisions for the regional population is 0.5 % (from 16 % to 16.5 %).

4.103 The potential magnitude of any impact of collision mortality on the Arctic skua population is therefore considered to be small and of no significance.

Table 4.18 Predicted significance of collision mortality of Arctic skua at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on annual collision risk estimates from boat-based surveys in 2010.

Parameters	Breeding birds within range[1,2]	Regional population	Great Britain (breeding)[3]	Britain & Ireland (breeding)[1]	Europe (breeding)[4]
Estimated population (individuals)	142	1,044	4,272	4,272	280,000
Number of birds lost per annum[5]	23	253	684	684	44,800
% additional mortality	4	0.4	0.75	0.75	0.01
Magnitude	Small	Negligible	Negligible	Negligible	Negligible
Significance	Minor	Negligible	Negligible	Negligible	Negligible

[1] Mitchell *et al.* (2004). Seabird populations of Britain and Ireland
[2] 40 km mean maximum foraging range based on Langston (2010)
[3] Baker *et al.* (2006). Populations estimates of birds in Great Britain and the United Kingdom
[4] BirdLife International 2004
[5] The number of birds lost per annum under normal conditions in each population based on an annual survival rate of 84% is shown.

Great skua

4.104 All of the predicted mortality of great skua occurred during May to August (inclusive), indicating probable impacts on breeding birds. Using Langston's (2010) mean maximum foraging range estimate of 42 km to identify breeding birds within range of the Wind Farm Site produced an estimate of one pair (Muckle Skerry). However, the abundance of this species estimated using the boat survey data peaked at 164 individuals across the whole boat based study area in May 2010. Breeding season distributions of great skua show concentrations around the main breeding colonies on Orkney and Shetland (Stone *et al.* 1995), with the distribution of birds originating from Orkney extending into the Moray Firth and encompassing the Wind Farm Site. Thus birds recorded on site are very likely to originate from colonies on Orkney. The largest of these, on Hoy and South Walls, accounts for 90 % of the Orkney population (Mitchell *et al*. 2004). Inclusion of this population in the category of breeding birds within range of the Wind Farm Site raises the effective population size to almost 4,000.

4.105 The predicted annual collision mortality for great skua was between 8 and 13 individuals (Tables 4.12 to 4.15). This equates to a predicted maximum increase in the breeding population's background mortality rate of 0.3 % (from 10 % to 10.3 %, Table 4.19). This magnitude of increase in mortality is predicted to have a negligible impact on the breeding population, which would be of no significance.

Table 4.19 Predicted significance of collision mortality of great skua at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on mean annual collision risk estimates from boat-based surveys in 2010.

Parameters	Breeding birds within range[1,3]	East coast potential passage[3]	Great Britain (breeding)[4]	Britain & Ireland (breeding)[3]	Europe (breeding)[5]
Estimated population (individuals)	3,994	9,055	19,268	19,270	32,000
Number of birds lost per annum[7]	399	905	1,927	1,927	3,200
% additional mortality	0.3 %	0.1 %	0.06 %	0.06 %	0.04 %
Magnitude	Negligible	Negligible	Negligible	Negligible	Negligible
Significance	Negligible	Negligible	Negligible	Negligible	Negligible

[1] Estimated as the entire Orkney breeding population. Although Langston (2010) reported a mean maximum range of 42 km, this appears insufficient to account for the number of great skua observed on the site. If this range is extended to 70 km the large colonies on Hoy and South Walls fall within range.
[2]
[3] Mitchell *et al.* (2004). Seabird populations of Britain and Ireland. Estimated as 50 % of Orkney and Shetland breeding populations.
[4] Baker *et al.* (2006). Populations estimates of birds in Great Britain and the United Kingdom
[5] BirdLife International 2004
[6] Skov *et al.* (1995). Important Bird Areas for seabirds in the North Sea
[7] The number of birds lost per annum under normal conditions in each population based on an annual survival rate of 90% is shown.

Kittiwake

4.106 The predicted annual collision mortality for kittiwake was between 100 and 132 individuals (Tables 4.12 to 4.15). This equates to a predicted increase in the local population's background mortality rate of 0.16 % (from 19 % to 19.16 %, Table 4.20). Most of the predicted mortality is concentrated in April, May and June. This indicates that birds seen on the Wind Farm Site are probably associated with the breeding colonies in the East Caithness Cliffs SPA. However, even with all the annual mortality concentrated on this population, the background mortality rate only increased by 0.16 %. Thus the potential collision impact on kittiwake is considered to be negligible and of no significance.

Table 4.20 Predicted significance of collision mortality of kittiwake at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on mean annual collision risk estimates from boat-based surveys in 2010.

Parameters	East Caithness Cliffs SPA[2]	Breeding birds within range[1,2]	East coast potential passage[2]	Great Britain (breeding)[3]	Britain & Ireland (breeding)[2]	Europe (breeding)[4]	North Sea (Winter)[5]
Estimated population (individuals)	80,820	175,516	587,160	733,664	831,990	6,000,000	1,032,690
Number of birds lost per annum[6]	15,356	33,348	111,560	139,396	158,078	1,140,000	196,211
% additional mortality	0.16	0.07	0.02	0.02	0.02	<0.01	0.01
Magnitude	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Significance	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

[1] 66 km mean maximum foraging range based on Langston (2010)
[2] Mitchell *et al.* (2004). Seabird populations of Britain and Ireland
[3] Baker *et al.* (2006). Populations estimates of birds in Great Britain and the United Kingdom
[4] BirdLife International 2004
[5] Skov *et al.* (1995). Important Bird Areas for seabirds in the North Sea
[6] The number of birds lost per annum under normal conditions in each population based on an annual survival rate of 81% is shown.

Great black-backed gull

4.107 The range of predicted collision mortality rates was between 231 and 302 great black-backed gulls per year (Tables 4.12 to 4.15). This eq uates to a predicted increase in the lo cal population's background mortality rate of 83 % (from 7 % to 90 % Table 4.21). Du ring the breeding season the mo rtality was esti mated at 62 individuals, which would increase the East Caithness Cliffs population mortality rate by 17 % (from 7 % to 24 %), while the increa se in the mortality rate on all b reeding birds potentially within range of the wind fa rm was 7.2 % (Table 4.20). However, breeding adults are reported to become closely associated with their breeding colonies between May and July, wh ere they catch their sea bird prey (Ta sker *et al*. 1987). I t therefore seems probable that some or all of the birds seen on the Win d Farm Site are n on-breeders. Of the birds for which an estimate of age was recorded during the boat surveys, only 37 % were recorded as adults. Thus the impact on the SPA population is expected to be lower.

4.108 Mortality outside the breeding season would be distributed amongst a co nsiderably larger population, with birds from more no rtherly breeding colonies passing throug h the regio n (Snow and Perrins 1998).

4.109 During the winter the population of great black-backed gulls in Brit ish waters is swelled by birds from mainland Europe. Mortality outside the breeding season would thus be distributed amongst a large population; in winter the UK population has been estimated at 71,000 to 81,000 individuals (Banks *et al.* 2007). Within the Moray Firth, this will include birds from more northerly breeding colonies passing through the region (Snow & Perrin s 1998, Wernham *et al*. 2002). Thus the population against which most of th e predicted mortality was assessed was that estimated to pass through the Moray Firth on passage and also wintering birds. As a conservative estimate this comprises 17,900 individuals (Mitchell *et al*. 2004). Assessing annual collision mortality against the potential passage population represents an addition to annual mortality of 1.7 % (from 7 % to 8.7 %).

4.110 Thus, great black-backed gull is predicted to experience at worst a small magnitude effect of minor significance.

Table 4.21 Predicted significance of collision mortality of great black-backed gull at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on mean annual collision risk estimates from boat-based surveys in 2010.

Parameters	East Caithness Cliffs SPA[3]	Breeding birds within range[1,2]	East coast potential passage[2]	Great Britain (breeding)[3]	Britain & Ireland (breeding)[2]	Europe (breeding)[4]	Great Britain (Winter)[3]
Estimated population (individuals)	362	860	17,902	34,168	39,382	220,000	43,108
Number of birds lost per annum[5]	25	60	1,253	2,392	2,757	15,400	3,018
% additional annual mortality	83.4	35.1	1.7	0.9	0.8	0.14	0.7
% additional breeding mortality	22.5	9.5	-	-	- -		-
Magnitude	Medium	Medium	Small	Negligible	Negligible	Negligible	Negligible
Significance	Moderate	Moderate	Minor	Negligible	Negligible	Negligible	Negligible

[1] 40 km maximum foraging range based on Ratcliffe *et al.* (2000)
[2] Mitchell *et al.* (2004). Seabird populations of Britain and Ireland, SMP (http://jncc.defra.gov.uk/smp/Default.aspx)
[3] Baker *et al.* (2006). Populations estimates of birds in Great Britain and the United Kingdom
[4] BirdLife International 2004
[5] The number of birds lost per annum under normal conditions in each population based on an annual survival rate of 93% is shown.

Herring gull

4.111 The predicted annual collision mortality for herring gull was between 409 and 494 individuals (Tables 4.12 to 4.15). This equates to a predicted increase in the local population's background mortality rate of 7 % (from 7 % to 14 %, Table 4.22). However, more than 94 % of all of the predicted mortality occurred outside the breeding season. This fits with the preferred foraging habits of this species during the breeding season, which is focussed in coastal areas (e.g. for intertidal invertebrates) or terrestrial locations (refuse sites; Snow and Perrins 1998). Thus the potential impact on the local breeding population is considered to be of negligible and of no significance. The same is true for the potential impact on the larger regional population.

Table 4.22 Predicted significance of collision mortality of herring gull at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on mean annual collision risk estimates from boat-based surveys in 2010.

Parameters	East Caithness	Breeding birds within	Regional population	Great Britain	Britain & Ireland	Europe (breeding)[4]	Great Britain

Table 4.22 Predicted significance of collision mortality of herring gull at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on mean annual collision risk estimates from boat-based surveys in 2010.

	Cliffs SPA[1]	**range[1,2]**		**(breeding)[3]**	**(breeding)[1]**		**(Winter)[5]**
Estimated population (individuals)	7,006	13,238	29,260	262,938	294,228	2,800,000	376,775
Number of birds lost per annum[6]	490	926	2,048	18,406	20,596	196,000	26,374
% additional annual mortality	7	3.7	1.7 0.2 0.2			0.02	0.1
% additional breeding mortality	0.7	0.4 0.2		0.02	0.02	<0.01	0.01
Magnitude	Medium	Small	Small	Negligible	Negligible	Negligible	Negligible
Significance	Moderate	Minor	Minor	Negligible	Negligible	Negligible	Negligible

[1] Mitchell *et al.* (2004). Seabird populations of Britain and Ireland
[2] 54 km maximum foraging range based on Camphuysen (1995)
[3] Baker *et al.* (2006). Populations estimates of birds in Great Britain and the United Kingdom
[4] BirdLife International 2004
[5] Skov *et al.* (1995). Important Bird Areas for seabirds in the North Sea
[6] The number of birds lost per annum under normal conditions in each population based on an annual survival rate of 93% is shown.

Arctic tern

4.112 The annual predicted collision mortality estimates for Arctic tern ranged between 5 and 8 across the two modelling scenarios (Tables 4.12 to 4.15). The nearest breeding colonies of Arctic tern to the Wind Farm Site are on the island of Muckle Skerry in the Pentland Firth and Portgower on the east Sutherland coast, located 40 km and 41 km respectively from the nearest point on the Wind Farm Site boundary. Arctic tern typically feed within 3 km of the colony, with maximum estimates of 20 km from the Farne Islands and 15 km from Papa Westray in Orkney (webref: BirdLife International Foraging range database, http://seabird .wikispaces.com/Arctic+Tern, checked 18/08/2011). It is therefore considered that the birds seen on site are not from either of these breeding colonies, and thus no breeding birds are present within foraging range of the Wind Farm Site.

4.113 The population from which the predicted collision mortality should be drawn is therefore a minimum of 29,776 (drawn from the Moray Firth coasts, North Caithness and Orkney colonies). The percentage increase in mortality above the background rate due to collisions is therefore 0.02% (from 12.5% to 12.52%, Table 4.23).

4.114 The potential magnitude of any impact of collision mortality on the Arctic tern population is therefore considered to be small and of no significance.

Table 4.23 Predicted significance of collision mortality of Arctic tern at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on annual collision risk estimates from boat-based surveys in 2010.

Parameters	**Breeding birds within range[1,2]**	**Regional population (Moray Firth**	**Great Britain (breeding)[3]**	**Britain & Ireland (breeding)[1]**	**Europe (breeding)[4]**

Table 4.23 Predicted significance of collision mortality of Arctic tern at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on annual collision risk estimates from boat-based surveys in 2010.					
		coast, North Caithness and Orkney)[1]			
Estimated population (individuals)	0	29,776	105,242	112,246	1,800,000
Number of birds lost per annum[5]	0	3,722	13,155	14,031	225,000
% additional mortality		0.02	0.03	0.03	0
Magnitude	Negligible	Negligible	Negligible	Negligible	Negligible
Significance	Negligible	Negligible	Negligible	Negligible	Negligible

[1] Mitchell *et al.* (2004). Seabird populations of Britain and Ireland
[2] 12 km mean maximum foraging range based on Langston (2010)
[3] Baker *et al.* (2006). Populations estimates of birds in Great Britain and the United Kingdom
[4] BirdLife International 2004
[5] The number of birds lost per annum under normal conditions in each population based on an annual survival rate of 87.5% is shown.

Common guillemot

4.115 The annual predicted collision mortality estimates for common guillemot ranged between 10 and 13 across the two modelling scenarios (Tables 4.12 to 4.15). Most of the predicted mortality is concentrated during the breeding season. This indicates that birds seen on the Wind Farm Site are probably associated with the breeding colonies in the East Caithness Cliffs SPA. However, even with all the annual mortality concentrated on this population, the background mortality rate only increased by 0.008 % (from 11.5 % to 11.508 %, Table 4.24). Thus the potential collision impact on common guillemot is considered to be negligible and of no significance.

Table 4.24 Predicted significance of collision mortality of common guillemot at Beatrice Offshore Wind Farm Site relative to background mortality at a range of population scales, based on mean annual collision risk estimates from boat-based surveys in 2010.

Parameters	East Caithness Cliffs SPA[3]	Breeding birds within range[1,3]	Great Britain (breeding)[2]	Britain & Ireland (breeding)[3]	Europe (breeding)[4]	North Sea (winter)[5]
Estimated population (individuals)	158,985	239,592	1,332,354	1,559,484	4,700,000	2,073,000
Number of birds lost per annum[6]	18283	27553	153221	179341	540500	238395
% additional annual mortality	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Magnitude	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Significance	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

[1] 61 km mean maximum foraging range based on Langston (2010)
[2] Baker *et al.* (2006). Populations estimates of birds in Great Britain and the United Kingdom
[3] Mitchell *et al.* (2004). Seabird populations of Britain and Ireland
[4] BirdLife International 2004
[5] Tasker *et al.* (1987). Seabirds in the North Sea

[6] The number of birds lost per annum under normal conditions in each population based on an annual survival rate of 88.5% is shown.

Razorbill

4.116 The annual predicted collision mortality estimates for razorbill was 1 individual. No further assessment was considered necessary for this negligible magnitude impact which was assessed as of no significance.

Wildfowl Collision Risk Modelling

4.117 Estimated numbers of waterfowl flying through the rotor-swept area (the 20-200 m height band) were used to calculate estimated mortality from turbine collisions (Table 4.25). The annual mortality was calculated as the possible and probable mortality estimates for both seasons (Table 4.11). The 1 % British population threshold for each target species is included for scale. As these are passage species, regional population estimates are not considered appropriate.

Table 4.25 Estimated possible and probable collision mortality for target waterfowl species.

Species	Extrapolated flights in rotor-swept area		Estimated possible annual mortality	Estimated probable annual mortality	Total annual mortality	GB 1% Population
	Possible	Probable				
Pink-footed goose	21401	33008	14.2	21.9	36.1	3,642
Greylag goose	986	5249	0.7	3.7	4.4	1,095
Barnacle Goose	22	124	0.01	.08	0.09	400
Unidentified goose	2893	3050	1.9	2.0	3.9	n/a
Whooper Swan	116	88	0.2	0.2	0.4	166

4.118 Background annual mortality for each target species were taken from SNH commissioned reports (Trinder *et. al*. 2005, Trinder 2010). Due to the large proportion of adult birds in each population, adult mortality figures were used for the entire population. This gives a conservative estimate of yearly mortality. Projected collision mortality numbers from the wind farm were added to this total, and mortality percentage recalculated to give the increase in overall annual mortality caused by turbine collisions (Table 4.26). No significant impacts were predicted for any of the species observed.

4.119 The proportion of flights estimated to result in collisions is of sufficiently small size that even if the estimated number of birds flying across the Wind Farm Site is twice that found in autumn and spring 2010-2011 the numbers predicted to be killed would still fail to attain any significance in terms of the UK populations.

Table 4.26 Impact of predicted collision mortality on GB wintering wildfowl populations.

Species	GB population	Annual Mortality		Additional mortality	Increase in total mortality (%)
		percent	number		
Pink-footed goose	364212	14	50990	36.1	<0.001
Greylag goose	109496	30	32849	4.4	<0.001
Barnacle Goose	58269	8	4662	0.1	<0.001
Whooper Swan	16618 15		2493	0.4	<0.001

Indirect effects on birds through impacts on the distribution of prey and foraging habitat

4.120 The turbine substructures may be coated with anti-fouling treatments to inhibit the settlement and growth of macro invertebrates. If this is the case the structures will be effectively neutral in terms of habitat creation within the water column. However, if such treatments are not used, micro-habitats supporting populations of invertebrates (e.g. molluscs, crustaceans etc.) and fish would be expected to develop. This could include fish species which might otherwise be scarce due to lack of suitable habitat. A potential indirect effect of such habitat modification is to increase prey availability for birds by raising the carrying capacity of the area for stocks of invertebrates and fish. Foundation structures might also influence tidal flow patterns and sediment dynamics, at least at the local microhabitat scale. This may give rise to habitat modifications that impact on some bird species.

4.121 Specific information on the response of particular fish species of importance to birds, such as sandeels and clupeids, to wind farm arrays is lacking. It is therefore difficult to assess any potential indirect impact of the Wind Farm prior to installation. Comparison of fish species composition in a wind farm site before and after construction found evidence for a high degree of variability, but no indication that these changes were influenced by the wind farm (Lindeboom 2011). Leonhard and Pedersen (2006) reported that fish biomass increased considerably in the vicinity of the turbine bases due to the shelter afforded by scour protection.

4.122 The preliminary impact assessment for sandeels (Brown and May 2011) reported evidence for probable high densities of these species across the Wind Farm Site, but also noted that much of the Moray Firth is predicted to provide suitable habitat. Studies of noise impacts on sandeels have found these species to be of generally low sensitivity which is attributed to their lack of a swim bladder. The direct loss of available habitat resulting from the worst case turbine foundations (gravity bases fitted to 277, 3.6 MW turbines) was estimated to be 2.5 % of the total area of the Wind Farm Site. The worst case inter-array cable option, in terms of disturbance to the seabed, would result from 325 km of cable laid on the surface with up to 50 % covered in protective matting with a width of 3 m (connecting 277, 3.6 MW turbines). This would lead to an additional 0.37 % of seabed loss within the Wind Farm Site. Overall, this magnitude of seabed loss was not considered likely to have a detectable impact on seabird species on the Wind Farm Site.

4.123 It appears possible that there may be a net positive effect on birds as a result of increasing prey abundance and availability. For example, cormorant have been recorded using offshore turbine bases for roosting, thereby opening up access to foraging areas hitherto unavailable to them due to the absence of places for them to dry their plumage. However, negative indirect effects are equally possible. For example collision risk could increase if birds are attracted to the turbines in greater numbers due to the presence of prey fish shoals around foundation structures. At present, the lack of detailed studies examining such effects preclude any further assessment, and the indirect effects of operation on prey species and foraging habitat are assumed to be neutral and thus not significant.

Assessment of collision risks on non-seabird passage species

4.124 The boat based and migration surveys were conducted during daylight hours only and may therefore have missed nocturnal movements of waders and passerines during migratory periods. However, the very few observations of potential migrants made during boat-based surveys is likely to reflect the fact that these species usually migrate over the sea at high altitudes (albeit often at night), beyond the detection range of the surveyors. Although for this reason peak numbers are unlikely to be recorded during surveys, such behaviour will result in very small risks of collision or barrier effects resulting from the wind farm. Evidence from operational offshore wind farms suggests that even when birds are at potential collision height, they generally take avoiding action, often well in advance of turbines, by both day and night (e.g. Blew *et al*. 2008, Christensen *et al*. 2004, Desholm and Kahlert 2005, Krijgsveld *et al*. 2005, Krijgsveld *et al*. 2010, Petersen *et al*. 2006, Tulp *et al*. 1999, Winkelman 1995).

4.125 It is acknowledged that certain species of wader migrate by night, during which time they may fly at lower altitudes than during the day (Newton 2010). Waders mostly take off in the 2-3 hours prior to sunset, depending on tide state (Newton 2008) and so those leaving from any nearby SPAs will therefore be likely to pass through the site during daylight hours, thereby reducing collision risk.

4.126 In a review of bird migration routes in relation to offshore wind farms, Wright *et al*. (in prep.) recommend that the assumption of a broad migratory front should hold unless there is specific information to the contrary, for example that the species concerned migrates along particular flyways. As such, from the evidence presented above, no non-seabird species are considered to be sensitive receptors, despite the fact that some waders and ducks may theoretically be classed as being of international importance on the basis of their inclusion as qualifying or assemblage species for nearby SPAs. Based on evidence presented on origins and likely migration routes for each species, the Beatrice site is considered very unlikely to pose a significant collision or barrier risk for any flyway or SPA population.

5 CUMULATIVE IMPACT ASSESSMENT

Requirement for a cumulative impact assessment

5.1 An EIA and subsequent Environmental Statement must include a description of the likely significant cumulative effects of a development. This is specified in the European Commission EIA Directive (85/337/EEC as amended by 97/11/EC) and has been transposed into the various UK EIA Regulations applying to different consenting regimes. In addition, for proposals that are likely to have a significant effect on a Natura 2000 site under the Conservation (Natural Habitats &c) Regulations 1994 (as amended) there is a requirement to assess the effects of the proposals alone and in combination with other plans or projects.

5.2 The methods for determining cumulative impacts have been developed in collaboration with the developers of the Moray Firth Round 3 Zone Eastern Development Area, and in discussion with SNH and JNCC. These follow the guidelines in King *et al.* (2009).

Identification of effects

5.3 The main potential cumulative impacts of the Beatrice Offshore Wind Farm on bird species in combination with other wind farm developments in the Moray Firth area are predicted to be:

- disturbance and potential displacement due to boat traffic at all stages of the project, but especially during construction;
- disturbance and potential displacement due to noise and vibration, mainly during construction and decommissioning, but also perhaps including operation;
- avoidance of turbines and subsequent displacement, including a barrier effect during operation;
- collision with turbines during operation; and,
- indirect effects through loss of, or changes to, habitat at all stages of construction, operation and decommissioning.

Scope of the study

5.4 The potential for cumulative impacts during construction phases will only arise if more than one of the site construction programmes were to coincide, however a detailed discussion on the projects for inclusion in this assessment is presented in MFOWDG (2011).

5.5 The cumulative area of study will be species-dependent, but for wide ranging species it may cover waters from Orkney in the north to the Firth of Forth in the south to take account of bird migration and general species mobility. The region may need to be extended for certain species (e.g. individual migratory species or those with a large foraging range) and may also include onshore areas where appropriate.

5.6 Projects to be taken into account in this cumulative assessment include the following, which mostly fall into the definition of 'reasonably foreseeable' (King *et al.* 2009):

- Beatrice Offshore Wind Farm;
- Moray Firth Round 3 Zone Eastern Development Area (EDA);
- Moray Firth Round 3 Zone Western Development Area (WDA);

- Beatrice Demonstrator Offshore wind farm;
- Beatrice Offshore Wind Farm transmission cable (offshore);
- Moray Firth Round 3 Zone Eastern Development Area transmission cable (offshore);
- Aberdeen Offshore Wind Farm (European Offshore Wind Deployment Centre);
- Proposed Scottish Hydro-Electric Transmission Limited cable route;
- Proposed Scottish Hydro-Electric Transmission Limited hub;
- Marine energy development (wave and tidal) in the Pentland Firth and Orkney waters;
- Dredging and sea disposal in the Moray Firth;
- Relevant oil and gas activities; and
- Firth of Forth and Tay offshore wind farms (all projects).

5.7 The proposed Moray Firth Round 3 Zone WDA has not been surveyed and thus no quantitative assessment is currently possible. The construction of this wind farm will not overlap with that of the Beatrice Offshore Wind Farm, thus no consideration for the cumulative construction effects is required. A qualitative assessment has been included of the potential cumulative operational effects to which the Moray Firth Round 3 Zone WDA could contribute.

5.8 It should be noted that the 'medium term' options outlined in Marine Scotland's current Strategic Environmental Assessment (SEA) of the Draft Plan for Offshore Wind Energy in Scottish Territorial Waters have been scoped out of this assessment as these are not considered to be 'reasonably foreseeable' and no data are likely to be available. For particularly wide-ranging species such as gannet, or migratory species such as geese and swans, where the effects of other wind farms, including onshore developments and other Round 3 zones, may need to be taken into account, additional sites will be considered on a case by case basis. For the purpose of this cumulative impact assessment, the most detailed data are for the Moray Firth Round 3 Zone Eastern Development Area wind farm and the Beatrice Demonstrator project. These are the only datasets available for quantitative comparison of potential impacts. The potential for cumulative impacts with all other developments considered here are based on expert consideration of the likelihood of such impacts occurring.

5.9 Non wind farm projects will be discussed briefly, but in the absence of any data from these projects no quantitative analysis can be conducted. Collision and barrier effects are fairly specific to wind farms, therefore no non-wind farm projects will be considered in the cumulative assessment of these effects. In relation to disturbance/displacement and indirect effects on habitat and prey species, there could be potential for cumulative effects with non-wind farm projects, such as other marine renewable projects (e.g. wave and tidal), although this has yet to be demonstrated.

Data used in the CIA

5.10 The boat-based survey data collected between October 2009 and July 2011 for the Beatrice Offshore Wind Farm and between April 2010 and March 2011 for the Moray Firth Round 3 Zone EDA EIAs have been used to form the basis of this cumulative impact assessment (note that no data have been collected for the Moray Firth Round 3 Zone WDA, hence no quantitative assessment for this proposed development are currently possible). These data were collected on the two sites following the same best practice methods, as described by Camphuysen *et al.* 2004 and modified in Maclean *et al.* 2009, and analysed using Distance methods (Buckland *et al*. 2001). Vantage point observations of birds in the vicinity of the Beatrice Demonstrator project have also been used, along with the assessment of impacts presented in the Environmental

Statement (Talisman 2005). The European Offshore Wind Deployment Centre Environmental Statement (Vattenfall 2011) does not provide quantitative information on potential impacts on birds, therefore this site could only be considered qualitatively.

Assessment methodology

5.11 SNH have advised that the initial comprehensive list of bird species likely to interact with these wind farm survey areas be kept comprehensive and should include all relevant SPA seabirds within foraging range of the wind farm sites, as well as passage / migratory SPA interests. It was also asked that this 'long-list' should consider the seasonality of each bird interest i.e. whether the species is present during breeding, post-breeding, passage and / or wintering periods. This long list is shown in Table 5.1 below.

Table 5.1: Long list of potential bird receptors for cumulative impact assessment

Species	Displacement/ disturbance	Collision	Barrier effects	Indirect effects	SPA feature with site-interaction potential?+	Use of site*
Whooper swan	none	low-medium	low	none	yes	W, P
Pink-footed goose	none	low-medium	low	none	yes	W, P
Greylag goose	none	low-medium	low	none	yes	W, P
Barnacle goose	none	low	low	none	yes	W, P
Wigeon	none	low	low	none	no	W, P
Teal	none	low	low	none	no	W, P
Pintail	none	low	low	none	no	W, P
Eider	none	low	low	none	no	B, P, W
Scaup	none	low	low	low	yes	W, P
Long-tailed duck	low-medium	low	low	low-medium	yes	W, P
Common scoter	low-medium	low	low	low-medium	yes	W, P
Velvet scoter	low-medium	low	low	low-medium	yes	W, P
Goldeneye	none	low	low	none	no	W, P
Red-breasted merganser	none	low	low	none	no	W, P
Goosander	none	low	low	none	no	W, P
Red-throated diver	low-medium	medium	low	low-medium	no	W, P
Black-throated diver	low-medium	medium	low	low-medium	no	W, P
Great northern diver	low-medium	medium	low	low-medium	n/a	W, P
Northern fulmar	medium-high	low	low	medium-high	yes	B, W
Sooty shearwater	low-medium	low	low	low-medium	n/a	p
Manx shearwater	low-medium	low	low	low-medium	yes	P
Storm petrel	low-medium	low	low	low-medium	n/a	P
Northern gannet	medium	medium	low	medium	yes	B, P
Cormorant	low	low	low	low	no	B, W
European shag	low	low	low	low	no	B, W
Slavonian grebe	low	low	low	low	no	W
Osprey	none	low	low	none	no	P
Peregrine falcon	none	low	low	low	no	P
Oystercatcher	none	low	low	none	no	P
Knot	none	low	low	none	no	P
Dunlin	none	low	low	none	no	P
Bar-tailed godwit	none	low	low	none	no	P
Curlew	none	low	low	none	No	P
Redshank	none	low	low	none	No	P
Pomarine skua	low	low	low	low	n/a	P
Arctic skua	low	low	low	low	no	P, B
Great skua	low	low	low	low	yes	B, P
Black-legged kittiwake	medium-high	medium-high	low-medium	medium-high	yes	P, B, W
Black-headed gull	low	low	low	low	no	P
Common gull	low	low	low	low	no	P
Lesser black-backed gull	low	medium	low	low	no	B, P, W
Herring gull	low	medium	low	low	yes	B, P, W
Iceland gull	low	low	low	low	n/a	W
Glaucous gull	low	low	low	low	n/a	W
Great black-backed gull	low	medium	low	low	yes	B, P, W
Common tern	low	low	low	low	no	P
Arctic tern	medium	low	low	medium	no	P
Common guillemot	medium-high	low	low-medium	medium-high	yes	B, P, W
Razorbill	medium-high	low	low-medium	medium-high	yes	B, P
Black guillemot	low	low	low	low	n/a	B, W
Little auk	low	low	low	low	n/a	P
Atlantic puffin	medium	Low	low-medium	medium	yes	B, P

* B = breeding; W = wintering; P = passage.
+ n/a indicates that there are no SPAs designated for this species

5.12 The predicted significance of each impact was assessed according to each species' ecology, the number of birds expected to be affected as a proportion of the relevant population and the species' conservation status. This exercise was only undertaken here for the purposes of EIA. Cumulative impacts on SPA populations will be dealt with in the Habitat Regulations Appraisal as a separate report. Population estimates for SPA species were taken from the Natura 2000 citation data unless more recent and robust data were available (e.g. from Mitchell *et al.* 2004, or other sources as agreed with SNH / JNCC). In discussion with SNH / JNCC it was accepted that the process of assigning birds to SPA populations across the study region is complex owing to the number of SPAs with the same qualifying and assemblage species. Therefore, this can only be accomplished on the basis of information about foraging ranges (where available) and assumptions about the foraging habits of individuals from each SPA.

5.13 Trends and conservation status of each population potentially impacted was considered in this cumulative impact assessment. The guidance on cumulative impact assessment states that impacts should not affect a population's trend i.e. increasing populations should not be reduced to stability, stable populations should not start to decline, already declining populations should not have their growth rate reduced further and any impacts should not prevent the population recovering. This assessment takes such trends into consideration.

Disturbance and Displacement

5.14 The assessment considers the potential for disturbance and displacement which may arise due to construction, operation and decommissioning activities. Disturbance and displacement were assessed by summing the number of individuals of each species which may be disturbed or displaced for consideration in relation to the relevant population (e.g. local, regional, national) and discussed in the context of the species conservation status. For those species of breeding seabird which were seen in greatest numbers on the Beatrice application site and the Moray Firth Round 3 Zone, displacement has been considered in relation to turbine avoidance distances. Consequent local population level impacts which would result from the reduced breeding success of displaced individuals have been investigated using simple population models. For species present in lower numbers during the breeding season, or those only seen in higher numbers outside the breeding season, assessments have been informed by studies conducted elsewhere.

5.15 The likely impact of any avoidance / displacement was then assessed, defining the theoretical significance of the impact using the matrix approach based on the magnitude and sensitivity (Table 2.7).

Collision Risks

5.16 Cumulative collision risk was calculated by summing collision estimates from each individual wind farm assessment. The total number is then presented as a percentage of the relevant population or populations (e.g. local, regional, national) and also a percentage change in background mortality rate. This is important as most seabirds are relatively long-lived and slow breeding, with the consequence that their population growth rates are typically most sensitive to changes in adult survival. Where effects are expected to be significant, these are discussed in the context of the life history of the species. In order that collision risk estimates from the two wind farm sites are comparable, the same methods of calculation were used. These followed the recently revised Band model for offshore wind farms (Band 2011). Since the collision risk modelling for the Beatrice Demonstrator project was conducted using a different method it was considered inappropriate to include these values in the cumulative totals. Collision mortality for this site is therefore included here qualitatively.

Barrier Effects

5.17 Barrier effects are deemed to be minimal for most migratory species, with many displaying far-field avoidance of wind farms with minimal effects on energy budgets (Speakman *et al.* 2009). For these species it is anticipated that qualitative assessments are sufficient. Where effects are expected to be significant (e.g. for avoidance of multiple wind farms on a migration route or regular avoidance such as where the wind farms lie between feeding areas and roosting sites) quantitative assessments, incorporating estimates of elevated energy demands are considered (Masden *et al.* 2009). These will be undertaken on a species-specific basis (Masden *et al.* 2010).

Indirect Effects

5.18 Construction effects on seabird prey species may have indirect effects on birds, an effect which may be more pronounced if there is concurrent construction over large areas. The potential for such effects is assessed following an approach similar to that used for estimating disturbance and displacement. This incorporates assessments of the possible changes to prey distributions and abundance, derived from studies conducted elsewhere.

Sensitive receptors

5.19 This CIA takes account of the COWRIE report *"Developing Guidance on Ornithological Cumulative Impact Assessment for Offshore Wind Farm Developers"* (King *et al.* 2009). The process involves a sequence of steps, an outline of which is provided below:

(1) Species selection (based on the Beatrice Offshore Wind Farm baseline data), where selection depends on conservation importance, species whose population within the survey area at any time exceed 1% of the national population as well as species' sensitivity to OWF developments (Garthe and Hüppop 2004, Maclean *et al*. 2009, Langston 2010);

(2) Site selection, which considers all protected sites within the entire zone of possible influence for each species;

(3) Selection of other relevant developments and activities within the predefined zone of possible influence, with the exception of the developments and activities that lack robust baseline information, usually not regulated by an EIA process;

(4) Establish the potential effects of each of these developments upon the relevant ornithological features; and,

(5) The significance of cumulative effects is then assessed by summing the impacts from each component development. The exception to summing will be in assessing cumulative impacts of disturbance and barrier-effects where the impacts accrue in a non-linear manner (King *et al.* 2009). It is proposed that these are first considered in a qualitative manner making best use of available information. If the cumulative impacts are subsequently thought to be significant, then a more detailed quantitative study may be required.

Species considered in the cumulative impact assessment

5.20 With reference to the long list of species for consideration, the species that have been included in this assessment were those of principal concern that were recorded in nationally-important numbers within the Beatrice Offshore Wind Farm boat based survey area. The species under consideration were therefore:

Meeting or exceeding 1% GB population on site

- Guillemot
- Razorbill
- Great black-backed gull
- Arctic Skua
- Storm petrel

5.21 The following target species were also considered in this study. A subset of these species, which are connected to SPAs, will be examined in more detail in the Habitats Regulations Appraisal.

- Herring gull
- Kittiwake
- Fulmar
- Puffin
- Gannet
- Great skua
- European shag
- Sooty shearwater
- Arctic tern

Cumulative Impacts during Construction

5.22 Potential cumulative effects of construction and decommissioning considered here were:

- Disturbance and potential displacement due to boat traffic;
- Disturbance and potential displacement due to construction noise and vibration; and,
- Indirect impacts of sequential pile driving upon local habitat conditions and prey (invertebrates and fish) stocks.

Cumulative disturbance and displacement due to increased boat traffic

5.23 The developments considered as possible contributors to this cumulative impact were:

- Beatrice Offshore Wind Farm;

- Moray Firth Round 3 Zone Eastern Development Area (EDA);
- Moray Firth Round 3 Zone Western Development Area (WDA);
- Beatrice Offshore Wind Farm transmission cable (offshore);
- Moray Firth Round 3 Zone Eastern Development Area transmission cable (offshore);
- Proposed Scottish Hydro-Electric Transmission Limited cable route;

5.24 Construction vessels for the Beatrice Offshore Wind Farm and the Moray Firth Round 3 Zone EDA Offshore Wind Farms are not expected to present a significant cumulative impact since the two sites are of sufficient size that any simultaneous activity will occur at widely separated locations. Construction of the Moray Firth Round 3 Zone WDA are not scheduled to overlap with construction of the Beatrice Offshore Wind Farm. The cable laying vessels will only be present in any one area for a short time and are not expected to present an impact either in isolation or when combined. Therefore, the level of coincidental additional boat traffic expected to result from the above developments, over and above that already present in the Moray Firth was not considered likely to constitute a significant cumulative impact on seabirds present in the region. Thus no further action other than the adoption of best practice at individual sites will be required.

Cumulative disturbance and displacement due to construction noise

5.25 The developments considered as possible contributors to this cumulative impact were:

- Beatrice Offshore Wind Farm;
- Moray Firth Round 3 Zone EDA;

5.26 Birds are likely to habituate rapidly to noise, and even where sudden noises trigger a response, the impact on bird behaviour is expected to be short lived. The fact that noise travels through water much further and faster than it does through air implies that the effects of noise may be more significant for fish prey species than for the birds themselves.

5.27 Overall, the effect of construction noise is not expected to present any increase over and above the disturbance effect caused by vessel presence alone. For this reason, any impact from construction noise is incorporated within the conservative assessment of disturbance and displacement impacts associated with increased vessel activity.

Cumulative indirect impacts upon prey

5.28 The developments considered as possible contributors to this cumulative impact were:

- Beatrice Offshore Wind Farm;
- Moray Firth Round 3 Zone EDA;

5.29 While wave and tidal developments in the Pentland Firth and Orkney waters could be perceived as contributing to a cumulative effect on fish prey, the locations suitable for such developments are by their nature typically of low suitability for the common seabird fish prey such as sandeels. For example, tidal developments are expected to be sited in areas of high flow, which tend to result in scoured bedrock substrates. Wave devices may be sited in more suitable locations for fish, however the nature of proposed wave energy devices is much less likely to have effects on fish. Therefore wave and tidal developments are not considered likely to have a cumulative effect with the Beatrice wind farm.

5.30 The potential for a cumulative impact of wind farm construction on prey availability for bird species is likely to depend on the extent to which foraging occurs within the two adjacent wind farm sites, the extent of construction impacts on fish prey species, the extent to which construction activities coincide on the two sites (and the proximity of such activity) and to some extent on the type of prey taken by the different bird species. Species that feed predominantly on fish are likely to be most affected. Within this fish specialist group, species vary in the extent of specialisation towards particular fish groups.

5.31 Assessment of the impact of construction noise on fish such as clupeids indicates that effects could be of significance especially if dense shoals or spawning aggregations are in close proximity to piling activities (Thomsen *et al.* 2006). Even if construction of different sites does not occur concurrently, there may still be a cumulative sequential effect on prey fish species of at least moderate magnitude. Given the lack of previous research on this issue, it is difficult to directly predict the potential effects of noise disturbance on fish communities.

5.32 No significant cumulative effects on fish prey species were identified in the fish impact assessment (see the Fish Ecology section of the Beatrice Offshore Wind Farm ES). This included consideration of potential habitat loss (due to both gravity bases and cable installation), temporary increases in suspended sediment and direct displacement or mortality resulting from construction activities such as piling. Therefore, the overall cumulative impacts expected to result from construction activities were assessed as being of minor significance and thus no further action other than the adoption of best practice will be required.

Cumulative Impacts during Operation

5.33 Potentially significant cumulative operational impacts of wind farms on birds include:

- Disturbance due to maintenance activity;
- Avoidance and displacement from the site due to the presence of the wind farm itself;
- Barrier effects limiting or preventing free movement;
- Direct collision of birds with turbines; and,
- Indirect effects on distribution of prey and foraging habitat.

Cumulative disturbance due to maintenance activity

5.34 The developments considered as possible contributors to this cumulative impact were:

- Beatrice Offshore Wind Farm;
- Moray Firth Round 3 Zone EDA;
- Moray Firth Round 3 Zone WDA;
- Beatrice Demonstrator Offshore wind farm; and
- Relevant oil and gas activities.

5.35 In comparison to the construction phase, maintenance activities at the Moray Firth wind farms are likely to involve fewer, smaller boats and shorter visits, reducing the magnitude of any impact. However, given that any disturbance effects will persist over the operational lifetime of the respective wind farms, temporal overlap in maintenance activity between sites is likely to occur. The cumulative disturbance impact of maintenance on all sites must therefore be considered. In addition, existing vessel traffic associated with the Beatrice Demonstrator turbines and oil and gas activities needs to be considered.

5.36 As disturbance due to maintenance vessels will occur over the operational lifetime of the respective wind farms, temporal overlap in maintenance activity between sites is very likely to occur. However, given the localised nature of the disturbance events spatial overlap between wind farms is unlikely. No overlap with other maintenance activities in the Moray Firth is expected.

5.37 The maximum number of maintenance boats predicted to be present on the Beatrice Wind Farm site on any day is five (see the Operations and Maintenance section of the Beatrice Offshore Wind Farm ES). Details of the maintenance schedule for the Moray Firth Round 3 Zone EDA were not available at the time of this assessment, however since the proposed developments are of a similar scale it therefore seems reasonable to assume that a similar number of maintenance vessels would be employed.

5.38 Similarly the proposed Moray Firth Round 3 Zone WDA is at an early stage of development and hence predicted maintenance requirements are unknown. However, this site is smaller than either the Beatrice Wind Farm Site or the EDA, and hence will require fewer site visits. In addition, it is likely that improvements in offshore turbine reliability will lead to lower maintenance requirements by the time this site is developed. Therefore the increase in vessel traffic due to the WDA is considered unlikely to contribute to a cumulative effect.

5.39 Vessels used for maintenance visits will be approximately 20 m in length. Therefore, the level of disturbance expected to result from the presence of a maintenance vessel is assumed to be similar to that which would occur in relation to a fishing vessel, consequently disturbance due to maintenance vessels are not considered to constitute a significant cumulative impact.

Cumulative displacement due to the presence of the wind farms

5.40 The developments considered as possible contributors to this cumulative impact were:

- Beatrice Offshore Wind Farm;
- Moray Firth Round 3 Zone EDA;

5.41 The Moray Firth Round 3 Zone WDA was not considered in this cumulative assessment as this site has not been surveyed and there are therefore no seabird density data available.

5.42 Displacement is defined here as the prevention of individuals from a seabird species from undertaking their normal behaviour within areas previously utilised, due to the presence of a novel stimulus. For the purposes of this assessment, the novel stimulus is considered to be the wind turbines (and associated structures) but does not include the wind farm related vessel traffic (e.g. maintenance vessels).

5.43 The cumulative impacts were considered separately for breeding birds against regional populations and non-breeding birds against larger passage or wintering populations. Of the bird recorded during the breeding season, the impact on those recorded in highest numbers on the Beatrice application site (fulmar, kittiwake, guillemot and razorbill) were considered using the displacement model and population models used in Section 4. The other species recorded across the two wind farm sites during the breeding season (Table 5.2) were assessed against regional population sizes without recourse to population models.

5.44 The impact of breeding birds being displaced from the combined Beatrice Offshore Wind Farm and the Moray Firth Round 3 Zone Wind Farm were considered to be not significant or of minor significance for all species. For those assessed without population modelling this was on the basis that the proportion of the breeding population within foraging range seen on the Wind Farm Site was small (gannet, shag, great skua, herring gull, puffin), or that the species was considered to be one very unlikely to avoid wind farms (arctic skua, great black-backed gull). The apparent presence of breeding Arctic tern on the Wind Farm Sites is considered to be misleading, since this species has a mean maximum foraging range of 12 km and a maximum recorded range of 20 km (www.seabird.wikispaces.com). This species was only recorded on the Moray Firth Round 3 Zone during the breeding season, and there are no breeding colonies within range of this site. Thus, the birds observed are not considered to be part of breeding populations within the wider region but rather non-breeding birds, such as immatures. Thus no impact on breeding birds is predicted for Arctic tern.

Table 5.2: The potential cumulative impact magnitude and impact significance for total displacement of combined peak abundance of birds seen during the breeding season as a percentage of the regional population (breeding seasons taken from Snow and Perrins 1998).

Species	Peak breeding season abundance estimates during overlapping survey period (April 2010 - August 2011, wind farm application sites)			Displacement as a percentage of the regional population (defined by mean max. foraging range)	Species sensitivity	Magnitude of impact	Significance of impact
	Beatrice	MF R3	Total				
Fulmar	879	1840	2719	1.9	High	Medium	See Table 5.3
Gannet	159	242 401		0.5	High	Small	Negligible
European shag	5	- 5		0.5	High	Small	Negligible
Arctic Skua	30	- 30		21.1	Medium	Medium	Minor
Great skua	26	516	542	13.4	Medium	Medium	Minor
Kittiwake	496	6653	7,149	6.2	High	See Table 5.3	See Table 5.3
Great black-backed gull	37	56 93		25.7	High	Small	Minor

Table 5.2: The potential cumulative impact magnitude and impact significance for total displacement of combined peak abundance of birds seen during the breeding season as a percentage of the regional population (breeding seasons taken from Snow and Perrins 1998).							
Species	**Peak breeding season abundance estimates during overlapping survey period (April 2010 - August 2011, wind farm application sites)**			**Displacement as a percentage of the regional population (defined by mean max. foraging range)**	**Species sensitivity**	**Magnitude of impact**	**Significance of impact**
	Beatrice	**MF R3**	**Total**				
Herring gull	19	- 19		0.3	High	Small	Minor
Arctic tern	0	779	779	0	Medium	Small	Minor
Guillemot	5,180	15,705	20,885	13.1	High	See Table 5.3	See Table 5.3
Razorbill	331	5194	5525	26	High	See Table 5.3	See Table 5.3
Puffin	1,455	6,736	8,191	13.2	High	See Table 5.3	See Table 5.3

5.45 For fulmar, kittiwake, guillemot razorbill and puffin further assessment of the potential cumulative impact of displacement on breeding birds was conducted.

5.46 The turbine option with the highest number of turbines and the closest spacing was considered to represent the worst case scenario for displacement. For both the Beatrice Offshore Wind Farm and the Moray Firth Round 3 Zone EDA wind farm, the worst case displacement scenario was the use of turbines placed at approximately 642 m intervals (both orientations). The total number of this size turbine which would be installed across the two developments is 597 (Table 4.4 in Section 4 provides estimates of the predicted displacement percentages for this turbine option in relation to bird avoidance distances). The Moray Round 3 Zone WDA has not been included in this assessment at this stage as there is currently no estimate available of the number or type of turbine likely to be used.

5.47 The displacement assessment in Section 4, based on a simple model relating turbine avoidance distances to displacement percentages, demonstrated that the Beatrice Offshore Wind Farm will be expected to have non-significant impacts on the populations of the key breeding species present on the site (fulmar, kittiwake, guillemot and razorbill).

5.48 For the cumulative impact assessment, Puffin were also identified as being present across the two wind farms in large numbers during the breeding season, due to high numbers observed on the Moray Firth Round 3 Zone EDA (Table 5.2). A population model was therefore developed for this species and is described below.

5.49 Demographic rates for puffin were taken from published studies of survival and reproduction from several locations (Snow and Perrins 1998). From these data the following population matrix, describing annual change in the population, was derived:

$$A.PU = \begin{bmatrix} 0 & 0.24 \\ 0.46 & 0.95 \end{bmatrix}$$

5.50 This model has two stages, pre-breeders aged from fledging to five year olds and breeding adults aged five and up, and incorporates both sexes in a post-breeding census format. The value in the first row, second column (0.24) is a product of the breeding adult survival rate (second row, second column, 0.95) and the number of young fledged per individual (0.51/2). Survival from fledging to age five can only be estimated as a composite over all years, since insufficient young birds return to breeding colonies at this age for reliable estimation. This was converted into an annual rate (0.824^4) for use in the model. Adult breeders have an annual survival rate of 0.95. In this format, the model is density independent and includes no environmental or demographic stochasticity (i.e. variations due to weather and chance were omitted). These additional components were considered to provide unnecessary complexity for little benefit. The model yields a long term annual population growth rate of 5.66%.

5.51 The initial population size was set at 8,641 individuals, derived as the sum of the East Caithness Cliffs (3,500 prs.) and the North Caithness Cliffs (3,500 prs.) breeding populations, divided by the estimated proportion of adults (0.81) in the population (calculated using the population model). The baseline prediction obtained from the model is that the population will increase from the starting size of 8,641 to 32,330 after 25 years.

5.52 Using the puffin model and the same population models described in Section 4 for fulmar, kittiwake, guillemot and razorbill, cumulative impact effects on the population growth rate of these combined populations were determined (Table 5.3). The impacts on the growth rates of these five populations predicted to occur as a result of displacement of the combined estimates on the Beatrice Offshore Wind Farm site and the Moray Firth Round 3 Zone EDA were all greater than those predicted just for the Beatrice Offshore Wind Farm (none of the single site impacts was judged to be significant).

5.53 The inclusion of the Moray Firth Round 3 Zone EDA reduced the predicted growth rate of all the populations, however for fulmar, guillemot, kittiwake and puffin these additional reductions were considered to be of minor significance, since even with complete displacement their population growth rates were reduced by less than 1 % which was considered to be of no significance.

5.54 Although it may be argued that the baseline population trends presented in Table 5.3 may not reflect those of the colonies at risk of impact, there are insufficient data to determine more accurately what the local population trends have been in recent years. However, the key aspect of the model results is the small relative change in population growth rate predicted to occur. Thus, even if the baseline population growth rates for fulmar, kittiwake, guillemot and puffin are lower than those presented here, the small magnitude of reduction predicted to result from the Beatrice and Moray Firth Round 3 wind farms indicates that these populations are not at risk of significant effects due to displacement.

5.55 For razorbill a greater reduction in the population growth rate was estimated, with complete displacement leading to a population decline at a rate of 0.24 % per year, an overall decrease in the growth rate of 2.48 % from the baseline value.

Table 5.3. Population growth rate of the key breeding species recorded on the Beatrice Offshore Wind Farm and Moray Firth Round 3 Zone Eastern Development Area **in relation to increasing levels of displacement causing breeding failure amongst displaced individuals.**

Radial avoidance distance (m)	Displacement (%)	Population growth rate (%)				
		Fulmar	**Kittiwake**	**Guillemot**	**Razorbill**	**Puffin**
0	0	3.29	4.35	5.68	2.21	5.66
50	2	3.28	4.34	5.68	2.18	5.64
100	7.6	3.27	4.32	5.67 2.09		5.62
200	30.5	3.19	4.21	5.62 1.66		5.50
300	68.6	3.04	4.0	5.55	0.68	5.28
400	100	2.92	3.81	5.48	-0.07	5.07
Significance of impact		Negligible	Negligible	Negligible	Minor	Negligible

5.56 The significant combined impact predicted for razorbill as a result of displaced birds failing to breed is in marked contrast to the same assessment for the Beatrice site in isolation which predicted a maximum reduction in the growth rate of only 0.17 %. This is due to the much higher number of razorbills estimated to be present on the Moray Firth Round 3 wind farm (5,194), compared with the estimate for the same month for the Beatrice Wind Farm of 331.

5.57 Razorbill have a smaller foraging range than either guillemot or puffin, thus all else being equal, it would be predicted that their density would decrease with distance from the coast across the two wind farm sites. This would result in higher densities on the Beatrice wind farm, rather than the apparent pattern described here which indicates higher densities farther offshore. This may indicate the presence of a favoured foraging region within the Moray Firth Round 3 wind farm, although this would still be expected to lead to relatively high numbers being recorded on the Beatrice site. Alternatively, the birds recorded on the Moray Firth Round 3 wind farm site may in fact be non-breeders which are more likely to remain at sea during the breeding season and may also be excluded from more preferred locations closer to the breeding colonies by the more dominant breeding birds. Thus, if a large proportion of the birds observed within the Moray Firth Round 3 wind farm are non-breeders, the current assessment, based on displacement of breeding birds is likely to over-estimate the effects on the breeding population. Therefore, the significant impact of displacement on the breeding razorbill population is considered to be of minor significance.

5.58 For non-breeding season displacement impacts, a similar process was undertaken (Table 5.4), however the populations against which the impact was considered included passage and wintering birds. For all species the impacts were determined to be of no significance or minor.

Table 5.4: The potential cumulative impact magnitude and impact significance for total displacement of combined peak abundance of birds seen during the non-breeding season as a percentage of the non-breeding population.

Species	Peak non-breeding season abundance estimates during overlapping survey period (March 2010 - April 2011, wind farm application sites)			Displacement as a percentage of the non-breeding population	Species sensitivity	Magnitude of impact	Significance of impact
	Beatrice	MF R3	Total				
Fulmar	123	717	840	0.13	High	Negligible	Negligible
Gannet	0	440	440	0.11	High	Negligible	Negligible
European shag	30	-	30	0.38	High	Negligible	Negligible
Arctic Skua	0	0	0	-	Medium	NA	NA
Great skua	0	0	0	-	Medium	NA	NA
Kittiwake	584	3889	4473	1.63	High	Small	Minor
Great black-backed gull	244	461	705	3.97	High	Small	Minor
Herring gull	203	-	203	0.69	High	Negligible	Negligible
Arctic tern	0	0	0	-	Low	NA	NA
Guillemot	2805	3,034	5,839	0.63	High	Small	Minor
Razorbill	421	2385	2806	3.87	High	Small	Minor
Puffin	1239	97	1336	1.07	High	Small	Minor

Cumulative barrier effects

5.59 The developments considered as possible contributors to this cumulative impact were:

- Beatrice Offshore Wind Farm;
- Moray Firth Round 3 Zone EDA;

5.60 There is a paucity of evidence in the scientific literature as to whether seabird movements are affected or inhibited by the presence of offshore wind farms. Energetic impacts are likely to be subtle and difficult to measure on individuals' fitness or reproductive success (Masden *et al.* 2010). It has been shown that some species such as divers and sea ducks avoid wind farms and take evasive detours, thereby potentially increasing energy expenditure (Petersen *et al.* 2005; 2006). Although this effect may be negligible when passing around one wind farm, if a series of wind farms are arranged to present a continuous barrier that requires one large detour or many smaller detours, then an individual's longer trip duration will reduce time spent foraging or roosting, or increase its migration length.

5.61 Any effects are likely to be greater on birds that regularly commute around a wind farm compared to passage migrants that pass the site once per season.

5.62 The risk to highly mobile species such as gannet and fulmar, the populations of which may include a proportion of breeding birds which could theoretically make repeat movements through the region might be greater than that for migrants undertaking more direct passage routes through the area. However, the wide ranging behaviour of these species means that deviations of even tens of kilometres around sites should not be associated with any significant cost in energetic terms.

5.63 Although not such a wide ranging species, the populations of great black-backed gull observed during surveys were also thought likely to include a mixture of migrants and breeding birds. This suggests a reduced risk of a barrier effect than if only breeding individuals making repeat foraging trips through the sites were involved. Moreover, there is currently no evidence to suggest that large gulls are likely to be vulnerable to barrier effects (Petersen *et al.* 2006).

5.64 The Moray Firth Round 3 Zone WDA was not considered in this cumulative assessment as there is currently no information on which areas of the site will be developed. While this additional development has the potential to contribute to a cumulative barrier effect, given the conclusions of the assessment without this wind farm it seems unlikely that a larger magnitude effect would result from its presence.

5.65 Overall the cumulative impact magnitude for barrier effects is assessed as small with just a minor shift away from baseline conditions.

Cumulative collision risk

5.66 The developments considered as possible contributors to this cumulative impact were:

- Beatrice Offshore Wind Farm;
- Moray Firth Round 3 Zone EDA;
- Beatrice Demonstrator Project; and
- European Offshore Wind Deployment Centre

5.67 The Moray Firth Round 3 Zone WDA was not considered in this cumulative assessment as there are currently no data with which to estimate collision mortality.

5.68 Direct comparison of the collision risks predicted by the wind farms that are operational or in construction can be problematic due to the differing assumptions made in the calculations used in the different studies, and limited amount of species data presented in ES chapters (see Maclean *et al.* 2009). This complication applies to the collision risk assessments presented in the Environmental Statements for the Beatrice Demonstrator Project and the European Offshore Wind Deployment Centre. Thus, only a qualitative cumulative assessment is possible using these sites.

5.69 However the assessments conducted for projects within the Moray Firth, were conducted in a more uniform manner, and therefore, were comparable. In all cases the results presented were estimated using the Band (2011) model, using site specific estimates of the proportion of birds at risk height. Table 5.5 summarises the collision risk modelling results from the Beatrice Offshore Wind Farm and Moray Firth Round 3 Zone EDA boat based surveys and presents the predicted impacts as percentages of the regional and GB populations. Only those species for which collision estimates were provided for the Moray Firth Round 3 Zone EDA are included. The additional species for which collision risk modelling was presented in Section 4 of this report were fulmar, Arctic skua, Arctic tern and great skua. Since these species were not considered at risk of collision on the Moray Firth Round 3 Zone EDA, their cumulative collision impacts are the same as presented for the Beatrice Offshore Wind Farm alone.

Table 5.5: Cumulative predicted annual collision mortality for the Beatrice Offshore Wind Farm and Moray Firth Round 3 Zone Eastern Development Area. The most recent recommended avoidance rate (BTO, 99%) is shown in all cases. Regional populations reflect the months when birds were recorded in snapshots (gannet and kittiwake – closest breeding populations within foraging range; great black-backed and herring gull – passage and wintering populations).

Species	Collision mortality estimates for the Moray Site	Collision mortality estimates for the Beatrice Site	Combined total mortality	Regional population	Britain & Ireland population	1% threshold		Percent additional mortality	
						Region	GB	Region	GB
Gannet	160	132	292	66,630	679,659	663	6,796	0.4	0.04
Kittiwake	186	132	318	80,280	733,670	803	7337	0.4	0.04
Great black-backed gull	104	302	406	17,902	43,108	179	431	2.3	0.9
Herring gull	143	494	637	29,260	262,938	293	2,629	2.2	0.2

5.70 Combined seabird mortality due to projected collisions with the turbines on both wind farms was low across all species on a national level, with fewer than 1 % of the national threshold population predicted to be killed for all species. If all the additional mortality occurred during the breeding season both gull species would be predicted to experience increases in mortality regionally of just over 2 %. However, since most of the predicted mortality for both gull species occurred outside the breeding season, the GB population represents a more realistic effective population size.

5.71 Consequently, cumulative collision risk impacts are predicted to be minor for those target species for which collision risk for both sites have been considered, including those with high conservation sensitivity (Table 5.6).

Table 5.6: The potential cumulative impact magnitude and impact significance for predicted collision risk mortality

Species	Cumulative collision mortality	Percentage of populations impacted		Species sensitivity	Magnitude of impact	Significance of impact
		Regional	GB			
Gannet	292	0.4	0.04	High	Small	Minor
Kittiwake	318	0.4	0.04	High	Small	Minor
Great black-backed gull	406	2.3	0.9	High	Small	Minor
Herring gull	637	2.2	0.2	High	Small	Minor

5.72 The European Offshore Wind Deployment Centre was predicted to have a negligible to minor impact on some gull species. No further details were presented. Given the distance of this site (approximately 140 km) from the Moray Firth wind farms it seems unlikely that a significant cumulative impact would occur.

5.73 The Beatrice Demonstrator Project was not considered likely to cause significant impacts on the observed bird species through collisions, with predicted increases in mortality of less than 1 % for all species.

5.74 Overall therefore, the inclusion of the Beatrice Demonstrator Project and the European Offshore Wind Deployment Centre in the cumulative collision mortality assessment does not alter the assessment based on just the Beatrice Offshore Wind Farm and the Moray Firth Round 3 Zone EDA.

5.75 Wildfowl collision mortality was considered as a combination of the Beatrice Offshore Wind Farm and the Moray Firth Round 3 Zone EDA only. The results of the single site assessments for these two sites were very similar, hence the cumulative impact is approximately twice that for the single site assessment described in Section 4. Therefore no further consideration of the combined impact of these two developments is considered here since the results of the assessments did not constitute a significant impact on any of the wildfowl populations observed crossing the region.

Cumulative indirect effects on the distribution of prey and foraging habitat

5.76 The developments considered as possible contributors to this cumulative impact were:

- Beatrice Offshore Wind Farm;
- Moray Firth Round 3 Zone EDA;

- Beatrice Offshore Wind Farm transmission cable (offshore);
- Moray Firth Round 3 Zone EDA transmission cable (offshore);
- Proposed Scottish Hydro-Electric Transmission Limited cable route;

5.77 There is some evidence that submerged wind farm foundation structures can provide suitable micro-habitats for invertebrates (e.g. molluscs, crustaceans) and fish (Linley *et al.* 2007). This may possibly include species that would otherwise be limited in the region by a lack of suitable habitat. As such, wind farms may increase the regional number and distribution of some invertebrates and fish, potentially enhancing prey availability for some bird species. However, the attraction of fish species to foundation structures could have an indirect negative impact on piscivorous bird species by attracting shoals of prey fish, which then attract birds increasing the potential for collision with turbines.

5.78 It is probable however that some form of anti-fouling coating will be applied to the sub-structures, thus the opportunities for macro-invertebrate colonisation may be very limited. Thus, while there is the potential for both positive and negative indirect effects on birds through habitat creation or alteration around foundation structures, there is currently insufficient evidence to draw any conclusions on the issue - especially on a cumulative scale. Consequently, this aspect is considered as neutral.

5.79 The worst case scenario for seabed loss is considered likely to result from the use of gravity based for the turbines. These are being considered for both the Beatrice Offshore Wind Farm and the Moray Firth Round 3 Zone EDA. The estimated total seabed area which would be permanently impacted by such bases is approximately 2.5 % of the available seabed within the Wind Farm Sites. A further 0.4 % of the areas may also be impacted due to inter-array cables laid underneath protective matting. Given the apparent uniformity of the substrate within the Wind Farm Sites (Brown and May 2011), this is not considered likely to result in a significant loss of suitable habitat for fish prey such as sandeels. Therefore the cumulative indirect impact due to loss of prey is considered to be not significant.

5.80 The Moray Firth Round 3 Zone WDA was not considered in this cumulative assessment, however given the conclusions based on the other developments above, it is not considered that a significant cumulative effect will result from the addition of this development.

Proposed offshore wind farms in the Firths of Forth and Tay

5.81 Quantitative assessment of the potential combined impacts of the proposed development and those proposed for development in the Firths of Forth and Tay is not possible here since no data are available for those developments. The potential for cumulative impacts on seabirds with these sites will vary between species and also with different times of year. Passage species may encounter several sites, however at such times effective population sizes are typically large and drawn from numerous sites both nationally and internationally, complicating impact prediction. During the breeding season, only the most far ranging species have the potential to encounter more than one wind farm area. Only two species are known to regularly undertake foraging trips of sufficient distance to bring them into this category: fulmar and gannet. However, this far ranging nature further complicates assessment, since the effective populations at risk become much greater with the inclusion of all possible breeding colonies located within the mean maximum range. This complication notwithstanding, the predicted cumulative impacts of wind farm sites beyond the Moray Firth on these two species are not expected to be significant, due to their low sensitivity (fulmar) and habitat flexibility (gannet).

Proposed underwater renewables in the Pentland Firth and Orkney

5.82 Virtually nothing is known about the potential for underwater renewable energy devices to impact on seabirds since only a handful of test devices have been tested or are currently in operation. Devices located beyond a few metres depth (e.g. tidal turbines) will only have the potential to impact on those species which forage at those depths (e.g. auks, shag), while devices at the surface (e.g. wave operated) can potentially impact all seabirds.

5.83 Most species are unlikely to be impacted significantly by both wind farms and underwater devices, due to mutually exclusive aspects of their ecology. For example, birds which fly at collision height rarely dive deep enough to bring them into contact with tidal turbines. Conversely, birds which dive to depths at which tidal turbines are likely to operate rarely fly higher than a few metres above the sea. Perhaps the most obvious exception to this is gannet. However, even this species is considered unlikely to make regular dives to depths greater than 8 m, which will prevent it from reaching depths at which tidal turbines would typically be located.

5.84 Until commercial scale wave and tidal developments are installed and monitored it is very difficult to predict the likelihood of their impacts on birds. It is worth noting, however, that the spatial scale of the current proposals is much smaller than that for wind farms, with tidal turbine arrays requiring perhaps less than a tenth of the seabed area for equivalent power generation. Wave and tidal devices will also be sited in very specific locations in order to maximise power generation, which has potentially important implications when it comes to the importance of these sites for seabirds.

5.85 In conclusion, currently no cumulative impacts of wave and tidal devices with wind farms can be predicted.

Non wind farm activities

5.86 The identified non-wind farm activities occurring in the Moray Firth area must also be considered when accounting for all possible cumulative effects on species. Such assessments are problematic due to the differences in level of data capture, and typically only a qualitative assessment is therefore possible.

Oil and gas exploration and production

5.87 Although there is oil and gas exploration activity in the wider Moray Firth area, no data are available on the disturbance or displacement which these activities may have on birds.

Transmission cables from the Beatrice Offshore Wind Farm and the Moray Firth Round 3 Zone Eastern Development Area Offshore wind farm

5.88 Cables, where buried, are likely to have a negligible impact on the habitat supporting seabirds, although repair of cable breakages may impact on the seabird population through direct disturbance to the birds and damage to the seabed. Any effects are however considered to be localised and short-term and so will be unlikely to cause additional significance impacts to any species. No cumulative impacts are therefore expected.

Shipping (including dredging of channels)

5.89 Any shipping activities are unlikely to cause any cumulative impacts on gulls, skuas or gannets due to their low sensitivity to such disturbance and flexibility of habitat choice (Garthe and Hüppop, 2004).

5.90 As it is likely that the existing seabird populations, including auks, are already adapted to shipping operations, and any increased effects would be short-term and temporary, it is expected that any increase in cumulative displacement effects would only be potentially significant when there was a concentration of activity in a single year within the main foraging areas for a species. It is, therefore, concluded that combining the offshore wind farms with the ongoing effects of dumping and extraction will not create in-combination effects that are significant. It follows that existing populations of all species are habituated to some extent to the other commercial vessel movements in the area, and so any effects of shipping are incorporated into the baseline survey results. Therefore the cumulative impact magnitude of shipping disturbance is considered to be small at worst, with perhaps a minor shift away from baseline conditions.

Commercial fisheries

5.91 The impacts of fisheries on seabird species over the life span of the Beatrice Offshore Wind Farm are very difficult to predict due to the lack of information on the likely intensity of fishing over this period and the level of information available on the existing impact of fisheries in the Moray Firth. If fishing intensity remains at its current levels, then the baseline survey results would be expected to include any impacts that are currently detrimentally affecting the species present in the area. Fisheries that are not impacting on the interest features of the site may continue not to, but changes in fishing effort, distribution and intensity could result in some of these fisheries having an impact on prey species in future. Offshore wind farms may have impacts on fisheries during both construction and operational phases.

5.92 Construction noise is expected to be greatest during piling activity. It is likely to displace fish in the area and fishing vessels may also be displaced as a result of this. It is likely that fish will return post-construction, and potentially before this if they become habituated to general construction noise (not including piling).

5.93 Fish may be attracted to the 'new' structures in the water column and sea bed, both for shelter and for new feeding opportunities (Leonhard and Pedersen 2006). Any restrictions placed on fishing within the wind farms may lead to reduced presence of species such as gulls and gannets, which often follow fishing vessels, leading to a reduction in collision risk. Overall therefore, given the current state of knowledge regarding fisheries in the region, and how these may change in the future, no significant cumulative impacts on birds are predicted.

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APPENDIX 1 – BOAT SURVEY DATA

The following tables provide the raw observations made during the boat surveys of the Beatrice Offshore Wind Farm and 4 km buffer zone. All data were collected by the Institute of Estuarine and Coastal Studies. The tables are taken from their trip reports.

Table A1. Survey 1 – October 2009

Species	No. on sea surface	No. in flight	Total abundance
Gannet	164	209	373
Fulmar	99	266	365
Razorbill	187	51	238
Guillemot	167	16	183
Kittiwake	68	108	176
Guillemot / razorbill	58	47	105
Great black-backed gull	10	40	50
Puffin	16		16
Herring gull	3	10	13
Sooty shearwater		4	4
Great skua	1	2	3
Red throated diver		3	3
Black-headed gull		2	2
Storm petrel	1	1	2
Arctic skua		1	1
Great cormorant		1	1
Dunlin		1	1
Goldcrest		1	1
Little auk		1	1
Manx shearwater		1	1
Storm Petrel / Leach`s Petrel		1	1
Total	**774**	**766**	**1540**

Table A2. Survey 2 – December 2009

Species	No. on sea surface	No. in flight	Total numbers
Fulmar	12	329	341
Herring gull	15	112	127
Great black-backed gull	4	41	45
Guillemot	32	4	36
Kittiwake		31	31
Gannet		15	15
Shag	6	6	12
Razorbill	1	4	5
Guillemot / razorbill	1	3	4
Wigeon		2	2
Large gull Sp.		2	2
Cormorant		1	1
Storm petrel	1		1
Little auk	1		1
Common gull		1	1
Total	**73**	**551**	**624**

Table A3. Survey 3 – February 2010

Species	No. on sea surface	No. in flight	Total numbers
Guillemot	199	638	833
Fulmar	15	396	411
Guillemot / Razorbill	25	298	323
Herring gull	6	100	106
Great black-backed gull	4	24	28
Kittiwake	2	16	18
Razorbill	7	11	18
Gannet	1	9	10
Herring gull / Lesse r black-backed gull / Great black-backed gull	2	6	8
Cormorant		6	6
Shag	3	1	4
Goose Sp.		2	2
Common gull		1	1
Eider		1	1
Total	**264**	**1,509**	**1,773**

Table A4. Survey 4 – March 2010

Species	No. on sea surface	No. in flight	Total numbers
Guillemot / razorbill	71	1361	1432
Guillemot	358	266	624
Fulmar	59	215	274
Razorbill	59	163	222
Kittiwake	33	55	88
Herring gull	25	44	69
Great black-backed gull	15	19	34
Herring gull / Lesser black-backed gull / great black-backed gull	13	7	20
Gannet	5	15	20
Shag	2		2
Common gull		1	1
Total	**640**	**2146**	**2786**

Table A5. Survey 5 – April 2010

Species	No. on sea surface	No. in flight	Total numbers
Guillemot	1623	444	2067
Guillemot / razorbill	114	860	974
Kittiwake	121	361	482
Razorbill	105	183	288
Fulmar	10	273	283
Great black-backed gull	23	25	48
Gannet	15	29	44
Pink-footed goose		38	38
Herring gull	10	11	21
Puffin	14	2	16
Passerines sp.		6	6
Black-headed gull		2	2
Lesser black-backed gull		2	2
Meadow pipit		2	2
Golden plover		1	1
Carrion crow		1	1
Great skua	1		1
Total	**2036**	**2240**	**4276**

Table A6. Survey 6 – April 2010

Species	No. on sea surface	No. in flight	Total numbers
Guillemot	1,604	574	2,178
Guillemot / Razorbill	455	503	958
Kittiwake	244	362	606
Fulmar	211	279	490
Razorbill	225	63	288
Great black-backed gull	22	45	67
Puffin	28	0	28
Herring gull	1	22	23
Gannet	8	11	19
Herring gull / Lesser black-backed gull / Great black-backed gull	0	19	19
Great skua	6	8	14
Black guillemot	0	3	3
Carrion crow	0	2	2
Manx shearwater	0	1	1
Lesser black-backed gull	0	1	1
Common tern / arctic tern	0	1	1
Red throated diver	0	1	1
Total	**2804**	**1895**	**4,699**

Table A7. Survey 7 – May 2010

Species	No. on sea surface	No. in flight	Total numbers
Guillemot	1,708	773	2,482
Kittiwake	924	796	1,720
Guillemot/Razorbill	71	1,002	1,073
Fulmar	264	328	592
Razorbill	66	69	135
Great skua	21	54	75
Gannet	40	25	65
Puffin	31	9	40
Great black-backed gull	8	9	17
Herring gull / Lesse r black-backed gull / Great black-backed gull	3	8	11
Arctic skua	6	5	11
Herring gull	4	1	5
Swallow	0	3	3
Dunlin	0	2	2
Wader sp.	0	2	2
Common tern / arctic tern	0	2	2
Diver sp.	0	2	2
Lesser black-backed gull	0	1	1
Total	**3,146**	**3,092**	**6,238**

Table A8. Survey 8 – June 2010

Species	No. on sea surface	No. in flight	Total numbers
Guillemot/Razorbill	296	1,638	1,934
Guillemot	1295	525	1,820
Kittiwake	632	486	1,118
Fulmar	58	194	252
Razorbill	101	82	183
Gannet	16	33	49
Puffin	31	13	44
Herring gull	5	37	42
Arctic tern		32	32
Great skua	8	20	28
Arctic skua	5	8	13
Great black-backed gull	3	6	9
Manx shearwater		5	5
Common tern / arctic tern		2	2
Curlew		2	2
Swallow		1	1
Shag		1	1
Common gull		1	1
Lesser black-backed gull	1		1
Total	**2,451**	**3,086**	**5,537**

Table A9. Survey 9 – July 2010

Species	No. on sea surface	No. in flight	Total numbers
Fulmar	133	769	902
Kittiwake	24	198	222
Puffin	82	16	98
Razorbill	52	28	80
Herring gull	5	61	66
Guillemot	43	13	56
Gannet	15	39	54
Great black-backed gull	7	34	41
Guillemot / razorbill	9	29	38
Great skua	5	24	29
Arctic tern	0	19	19
Arctic skua	0	16	16
Common / arctic tern	0	4	4
Manx shearwater	0	3	3
Shag	2	0	2
Sooty shearwater	0	1	1
Common tern	0	1	1
Lesser black-backed gull	0	1	1
Total	**378**	**1,255**	**1,633**

Table A10. Survey 10 – August 2010

Species	No. on sea surface	No. in flight	Total numbers
Fulmar	96	597	693
Gannet	96	209	305
Puffin	273	17	290
Guillemot	194		194
Guillemot/Razorbill	164	12	176
Great Black-backed Gull	9	69	78
Great Skua	2	27	29
Razorbill	3	9	12
Sooty Shearwater	1	10	11
Kittiwake		10	10
Arctic Skua		5	5
Manx Shearwater	1	3	4
Common/Arctic Tern		4	4
Arctic Tern		4	4
Storm Petrel		2	2
Herring Gull		2	2
Shag		1	1
Black Guillemot		1	1
Grey Phalarope		1	1
Total	**839**	**983**	**1,822**

Table A11. Survey 11 – September 2010

Species	No. on sea surface	No. in flight	Total numbers
Fulmar	27	303	330
Gannet	45	213	258
Great Black-backed Gull	6	111	117
Sooty Shearwater	60	27	87
Puffin	55		55
Guillemot/Razorbill	26	15	41
Guillemot	19	20	39
Razorbill	21	14	35
Kittiwake	1	25	26
Manx shearwater		16	16
Dunlin		4	4
Herring Gull	3		3
Storm Petrel		2	2
Great Skua	1	1	2
Meadow Pipit		1	1
Goose sp.		1	1
Passerine sp.		1	1
Grey Heron		1	1
Total	**839**	**983**	**1,822**

Table A12. Survey 12 – October 2010

Species	No. on sea surface	No. in flight	Total numbers
Pink-footed Goose		1,060	1060
Puffin	252	5	257
Gannet	11	126	137
Fulmar	49	76	125
Kittiwake		70	70
Great Black-backed Gull	12	48	60
Razorbill	11	29	40
Guillemot/Razorbill	17	14	31
Shag	27	3	30
Guillemot	20	5	25
Sooty Shearwater	20		20
Herring / Lesser Black-backed Gull / Great Black-backed Gull.		9	9
Lesser Black-backed Gull	3	4	7
Herring Gull	1	3	4
Goose sp.		4	4
Duck sp.		4	4
Common Gull		3	3
Storm Petrel		2	2
Long-tailed Duck		2	2
Arctic Skua		1	1
Starling		1	1
Passerine sp.		1	1
Red-throated Diver		1	1
Total	**423**	**1,471**	**1,894**

Table A13. Survey 13 – December 2010

Species	No. on sea surface	No. in flight	Total numbers
Fulmar	228	457	685
Great Black-backed Gull	29	85	114
Herring Gull	2	73	75
Guillemot	20	20	40
Goose sp.		27	27
Shag	11	14	25
Kittiwake	1	21	22
Herring / Lesser Black-backed Gull / Great Black-backed Gull.		13	13
Guillemot / Razorbill	1	11	12
Little Auk	7	2	9
Gannet		7	7
Cormorant		4	4
Razorbill	1		1
Total	**300**	**734**	**1,034**

Table A14. Survey 14 – January 2011

Species	No. on sea surface	No. in flight	Total numbers
Fulmar	4	376	380
Guillemot/Razorbill	13	352	365
Razorbill	4	150	154
Guillemot	25	109	134
Herring Gull	7	107	114
Great Black-backed Gull	7	61	68
Pink-footed Goose	0	52	52
Kittiwake	2	36	38
Cormorant	0	25	25
Gannet	1	13	14
Unidentified Herring Gull / Great Black-backed Gull / Lesser Black-backed Gull.	0	11	11
Shag	0	5	5
Passerine sp.	0	2	2
Great Northern Diver	0	1	1
Total	**63**	**1,300**	**1,363**

Table A15. Survey 15 – January 2011

Species	No. on sea surface	No. in flight	Total numbers
Fulmar	83	741	824
Guillemot	148	331	479
Herring Gull	292	44	336
Guillemot/Razorbill	9	274	283
Great Black-backed Gull	20	103	123
Razorbill	61	54	115
Kittiwake	45	32	77
Gannet	8	32	40
Shag	11	21	32
Large gull sp.	0	20	20
Pink-footed Goose	0	10	10
Little Auk	1	0	1
Puffin	1	0	1
Duck sp.	0	1	1
Total	**432**	**1,910**	**2,342**

Table A16. Survey 16 – February 2011

Species	No. on sea surface	No. in flight	Total numbers
Guillemot	581	773	1354
Large Gull Species	0	1,000	1,000
Herring Gull	142	271	413
Razorbill	100	243	343
Guillemot/Razorbill	65	257	322
Fulmar	15	245	260
Kittiwake	90	111	201
Great Black-back Gull	74	101	175
Gannet	7	54	61
Pink-footed Goose	0	12	12
Shag	3	3	6
Total	**1,077**	**3,080**	**4,157**

Table A17. Survey 17 – April 2011

Species	No. on sea surface	No. in flight	Total numbers
Guillemot/Razorbill	2	860	862
Guillemot	153	599	752
Kittiwake	249	301	550
Razorbill	69	143	212
Great Black-backed Gull	120	46	166
Puffin	76	61	137
Fulmar	19	115	134
Gannet	4	27	31
Herring Gull		8	8
Large Gull Species		8	8
Great Skua	5	2	7
Lesser Black-backed Gull		3	3
Whopper Swan	2		2
Shag	1		1
Total	**700**	**2,173**	**2,873**

Table A18. Survey 18 – May 2011

Species	No. on sea surface	No. in flight	Total numbers
Guillemot	232	1,398	1,630
Guillemot/Razorbill	212	603	815
Fulmar	61	295	356
Kittiwake	101	239	340
Razorbill	132	153	285
Great Skua	14	59	73
Gannet	22	33	55
Puffin	17	31	48
Arctic Tern	5	41	46
Arctic Skua	1	34	35
Great Black-backed Gull	11	24	35
Large gull sp.		14	14
Black Guillemot		2	2
Swallow		2	2
Storm Petrel	1		1
Total	**809**	**2,928**	**3,737**

Table A19. Survey 19 – June 2011

Species	No. on sea surface	No. in flight	Total numbers
Guillemot	134	1,214	1,348
Guillemot/Razorbill	9	515	524
Razorbill	73	361	434
Fulmar	18	351	369
Kittiwake	69	123	192
Arctic Tern	12	40	52
Puffin	24	26	50
Gannet	8	26	34
Great Skua	4	15	19
Herring Gull		5	5
Manx Shearwater	1	2	3
Great Black-backed Gull	1	2	3
Common Tern/Arctic Tern		2	2
Arctic Skua		2	2
Duck sp.		1	1
Little Tern		1	1
Total	**353**	**2,686**	**3,039**

Table A20. Survey 20 – July 2011

Species	No. on sea surface	No. in flight	Total numbers
Guillemot	208	733	941
Guillemot/Razorbill	30	404	434
Fulmar	22	335	357
Razorbill	43	292	335
Kittiwake	69	156	225
Puffin	22	51	73
Gannet	1	26	27
Great Skua	8	14	22
Great Black-backed Gull		11	11
Arctic Skua		9	9
Common Tern/Arctic Tern		8	8
Arctic Tern		6	6
Herring Gull		6	6
Manx Shearwater	1	1	2
Shag		2	2
Storm Petrel		1	1
Total	**404**	**2,055**	**2,459**

Table A21. Survey 21 – August 2011

Species	No. on sea surface	No. in flight	Total numbers
Fulmar	176	389	565
Puffin	519	32	551
Razorbill	215	3	218
Guillemot	132	33	165
Great Black-backed Gull	43	83	126
Guillemot/Razorbill	110	1	111
Gannet	26	55	81
Kittiwake	37	43	80
Herring Gull	0	44	44
Great Skua	3	17	20
Arctic Tern	1	11	12
Golden Plover	0	7	7
Lesser Black-backed Gull	0	7	7
Arctic Skua	0	5	5
Storm Petrel	0	4	4
Manx Shearwater	0	4	4
Sooty Shearwater	1	2	3
Common Gull		1	1
Total	**1,263**	**741**	**2,004**

Table A22. Survey 22 – September 2011

Species	No. on sea surface	No. in flight	Total numbers
Fulmar	243	286	529
Gannet	42	147	189
Guillemot/Razorbill	161	12	173
Razorbill	143	2	145
Puffin	90	14	104
Guillemot	81	4	85
Sooty Shearwater	52	15	67
Great Skua	2	18	20
Kittiwake		18	18
Great Black-backed Gull	1	7	8
Storm Petrel	2	4	6
Manx Shearwater		6	6
Arctic Skua		3	3
Common Tern / Arctic Tern	1	1	2
Common Gull		1	1
Black throated Diver / Red throated Diver	1		1
Total	**819**	**538**	**1,357**

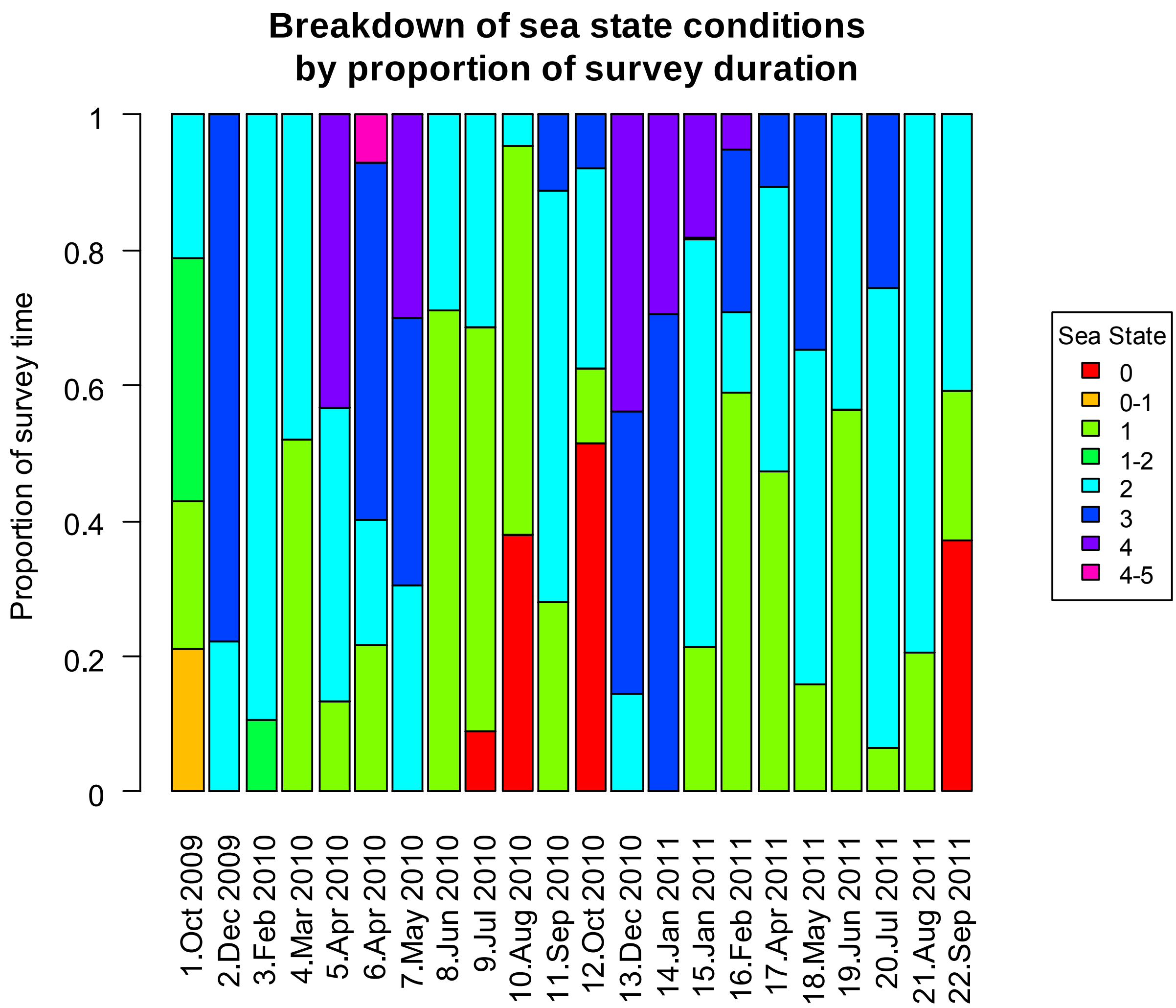

Figure A1.1 Sea state recorded during the boat surveys of the Beatrice Offshore Wind Farm, October 2009 to September 2011.

APPENDIX 2 – SUMMARY OF KEY CONSULTATIONS WITH STAKEHOLDERS, REGULATORY AUTHORITY AND STATUTORY NATURE CONSERVATION AGENCIES

Table A2. Key consultations conducted during production of ornithology impact assessment for the Beatrice Offshore Wind Farm

Purpose of consultation	**Sent to**	**Means of communication**	**Date**	**Requested actions resulting from consultation**	**Actions taken by Beatrice Offshore Wind Limited or Consultants on their behalf**
Approval of boat survey methodology	SNH	Report submitted electronically	October 2009	Minor revisions to methods	Revisions accepted and implemented. Revised report submitted to SNH.
Presentation of analysis of data from the Beatrice Demonstrator Project – seeking to obtain approval for use as supporting evidence in Impact Assessment.	SNH	Report submitted electronically	November 2009	None	
Presentation of initial survey results and Demonstrator data analysis	SNH	Meeting between representatives of SNH, Beatrice Offshore Wind Ltd. and RPS	June 2010	Further analysis of Demonstrator data	Additional analysis undertaken and a revised report submitted to SNH.
Presentation of results from autumn 2010 migration surveys	SNH	Report submitted electronically	February 2011	None	
Approval of proposed CIA methods	SNH / JNCC	Electronic and meetings	Spring 2011 (earlier?)	Revisions to methods	Refinement of CIA methodology

Purpose of consultation	Sent to	Means of communication	Date	Requested actions resulting from consultation	Actions taken by Beatrice Offshore Wind Limited or Consultants on their behalf
Presentation of initial survey results	RSPB	Report submitted electronically and followed up with a meeting between representatives of RSPB, Beatrice Offshore Wind Ltd. and RPS	April 2011	No further actions requested.	NA
Presentation of initial survey results and proposed methods	MS, SNH, JNCC	Report submitted electronically and followed up with a meeting between representatives of MS, SNH, JNCC, Beatrice Offshore Wind Ltd., Moray Offshore Wind Ltd, Natural Power Consultants and RPS	June 2011	Further refinements requested	Report produced providing further details of proposed methods.
Presentation of results from spring 2011 migration surveys	SNH	Report submitted electronically	July 2011	None	
Approval for analysis methods for impact assessment and SPA population sizes	SNH / JNCC	Report submitted electronically	July 2011	Revisions to methods	Some revisions accepted. Response by email.

APPENDIX 3 – DERIVATION OF AVOIDANCE RATES FOR COLLISION RISK MODELLING

Justification for avoidance rates higher than 98% for use in CRM for the Beatrice Offshore Wind Farm

The current SNH guidance is to use an avoidance rate of 98% as a default for estimating collision mortality (SNH 2010). This is largely based on onshore wind farm studies.

The following is extracted from the SOSS-02 report (Cook *et al*. 2011). For clarity Table 3.2 in the original report has been split into two, grouping avoidance rates into near-field ('micro') and far-field ('macro'). Ideally these could be combined to give an overall avoidance rate for those species for which estimates of both type of avoidance are available. Unfortunately, the distinction between the two forms of avoidance (i.e. at what distance from the turbine macro avoidance becomes micro avoidance) has not always been defined, thus the two rates cannot be simply combined. However, the studies do provide valuable guidance on the range of rates which are appropriate for certain species.

In Table A3.1, micro avoidance rates are presented. It is of considerable note that none of the species in this table has a micro-avoidance rate of less than 99.1% (for migrant seaduck at night). The gull estimates range from 99.7 % to 99.9 %. Thus, when taking macro avoidance into account, overall avoidance must be higher than these rates.

Table A3.1. Extracted from Cook *et al*. (2011). Micro-avoidance rates for Offshore Wind Farms.

Species	Site	Avoidance rate	Type	Method	Source
Black-headed Gull	Brugge	0.997	Micro	Corpse Search	Everaert & Kuijken 2007
Black-headed Gull	Brugge	0.997	Micro	Corpse Search	Everaert & Kuijken 2007
Common Tern	Zeebrugge	0.999	Micro	Corpse Search	Everaert & Stienen 2007
Common Tern	Zeebrugge	0.999	Micro	Corpse Search	Everaert & Stienen 2007
Gulls	"De Put" Nieuwkapelle	0.997	Micro	Corpse Search	Everaert & Kuijken 2007
Gulls	Zeebrugge	0.996	Micro	Corpse Search	Everaert & Kuijken 2007

Species	Site	Avoidance rate	Type	Method	Source
Gulls	Brugge	0.999	Micro	Corpse Search	Everaert & Kuijken 2007
Herring Gull	Brugge	0.999	Micro	Corpse Search	Everaert & Kuijken 2007
Herring Gull	Brugge	0.999	Micro	Corpse Search	Everaert & Kuijken 2007
Migrant Sea Duck – Day	Nysted	0.996	Micro	Radar Observations	Desholm & Kahlert 2005
Migrant Sea Duck - Night	Nysted	0.991	Micro	Radar Observations	Desholm & Kahlert 2005
Mixture of resident and migrant species, including Gulls	3 Dutch onshore windfarms	0.999	Micro	Corpse Search	Krijgsveld *et al.* 2009
Sandwich Tern	Zeebrugge	0.999	Micro	Corpse Search	Everaert & Stienen 2007
Sandwich Tern	Zeebrugge	0.995	Micro	Corpse Search	Everaert & Stienen 2007

Table A32.2 presents macro avoidance rates. These are slightly more difficulty to interpret, however certain key aspects remain. Macro avoidan ce of offshore wind farms is typically lowe r than micro a voidance, with some species showing no avoidance at all (e.g. auks and grebe s). Highest rates of macro a voidance have been recorded for gann et (96% and gulls (73 % – 7 6.4 %), while seaducks, wildfowl and ot her species all have lower rates of macro avoidance.

Table A3.2. Extracted from Cook *et al*. (2011). Macro-avoidance rates for Offshore Wind Farms.

Species	Site	Avoidance rate	Type	Method	Source
Alcids	Egmond aan Zee	0	Macro	Visual Observations	Everaert & Stienen 2007
Common Eider	Tuno Knob	0.53	Macro	Visual	Larsen & Guillemette

Species	Site	Avoidance rate	Type	Method	Source
				Observations	2007
Common Scoter	Horns Rev	0.9	Macro	Radar Observations	Christiansen *et al.* 2004
Common Scoter	Horns Rev	0.886	Macro	Radar Observations	Christensen *et al.* 2006
Cormorants	Egmond aan Zee	0.43	Macro	Visual Observations	Krijgsveld *et al.* 2010
Divers	Egmond aan Zee	0.52	Macro	Visual Observations	Krijgsveld *et al.* 2010
Gannets	Egmond aan Zee	0.96	Macro	Visual Observations	Krijgsveld *et al.* 2010
Geese & Swans	Egmond aan Zee	0.82	Macro	Visual Observations	Krijgsveld *et al.* 2010
Grebes	Egmond aan Zee	0	Macro	Visual Observations	Krijgsveld *et al.* 2010
Gulls	Egmond aan Zee	0.73	Macro	Visual Observations	Krijgsveld *et al.* 2010
Gulls	Horns Rev	0.764	Macro	Radar Observations	Christensen *et al.* 2006
Landbirds	Egmond aan Zee	0.53	Macro	Visual Observations	Krijgsveld *et al.* 2010
Migrant Sea Duck	Nysted	0.9	Macro	Radar Observations	Christensen *et al.* 2006
Other Ducks	Egmond aan Zee	0.45	Macro	Visual Observations	Krijgsveld *et al.* 2010
Raptors & Owls	Egmond aan Zee	0.22	Macro	Visual Observations	Krijgsveld *et al.* 2010
Sea Ducks	Egmond aan Zee	0.67	Macro	Visual Observations	Krijgsveld *et al.* 2010
Skuas	Egmond aan Zee	0	Macro	Visual Observations	Krijgsveld *et al.* 2010

Species	Site	Avoidance rate	Type	Method	Source
Terns	Egmond aan Zee	0.51	Macro	Visual Observations	Krijgsveld *et al.* 2010
Terns	Horns Rev	0.695	Macro	Radar Observations	Christensen *et al.* 2006
Waders	Egmond aan Zee	0.51	Macro	Visual Observations	Krijgsveld *et al.* 2010

The key aspect of this is that for those seabird species for which both micro and macro avoidance have been recorded, even allowing for uncertainty in the distinction between the two, the overall avoidance rates will be higher than that for either in isolation. Thus for gulls, the micro avoidance estimates of 99.7 % – 99.9 %, when combined with a macro rate of up 73 % will give rise to a higher rate. For example, a macro rate of 73 % and a micro rate of 99.7 % give an overall rate of 99.92 %. However, even if macro avoidance is reduced to 50%, the overall rate only declines to 99.85%. Perhaps most importantly, even if it is assumed that no birds avoid the wind farm (i.e. macro avoidance = 0), the overall avoidance rate cannot be less than the micro rate.

Determining appropriate precautionary avoidance rates

For gulls an overall avoidance rate of 99.5 % can be seen to be precautionary as this is in fact lower than the lowest reported micro rate.

For gannet, only macro avoidance has been reported (96 %). However, a micro avoidance rate of only 88% is sufficient to generate an overall rate >99.5 %. Such a micro-avoidance rate is considerably lower than for any other bird species (all >99 %), and this is therefore considered likely to be extremely precautionary.

For tern species, the lowest micro avoidance rate reported is 99.5 %, which is considered to provide a precautionary rate.

For skua, no macro avoidance has been observed, and no micro avoidance rate has been reported. Given the aerial abilities of these species, there seems little justification for assuming they would be at greater risk of collision than species such as gulls (indeed since they chase gulls on the wing they can be assumed to be at least as manoeuvrable), thus the 99.5% rate was used.

No avoidance estimates are available for fulmar. Maclean *et al*. (2009) suggest that 99.9% is suitable for this species, however a lower rate of 99.5% was considered appropriate until further data have been collected.

Overall an avoidance rate of 99 % has been used in the collision risk assessment presented for the Beatrice Offshore Wind Farm. Given the information presented above this is considered to be highly precautionary.

APPENDIX 4 – USAGE OF MORAY FIRTH BY BREEDING SEABIRDS: RESULTS OF TRACKING STUDY 2011

The following figures were taken from the Seabird Tracking Technical Report provided by the Marine biology and Ecology Research Centre, University of Plymouth (Bicknell *et al*. 2011).

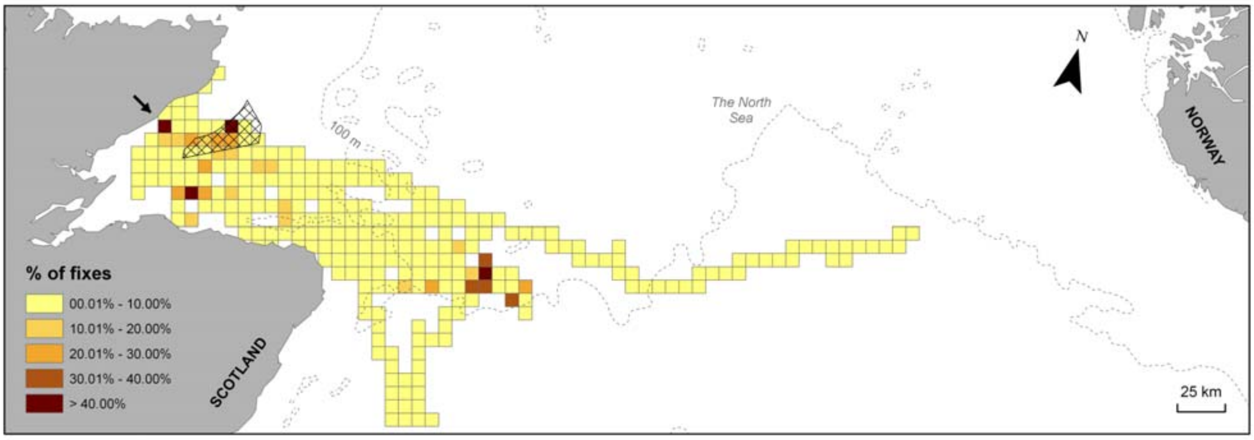

Figure A4.1 Distribution and space use of all fulmars inferred from 2-minute resolution GPS positions. Positions from all birds are binned into 3 km x 3 km grid cells and summed with darker areas representing high-density areas (n=17 individuals, n=34 trips).

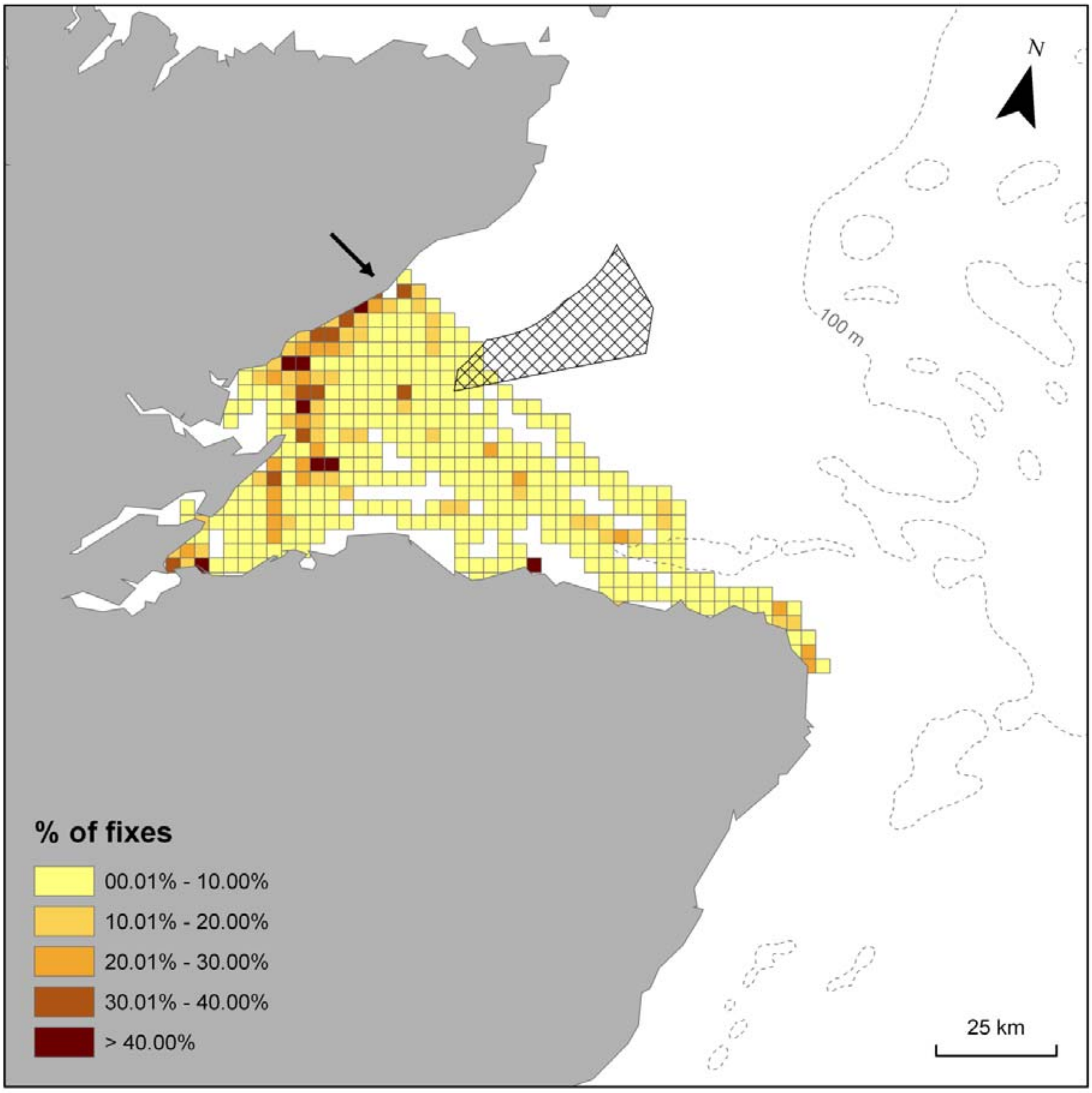

Figure A4.2 Distribution and space use of all Kittiwakes inferred from 2-minute resolution GPS positions. Positions from all birds are binned into 3 km x 3 km grid cells and summed with darker areas representing high density areas (n=19 individuals, n=34 trips).

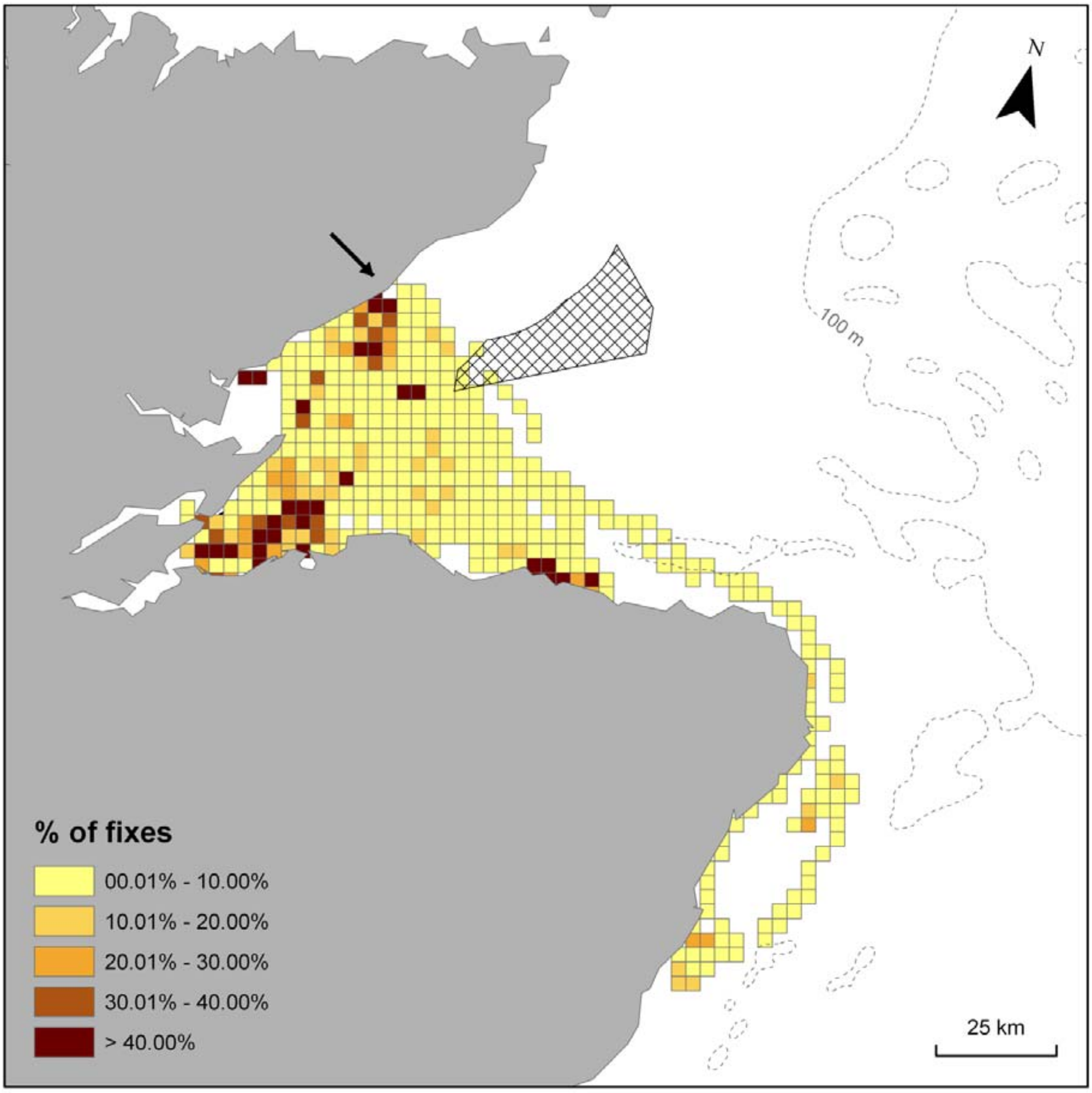

Figure A4.3 Distribution and space use of all Guillemots (n=20 individuals, n=62 foraging trips) inferred from 2-minute resolution GPS positions. Positions from all birds are binned into 3 km x 3 km grid cells and summed with darker areas consistent with foraging activity.

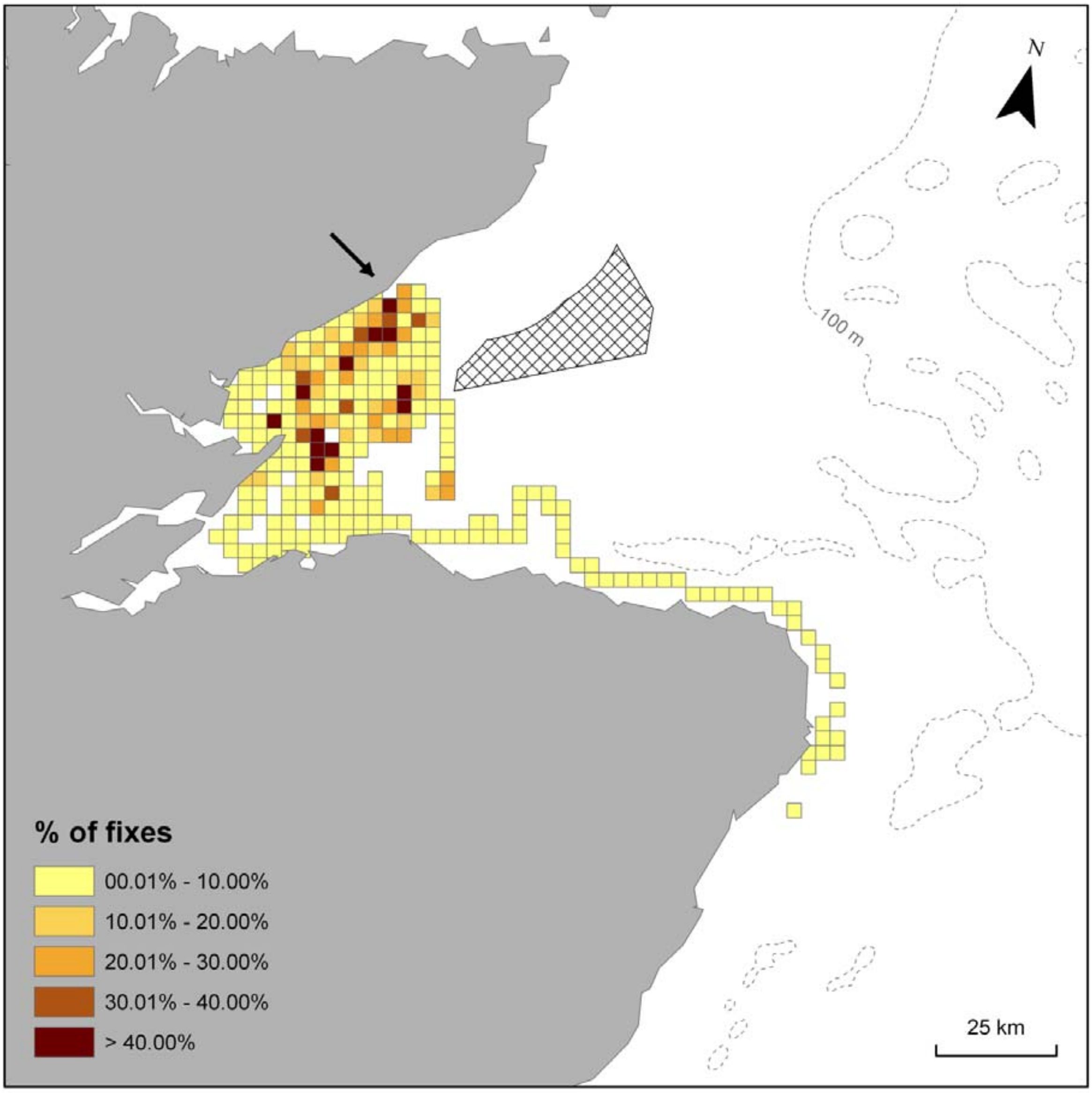

Figure A4.4 Distribution and space use of all Razorbill inferred from 2-minute re solution GPS positions. Positions from all birds are binned into 3 km x 3 km grid cells and summed with darker areas representing areas of more intense use consistent with foraging behaviour (n=18 individuals, n=58 trips).