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Rowena H W Langston & Sergio Boggio

The Royal Society for the Protection of Birds, Sandy, Bedfordshire SG19 2DL

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Foraging ranges of northern gannets *Morus bassanus* in relation to proposed offshore wind farms in the North Sea

ROWENA H. W. LANGSTON[1*] & SERGIO BOGGIO[1]

[1]The Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire SG19 2DL

ABSTRACT

In July 2010, fourteen adult northern gannets (*Morus bassanus*) from Bempton Cliffs, on the northeast coast of England, were fitted with satellite tags to investigate their foraging ranges during chick-rearing. This was the first time that such a study had been undertaken on gannets from the Bempton Cliffs nesting colony, which is a technically challenging site to work at. In particular, we were interested in finding out the likelihood of overlap with potential development zones for offshore wind energy generation in the North Sea. All fourteen tags provided data for between 13 and 84 days (mean = 49 days), indicating that most foraging trips from Bempton occurred within 50 - 100 km of the colony. Locations of tagged birds coincided with the Hornsea offshore wind energy zone in particular, with some birds recorded on Dogger Bank, a single recorded trip to the East Anglia zone, and a few recorded locations within the Greater Wash strategic area for wind energy generation. This study represents just one chick-rearing period, so it is unclear how representative the data are of foraging activity by breeding gannets from year to year.

Keywords: gannet, wind energy, satellite telemetry,

BACKGROUND

The European Union Renewable Energy Directive target requires the UK to meet 15% of its energy supply from renewable sources by 2020 (Directive 2009/28/EC). This is equivalent to 35–45% of electricity and places heavy reliance on wind energy for its delivery, requiring a substantial increase over the current 4.5 GW installed capacity. Estimates vary as to the exact scale of expansion needed, but it is generally thought that onshore wind generation will need to increase to 13–15 GW by 2020, and offshore wind generation to 25–30 GW installed capacity during the same period. In response to these ambitious targets, there has been an order-of-magnitude increase in potential offshore wind energy projects, in particular the large proposed Round 3 development zones (Figure 1), initiated by The Crown Estate (http://www.thecrownestate.co.uk/newscontent/round3, accessed 27 January 2011).

Britain and Ireland are of outstanding international importance for their breeding seabirds and migratory waterbirds, for which they host a high proportion of the biogeographical populations of several species, especially breeding Manx shearwater *Puffinus puffinus*, northern gannet *Morus bassanus* (hereafter, gannet), great skua *Catharacta skua* and lesser black-backed gull *Larus fuscus* (Mitchell *et al.* 2004). Several proposed offshore wind energy development zones lie within the expected foraging range of breeding seabirds from the Bempton and Flamborough Special Protection Area (SPA), notably for gannets, for which studies from the Bass Rock indicate regular foraging ranges in excess of 100 km (eg Hamer *et al.*, 2007). The foraging areas used by gannets from Bempton Cliffs are unknown. Given that breeding gannets are central place foragers (Grémillet *et al.* 2006), their foraging ranges are likely to be most constrained when provisioning growing chicks.

There were estimated to be approximately 261,000 Apparently Occupied Nests (AON) of gannets in Britain and Ireland when the last complete census was carried out in 2003/04 (Wanless *et al.* 2005). The gannet is amber-listed on the Birds of Conservation Concern (BoCC, Eaton *et al.* 2009). There has been a consistent rise in world population of northern gannets throughout the period since regular censuses began in 1900, of 2% per annum. Bempton & Flamborough SPA (hereafter, Bempton/ Bempton Cliffs) is the only breeding colony in England for gannets, with 7,859 nests in 2009 (http://www.jncc.gov.uk/page-2875, accessed 27 January 2011). The steady rate of increase at Bempton Cliffs, since its colonisation in the 1960s, has become more rapid since 2000. The potential for further growth of this colony is considerable in view of the large number of non-breeding immatures associated with the colony; 1,479 in 2009.

An essential part of environmental impact assessment (EIA) for offshore wind farms is to determine the bird populations that may be affected, and in particular to assess the risk of adverse impact on relevant SPAs (EU Birds Directive 79/409/EEC, as amended in Directive 2009/147/EC). Gannets may be vulnerable to collision with offshore wind turbines (Langston 2010). The risk is unclear, depending on levels of flight activity within the wind farm footprints and within the rotor swept area. It is known that gannets fly at and plunge-dive from elevations within rotor swept height. Flight activity, within a given area, may increase either as a result of feeding aggregations e.g. in response to fish shoals or discards from fishing vessels, or individuals commuting to the same foraging locations. It is anticipated that any risk is likely to be increased during chick-rearing, a higher-pressure time when adult birds are constrained by the need to return to the nest.

Aerial or boat-based surveys provide information about the overall distribution and abundance, including feeding aggregations, but do not enable colony origins of birds seen at sea to be determined, nor provide information on the frequency of foraging trips by individuals.

Satellite tracking is a reliable method for tracking gannets from their breeding colonies (Hamer *et al*., 2000, 2001, 2007). Satellite tags can be deployed without the need for recapture of the bird, which reduces disturbance to the colony and reduces the risk of data loss. The chalk cliffs at Bempton present particularly challenging conditions, requiring skilled climbers to minimise risks both to climbers and breeding birds. A single visit to the Staple Newk section of the colony was the preferred approach, hence the choice of satellite telemetry rather than the use of GPS data loggers which would have required recapture or close approach to remotely download data.

The study had the following objectives: to determine foraging ranges, flight directions, and foraging destinations of gannets from the breeding colony at Bempton; to determine whether gannets from Bempton forage within areas of the North Sea proposed for wind energy development, notably the Round 3 zones of Dogger Bank, Hornsea and East Anglia; and to seek to obtain a measure of relative importance of the foraging areas identified, bearing in mind that the data presented here are currently confined to one chick-rearing season.

METHODS

SATELLITE TELEMETRY

Microwave Telemetry Inc battery powered Platform Terminal Transmitters (PTTs), weighing 45g, with a duty cycle of continuous transmission, were fitted to fourteen breeding adult gannets at Bempton Cliffs RSPB reserve, on 14th July 2010 (Figure 1). The tags were attached by means of Tesa© tape and cable ties to the underside of the central three or four tail feathers, close to the base of the tail, with the antenna pointing upwards through the tail, following Hamer *et al.* (2007). This arrangement was found to minimise drag when the birds were in flight and prevented displacement of tags when birds plunge-dive (Hamer *et al.* 2007).

Birds were caught at the nest, using a pole with a brass noose, by climbers roped securely to the cliff top. Each bird was transferred to the cliff top for fitting of the PTT, individually numbered metal ring (BTO ringing scheme), and biometrics, before release from the cliff top, within 15 minutes of capture and delivery to the cliff top.

Adult gannets were tracked during the chick-rearing period. Regular observations were made at several monitoring plots at Bempton Cliffs, including Staple Newk at which several of the tagged birds could be seen from the cliff top, when they were at the nest. This provided observations of a sample of tagged birds, and timing of fledging of their chicks, compared with untagged birds. The peak fledging period was between 20 August and 7 September, and fledging from the three nests occupied by tagged birds that could be viewed from the cliff top occurred during this time. Unfortunately, most tagged birds were from nests that could not be seen from the cliff-top observation position.

DATA PROCESSING AND ANALYSIS

Satellite data were processed by ARGOS (CLS, France). Regular downloads were made from the ARGOS online system and the resulting data compiled into a seamless dataset. One tag failed after just 13 days; three tags continued to function for more than 80 days (range 13 to 84 days; mean = 49 days). Data were truncated at 15 September 2010, as the majority of satellite tags had ceased functioning or been lost by this date. Thus, data were analysed for a two-month (63 day) window during the chick-rearing period.

To account for positional error, only locations with ARGOS quality codes 3, 2, 1, 0, A were used. Further points were removed, as unrealistic, in instances where the calculated bird flight speed between adjacent registrations exceeded 90 kmh (Hamer *et al.* 2007); usually the first point in the sequence was retained, unless this was unlikely in relation to the previous location. All locations recorded within 5 km of the central location of Staple Newk were considered to be at the colony. The resulting data were plotted in MapInfo (MapInfo Professional 9.0 Release Build 36 ©Pitney Bowes) or ArcGIS (ArcGIS Desktop 9.3.1 ©ESRI), on a backdrop showing the indicative offshore wind energy project boundaries and graduated bathymetry.

RESULTS

The 2,506 recorded locations at sea comprised 508 foraging tracks from 13 adult gannets (Figures 1 & 2). One tagged bird was excluded from analysis as it was only rarely recorded at the colony and was assumed to have lost its chick (unfortunately one chick was lost during capture of adults to fit tags), although its foraging tracks were comparable with other tagged birds. Most locations at sea fell within 100 km of Bempton Cliffs, with the highest density of locations within 50 km. On average, foraging trips lasted 13.4 ± 10.7 hours (Mean ± SD, n = 508, Figure 3). The average foraging range (straight-line distance from Bempton) was 63.6 ± 8.9 km (random n = 100, 95% CI,), whilst the average length of foraging trip (total distance covered during a foraging trip) was 158.6 ± 22.7 km (random n = 100, 95%CI). The maximum foraging range recorded for Bempton, was 308 km (range 8 – 308 km), whilst the maximum trip length was 710 km (range 17 – 710 km).

In relation to the proposed offshore wind energy development zones, flights occurred through and to the Hornsea Round 3 proposal zone in particular (Figures 1, 2, 4). There were also flight end points, and likely flights through, the western part of Dogger Bank, a single record within the East Anglia Round 3 zone, and a few within and close to Round 1 and Round 2 sites (see discussion) in the Greater Wash strategic area.

The recorded locations and putative tracks are available as GIS layers from the Conservation Data Management Unit (CDMU) at the RSPB and the BGS DECC SEA data portal.

DISCUSSION

The main concerns relating to birds in association with wind farms are as follows (Drewitt & Langston 2006): (1) disturbance displacement, leading to effective habitat loss (2) collision mortality, (3) habitat loss/change influencing prey availability, and (4) barriers to movement potentially increasing flight energy demands. In particular, the cumulative or in combination effects are of greatest concern, whereby the multiplicative effect across wind farms, unchecked, may lead to significant risk of population reduction.

This study reflects gannet foraging tracks prior to placement of wind turbines in the Round 3 zones. Of the Round 2 sites, Sheringham Shoal is under construction, the rest are mostly either in planning or consented and none of the Round 2 sites within the area encompassing locations of gannets from Bempton are operational yet. Of the Round 1 sites, Lynn & Inner Dowsing is operational, whilst Lincs and Teesside are consented. So, it is too early to determine flight responses by gannets from Bempton to constructed wind farms, based on the small number of locations in the vicinity of operational wind farms. Gannets are considered to be at risk of collision with wind turbines, owing to their flight elevation and plunge dive height, from 10-40 m, which coincide with the rotor swept area. Cumulatively, this hazard could become significant, given the substantial scale of proposed wind energy development across the North Sea, not just in UK waters. However, recent studies of gannets, during spring and autumn, at offshore wind farms in the Netherlands, indicate strong avoidance of wind turbines (Krijgsveld *et al.* 2010), which may indicate that displacement may be more likely, although it is not known whether this response will apply to breeding gannets, especially during chick-rearing. Displacement *per se* may, or may not, be detrimental, even if applicable to breeding gannets, unless it persists and alternative, good quality foraging areas are not available. Nonetheless, cumulative effects arising from multiple wind farms may lead to adverse effects if access to high quality habitat is restricted or prevented. Collision and displacement may have differential effects, depending on the season, age, sex, breeding status, and behaviour of individual gannets. There is considerable uncertainty at present about likely effects of the proposed scale of offshore wind farm development on gannets.

Understanding the spatial and temporal coincidence of gannets with proposal areas for wind turbines is the first step in understanding any potential impact of offshore wind energy generation on gannets. The limitations of this study result primarily from the small number of birds tracked during the chick-rearing period in a single breeding season, together with the lower resolution data associated with locations from PTTs, compared with GPS data loggers. Nonetheless, these results provide the first record of foraging ranges and destinations for breeding gannets from Bempton Cliffs. The majority of foraging trips were within 100 km of Bempton Cliffs, representing a smaller foraging range than recorded for breeding gannets from the Bass Rock (mean range 155.2 ± 65.3 km, range 68-276 km, Hamer *et al.* 2009). The maximum foraging range recorded for Bempton, 308 km, was considerably lower than the 540km for Bass Rock (Hamer *et al.* 2000). Whilst it is not clear whether this pattern of foraging is typical for Bempton, the observations fit with the theories of intraspecific competition and colony size, whereby birds from larger colonies have to forage further afield because of intraspecific competition and prey depletion (Lewis *et al.* 2001). There were an estimated 3,940 AONs (apparently occupied nests) of gannets at Bempton Cliffs, compared with 48,065 AONs at Bass Rock in 2003/04 (Wanless *et al.* 2005).

The mean duration of foraging trips for gannets from Bempton was 13.4 ± 10.7 hours (Mean ± SD, n = 508 trips, 13 birds), compared with 27.3 ± 10.2 hours (n = 43 birds, Hamer *et al.* 2007) for Bass Rock, recorded from PTTs, although interannual variation in trip duration has been observed in gannets from Bass Rock. Foraging trips by birds from Bempton lasted up to 71 hours, although this was an exceptional value; most were considerably less than 50 hours, in contrast with a maximum of 84 hours recorded at Bass Rock (Hamer *et al.* 2000).

Overlap of foraging areas used by birds from Bempton Cliffs and Bass Rock was apparent in the sea area north of Bempton (Figure 1, Hamer *et al.* 2007). GPS loggers from Bass Rock indicate that, during foraging trips, gannets tend to intersperse rapid direct flights with slower sinuous tracks over foraging areas (Hamer *et al.* 2009). Although less distinct, there were indications from the Bempton PTTs of sections of foraging tracks involving more changes in direction over short distances, indicating foraging areas or drift during nocturnal loafing at sea.

Peak fledging at Staple Newk occurred between 20 August and 7 September, with most of the rest fledging by the end of September. The earliest fledging date was 20 July, considerably earlier than most gannets at Bempton, and the last chick fledged in late October from a replacement clutch (L. McKenzie pers. comm.). The 2010 breeding season at Bempton was a good one, in marked contrast to the high failure rates at some of the seabird colonies in northern Scotland. There was no indication of a difference in breeding performance by gannets with or without a PTT. Birds flew strongly when released with their PTT fitted, the weight ratio of which, at approximately 1.5% of body mass, was well within the recommended range (less than 3% of body mass, Phillips *et al*. 2003). Birds observed at the colony ignored the tag and antenna, even when preening.

Cliff-top observations indicated that PTTs were lost; three of the birds identified at the nest with tags in place were observed later in the season without tags. Mounting the PTTs on tail feathers, they were expected to shed tags at least when moulting if not sooner due to a reaction between the tape adhesive with seawater over time.

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

Fourteen breeding adult gannets, tracked via satellite Platform Transmitter Terminals, from Bempton Cliffs, yielded information about their foraging ranges during chick-rearing, and the extent of overlap of their foraging trips with potential development zones for offshore wind energy generation in the North Sea. Most foraging trips were within 100 km of Bempton Cliffs, and considerable overlap was noted in particular with the Hornsea Round 3 development zone for offshore wind energy generation.

Further data collection at Bempton is highly recommended, to provide comparative data for at least a second season to investigate inter-annual variation in gannet foraging range and destinations during chick-rearing. There is a clear advantage in repeating the approach used in 2010 to provide comparable data for 2011. However, there may be merit in substituting some of the battery-powered PTTs with other tags with the potential to extend the period of study beyond fledging of chicks and so cover some of the time when adult gannets have greater flexibility in their choice of foraging locations. Some further assessment of tag types will be undertaken before finalising the recommended approach, with a view to extending the study period.

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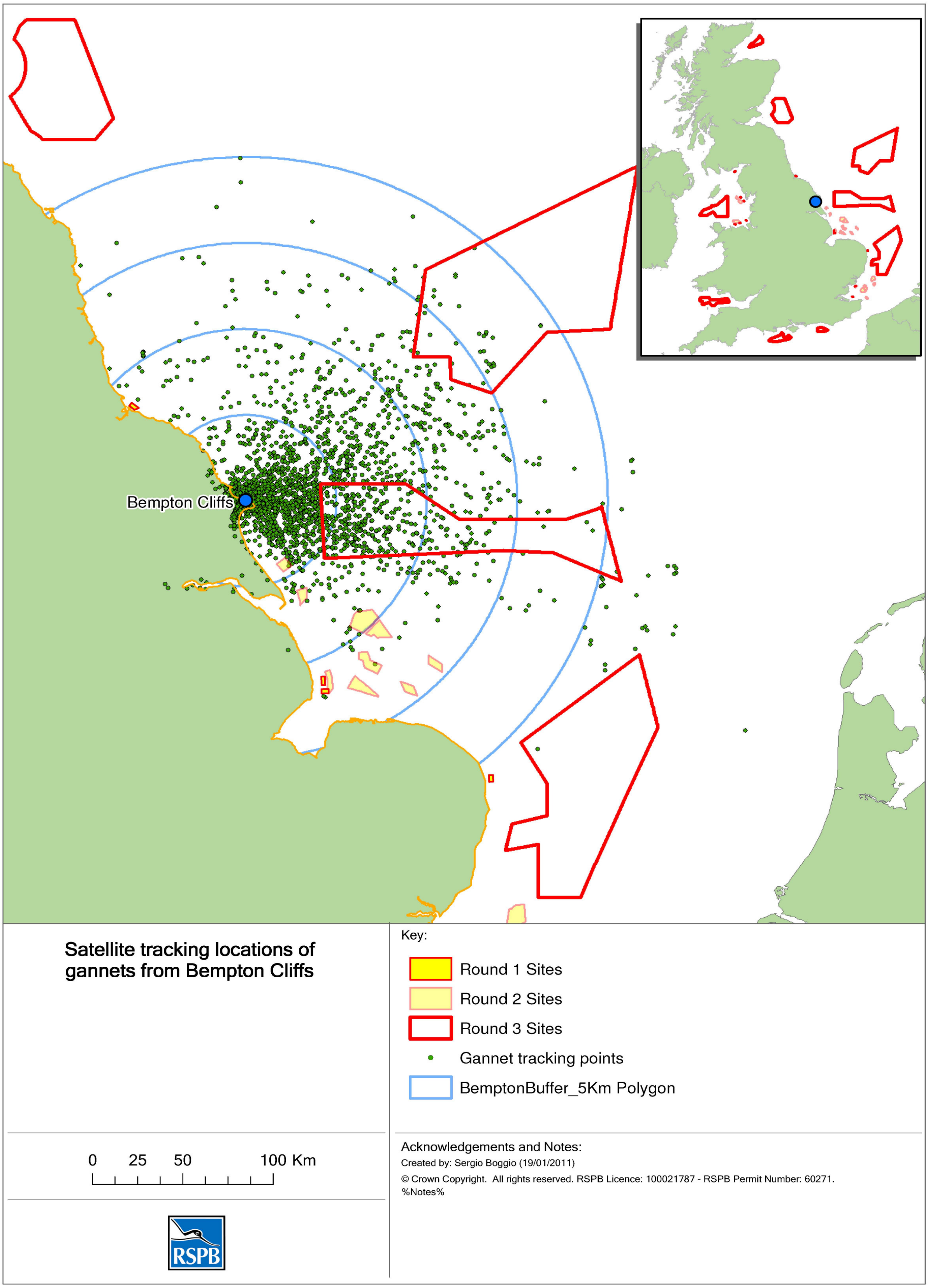
FIGURE LEGENDS

Figure 1 Combined tracking locations for adult gannets from Bempton Cliffs, based on 2,506 at sea locations from 13 chick-rearing adults. The blue circle is the 5km buffer around the central location of Bempton Cliffs, with added 50km, 100km, 150km and 200km buffers to aid interpretation of foraging distances. Inset shows the location of Bempton Cliffs.

Figure 2 Gannet foraging tracks from Bempton Cliffs breeding colony. Straight lines are putative, not actual, tracks, shown for illustration.

Figure 3 Foraging trip duration for gannets from Bempton during chick-rearing (n = 508 foraging trips from 13 birds)

Figure 4 Tracks for individual gannets from Bempton Cliffs. NB straight lines connecting locations are for illustration and do not represent known flight paths between points. The red circle is the 5km buffer around the central location of Bempton Cliffs. Offshore wind development areas are indicated as follows: light blue = Round 1, purple = Round 2, green = Round 3.



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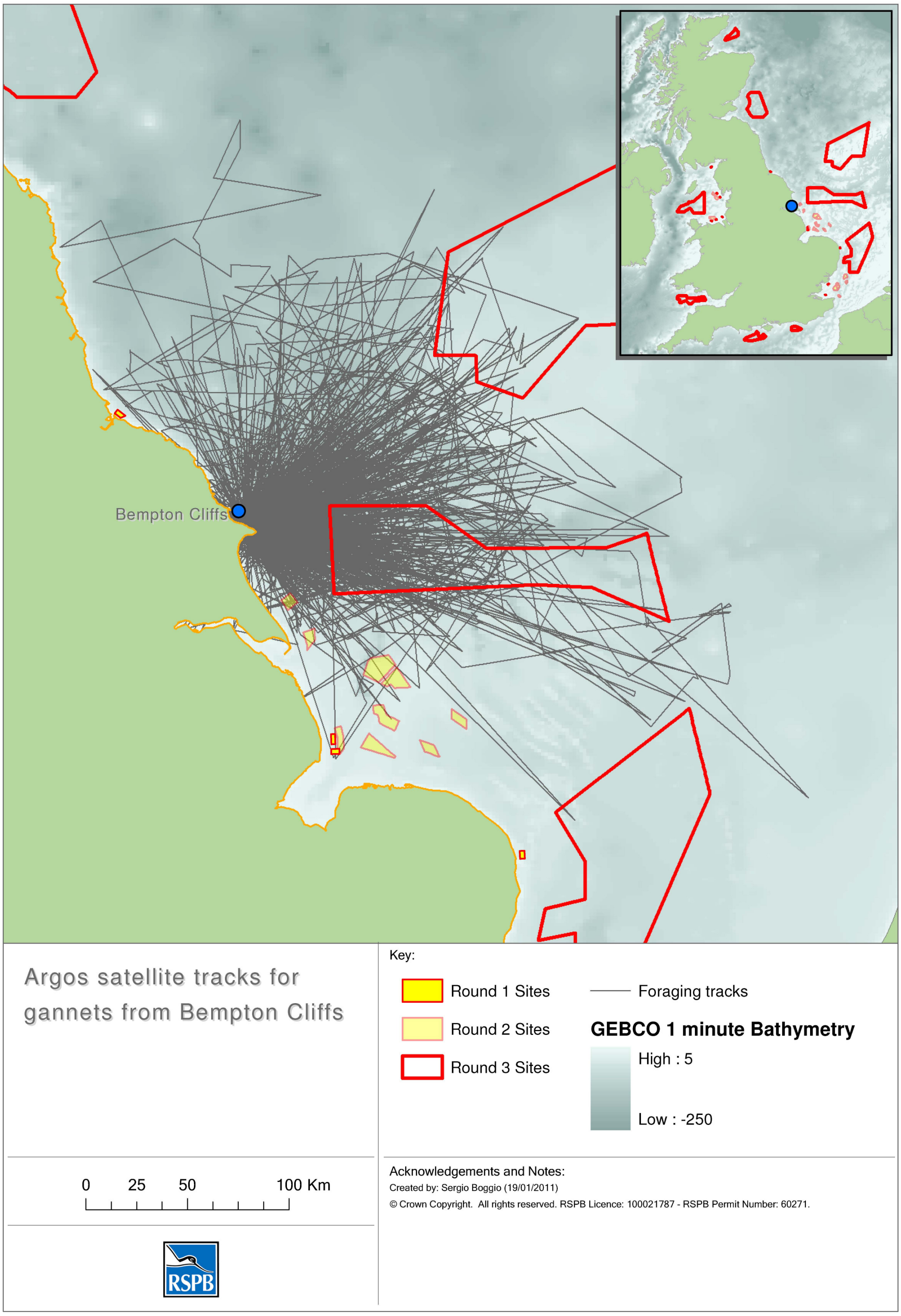

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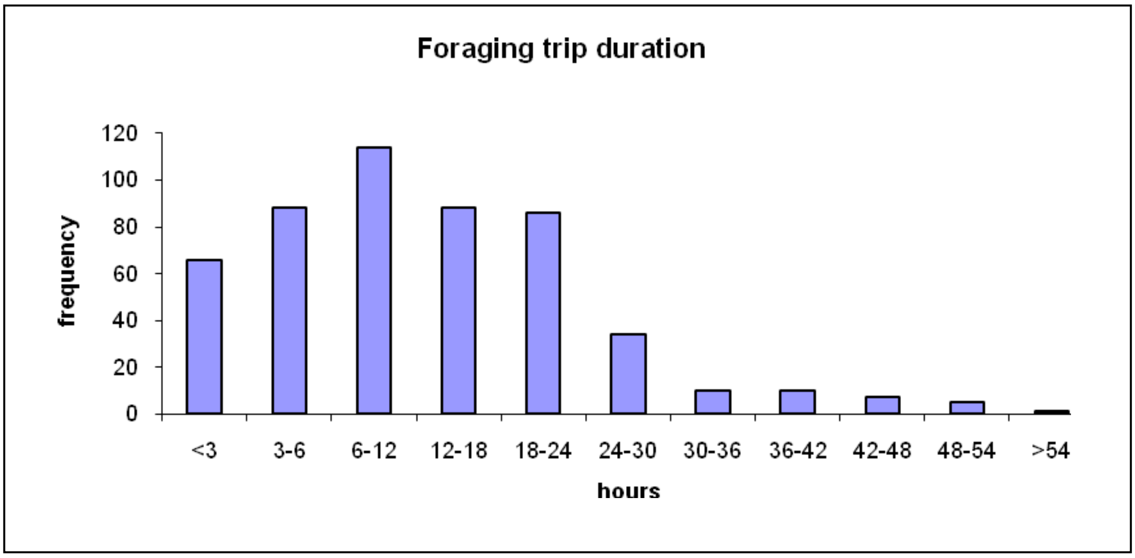

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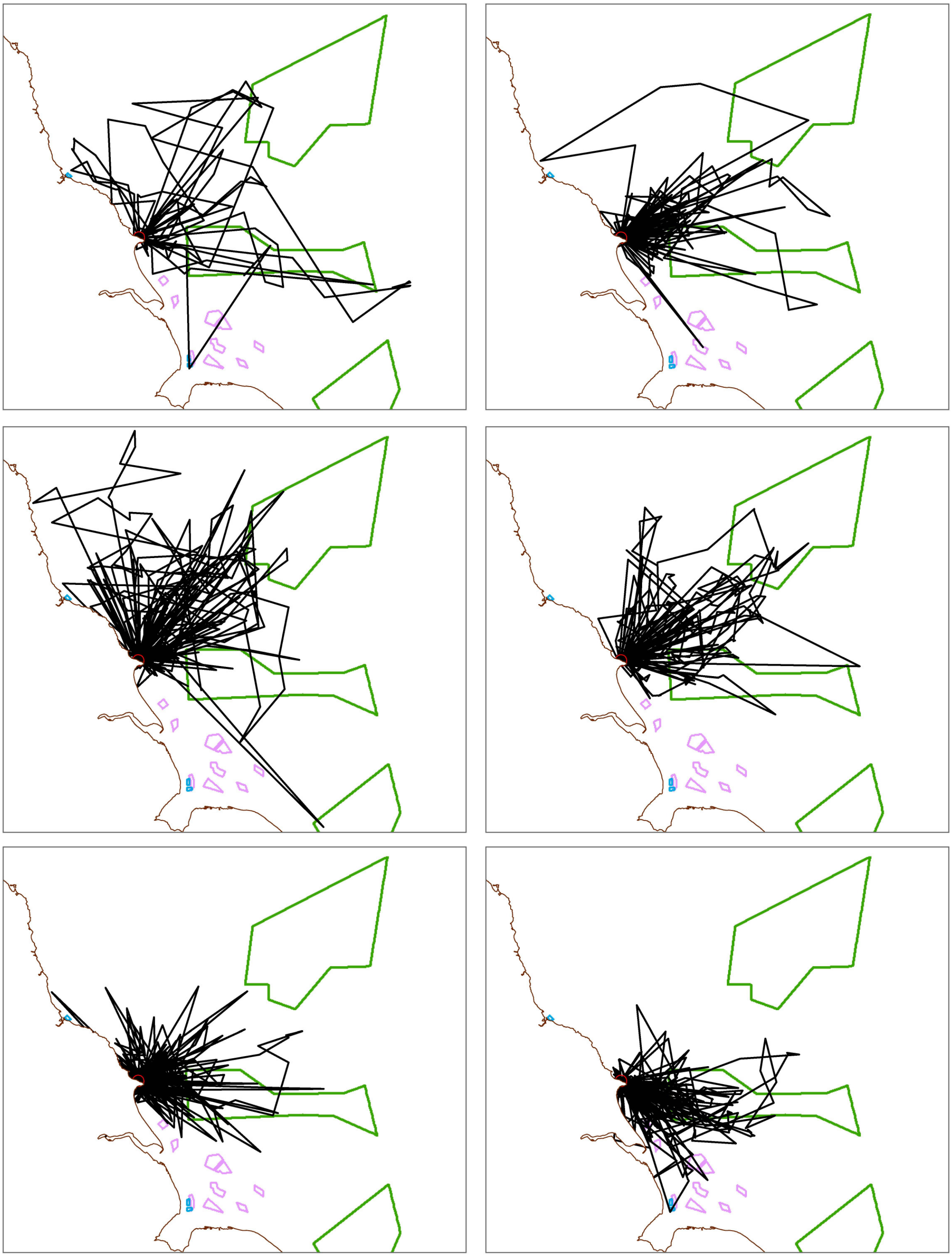

Figure 4 Tracks for individual gannets from Bempton Cliffs. NB straight lines connecting locations are for illustration and do not represent known flight paths between points. The red circle is the 5km buffer around the central location of Bempton Cliffs. Offshore wind development areas are indicated as follows:
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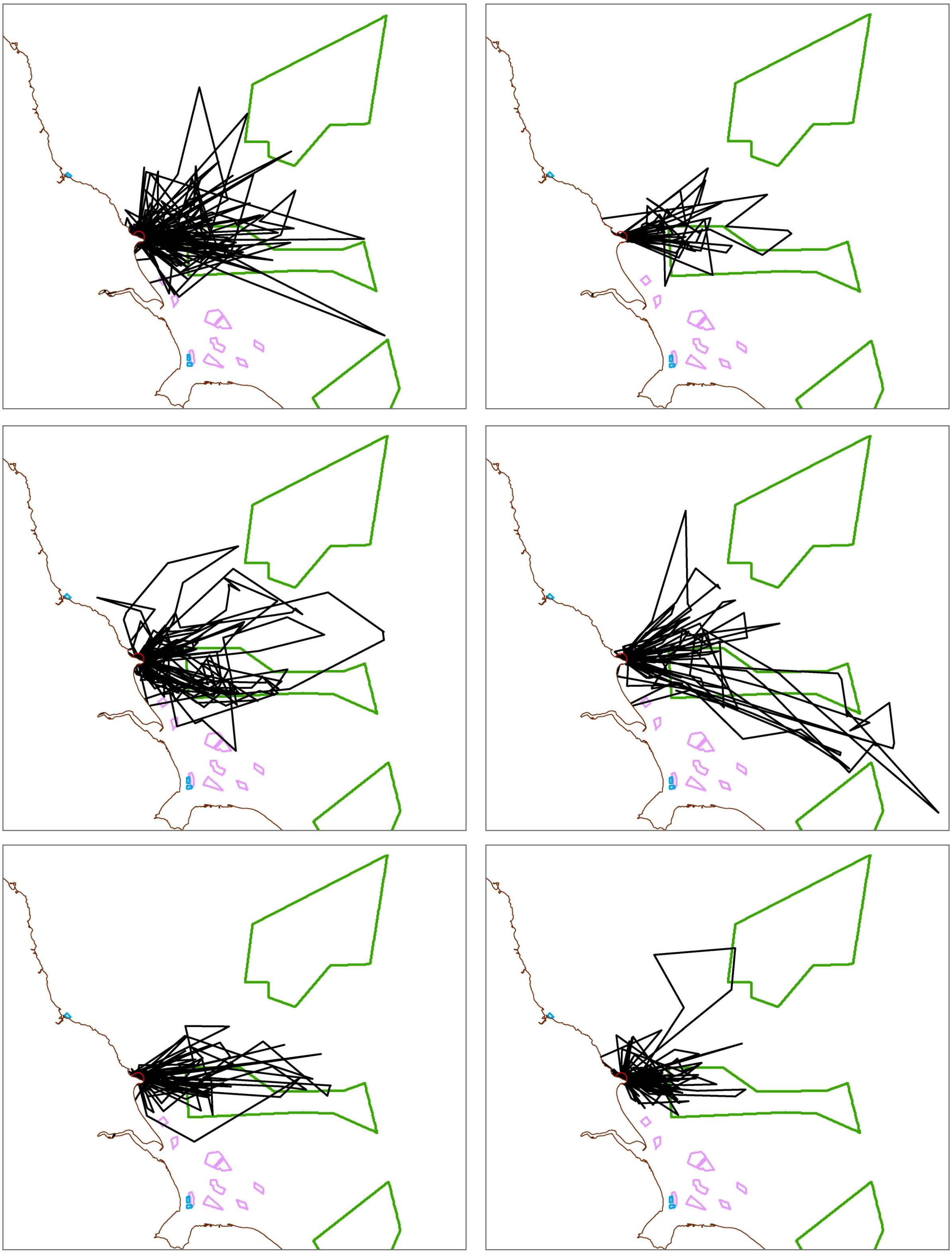

Figure 4 continued Tracks for individual gannets from Bempton Cliffs. NB straight lines connecting locations are for illustration and do not represent known flight paths between points. The red circle is the 5km buffer around the central location of Bempton Cliffs. Offshore wind development areas are indicated as follows: light blue = Round 1, purple = Round 2, green = Round 3.