**BTO Research Report No. 694**

# Assessing the habitat use of Lesser Black-backed Gulls (*Larus fuscus*) from the Bowland Fells SPA

Authors

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## EXECUTIVE SUMMARY

1. Findings from a GPS tracking study of Lesser Black-backed Gulls breeding in the Bowland Fells Special Protection Area (SPA) are presented in this report. The aims were to i) describe the home range of Lesser Black-backed Gulls during the breeding season and the spatial overlap with the SPA; ii) quantify the maximum foraging distances; and iii) assess the time spent by individual birds inside the SPA.

2. Twelve GPS-GSM tags (Movetech Telemetry) were deployed during 2015 but unfortunately subsequent performance was not as expected and the work was repeated in 2016, with an additional sample of tags also deployed, resulting in 22 deployments across two sites (Tarnbrook Fell and Langden Head). In total, data from 20 individuals were considered suitable for analysis (one individual from both years). Data were only analysed up until the last date that each individual was present in the SPA.

3. Home range analyses were carried out using time invariant kernel density estimate methods and were performed separately for day and night periods due to different GPS sampling rates. GPS fixes obtained from inside the colony boundary were excluded from home range analyses to give a more accurate reflection of foraging space use. Foraging distance was the maximum distance away from the nest and was calculated for each discrete trip away from the colony.

4. Tracked Lesser Black-backed Gulls from the Bowland Fells SPA likely foraged almost exclusively in terrestrial habitats. There was some individual variation in the extent and pattern of their foraging ranges, but generally the degree of overlap with the SPA was low for most birds and in total was <10%. The most frequently visited habitats tended to be urban areas and landfill sites to the south and southwest of the SPA but regular use of nearby agricultural land was also seen. Unfortunately it was not possible to tag an equal sample from each colony, and the sample from Tarnbrook was much smaller, but it appears that birds from each colony are highly segregated inside the SPA and may even have different foraging site preferences outside the SPA boundary.

5. Birds spent only a small proportion of their time – on average 12% – within the SPA during the periods that they were away from the colony. Total time within the SPA was closer to 50% when GPS data recorded from inside the colony boundary were also included, as would be expected from sharing of nest attendance by pairs during incubation and chick rearing. It was not possible to precisely know the behaviour of the Lesser Black-backed Gulls from the tracking data; however, data on estimated ground speed suggest that most fixes within the SPA but outside the colony were obtained during active flight. However, there is low certainty around this without further analyses.

6. While the SPA provides an important breeding site for the Lesser Black-backed Gulls, the tracking data indicate that it does not currently provide important foraging sites and that the gulls travel daily to other sites outside the SPA. It is likely that a small proportion of individuals spent relatively more time within the SPA and make greater use of nearby agricultural land but at present it seems profitable for most birds to continue to travel relatively long distances to forage around human occupied environments, predominantly urban areas, but also farmland.

# 1. INTRODUCTION

## 1.1 Background

The Bowland Fells Site of Special Scientific Interest (SSSI) and Special Protection Area (SPA) is located to the east of Lancaster within north Lancashire. It supports the largest area of blanket bog and heather moorland within Lancashire and provides a habitat for an internationally important upland breeding bird community. The diverse mosaic of upland habitats across the Fells contributes greatly to the ornithological interest of the site, which supports breeding Hen Harrier (*Circus cyaneus*) (at its only regular breeding site in England), Merlin (*Falco columbarius*) and one of the five largest UK breeding colonies of Lesser Black-backed Gull (*Larus fuscus*), which is a SPA review (Stroud *et al.* 2001) and pSPA (potential SPA) feature.

The Lesser Black-backed Gull breeding population has recently been growing since control measures ceased in 2009. Landowners have expressed concern that, without control, the population will reach levels which significantly impact on other birds and on vegetation communities within the Bowland Fells SSSI/SPA, as well as on the quality of water emerging from catchment land. When Lesser Black-backed Gull numbers were at their highest, it is thought (from observation and ringing studies) that a large part of their diet was sourced at landfill sites at Lancaster and Warrington. These sites have since become inaccessible and there is concern from landowners that feeding now takes place more within the Bowland Fells SSSI/SPA and on fringing in-bye land, which is important for breeding waders. This poses a largely unquantified risk to the wider bird assemblage and to landowner interests – mostly grouse shooting. An additional risk is to the Bowland Fells Hen Harrier population, which is within one mile of some parts of the colony.

## 1.2 Project Objectives

The aim of this study is to use new state-of-the-art Movetech Global Positioning System-Global System for Mobile communication ('GPS-GSM') tracking devices to:

i. Identify potential feeding areas (both within and outside the SSSI/SPA) used by Lesser Black-backed Gulls from this breeding population; and
ii. Quantify the amount of time spent by the gulls in these areas.

The outputs from this would help to inform understanding of the space use of Lesser Black-backed Gulls from this breeding population in comparison to birds from the colony at South Walney in the Morecambe SPA, and would also help to inform understanding of the extent of interaction of the Bowland Fells population with the breeding populations at South Walney and the Ribble Estuary. The study would provide a better evidence base to inform Natural England's discussions over the need to manage risks in the growth of the Lesser Black-backed Gull population within the Bowland Fells SSSI/SPA to ensure that favourable conservation status is maintained and sustained. Furthermore, the study would help to inform any Habitats Regulations Assessment required to assess likely significant effects of land use changes and management activities both within and outside the SPA.

Initial work was undertaken to fit 12 Lesser Black-backed Gulls with GPS-GSM tags in spring 2015. While these tags provided some useful information during the breeding season, the life-span of the tags was not as expected and thus this work was repeated in 2016 with an additional sample of 12 tags (24 in total).

## 2. METHODS

### 2.1 Focal Species

The Lesser Black-backed Gull (the UK sub-species of which is *L. fuscus graellsii*) is a qualifying feature of four breeding colony SPAs and one potential SPA in England, two in Scotland and one in Wales (SPA Review: Stroud *et al*. 2001; SNH SPA extensions). At-sea data have been used to investigate the species' distributions and habitat associations, for instance in the German North Sea (Schwemmer & Garthe 2008), and placement within multi-species feeding associations (Camphuysen & Webb 1999). Research has also focused particularly on general breeding biology, diet, and kleptoparasitism (Camphuysen 1995; Calladine 1997; Galván 2003; Kubetzki & Garthe 2003; Kim & Monaghan 2006). However, only recently has the species been tracked, e.g. in studies of birds breeding in the Netherlands (Shamoun-Baranes *et al*. 2011), Germany (Corman & Garthe 2014) and in eastern England (Thaxter *et al.* 2011, 2012a, 2013, 2014b, 2015, 2016) and hence limited data are available concerning foraging movements.

During the non-breeding season, the extent of migration varies between and within populations. Lesser Black-backed Gulls tracked from colonies in the Netherlands (sub-species *L. fuscus graellsii* and *L. fuscus intermedius*) are known to migrate initially to the UK immediately after breeding, before travelling further south to over-winter on the coasts of the Iberian Peninsula and north-west Africa (Ens *et al*. 2008). This pattern is also well-documented for other populations of the same sub-species from ringing data (Wernham *et al*. 2002). However, *L. fuscus graellsii* breeding in the UK may differ in their migratory strategy to those on the continent, and to members of the *L. fuscus intermedius* sub-species, which overlap with *L. fuscus graellsii* in their breeding range.

### 2.2 Field Sites

Fieldwork was carried out on two Lesser Black-backed Gull nesting areas within the Bowland Fells SPA. One colony on Tarnbrook Fell (54.015° N, 2.59° W) and one at Langden Head near Sykes Fell (53.95° N, -2.64° W). Gulls nest widely over both areas but catching efforts were kept within the maximum boundaries shown in Fig. 2.1. Landowners were informed of all access to both sites and visits were not made during inclement weather.

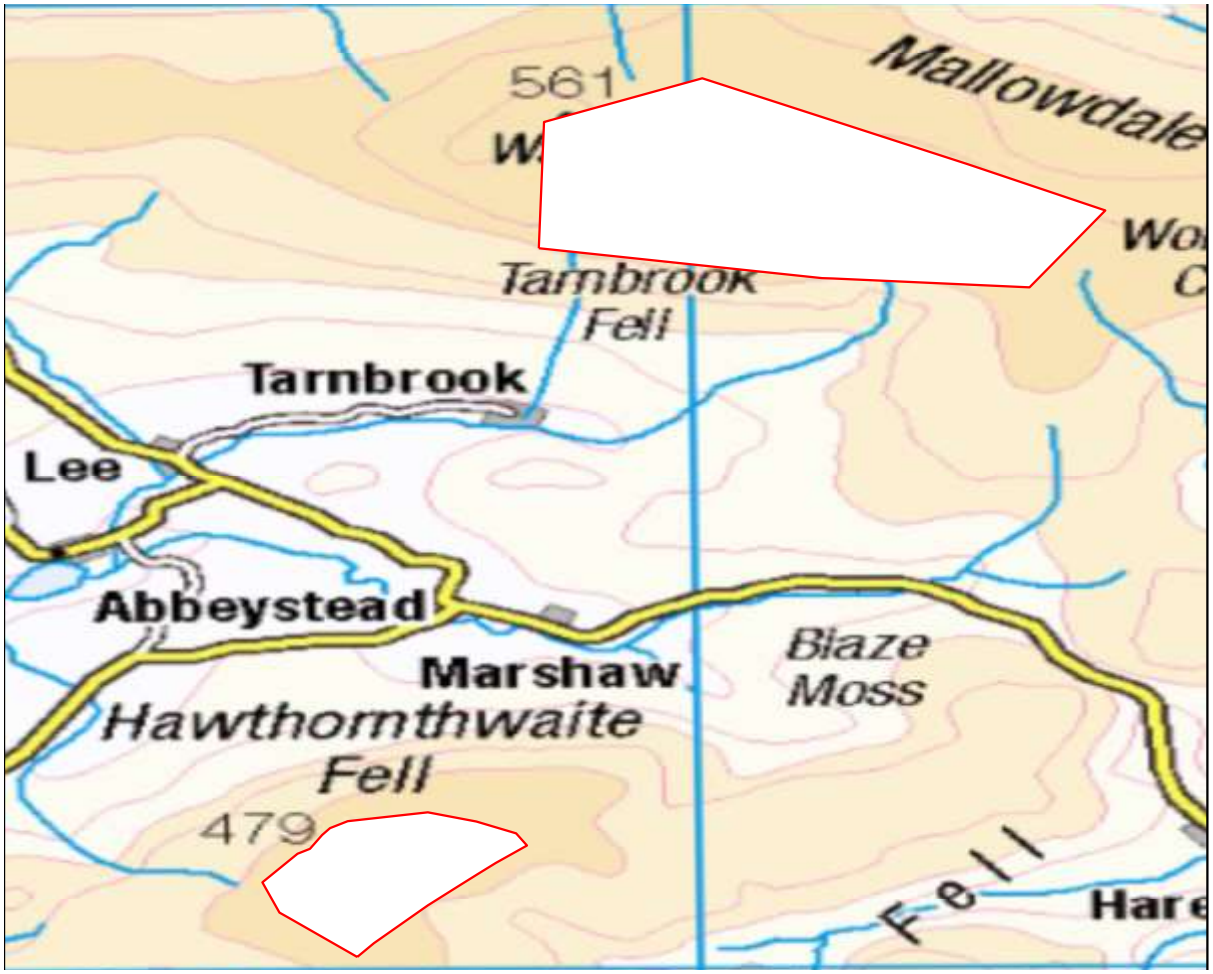



**Figure 2.1** Location of each field site within the Bowland Fells SPA and the approximate boundary of the areas of colony visited.

### 2.3 Capture and Attachment Methods

Breeding adult Lesser Black-backed Gulls were captured during incubation using wire mesh traps, with a single funnel entrance, placed over the nest and pegged down (Bub 1991). Where possible, traps were observed from a distance or left for up to 30 minutes and once a bird had entered and settled onto the nest, the trap could be approached and bird retrieved. Birds during late incubation with a full clutch (three) of warm eggs were targeted for improved capture efficiency but some nests with smaller clutches (one or two) or small chicks were targeted if required. Each nest targeted was marked with an individually identifiable marker placed c. 1 m away to ensure each nest was only targeted once per visit and allow subsequent nest recording (Appendix 1). Nest locations were recorded using a handheld GPS (Fig. 2.2).

Two capture visits were made to each site during 2015 and three visits to Tarnbrook and four visits to Langden Head were carried out in 2016. To comply with licensing requirements to fit the tags, birds needed to be above a minimum weight, consequently, a total of 92 individuals (Appendix 1) were captured in order to attach the majority of the requisite sample of tags (as some tags were heavier than specified, only 22 of the 24 tags were fitted in 2016). All birds were weighed and measured and fitted with a unique metal leg ring. Additionally, all birds tagged and a further sample of 19 birds was fitted with a unique engraved colour ring.

GPS tags were fitted to the birds using a permanent wing loop harness made from tubular Teflon (see Thaxter *et al*. 2014a, 2014b for detailed harness design). Tags weighed 20-25.5g, which represented < 3% body mass for the birds in this study: mean ± SD: 788 ± 90g, range: 620-1040g. During 2016, on average birds at Tarnbrook did weigh slightly less than Langden Head although this difference was not significant (t = -0.91, d.f. = 69, P=0.37), however, capture efficiency was lower on the Tarnbrook site and an equal sample of tags at each site was not feasible. A possible sample bias was introduced as only heavier birds, which are more likely to be males, were tagged in order that the combined weight of tag and harness was below 3% of body mass.

The mean time from capture to release was 36 minutes (maximum 1 hour). After tagging, birds were released and resumed normal incubating behaviour after a period of time away from the nest area.

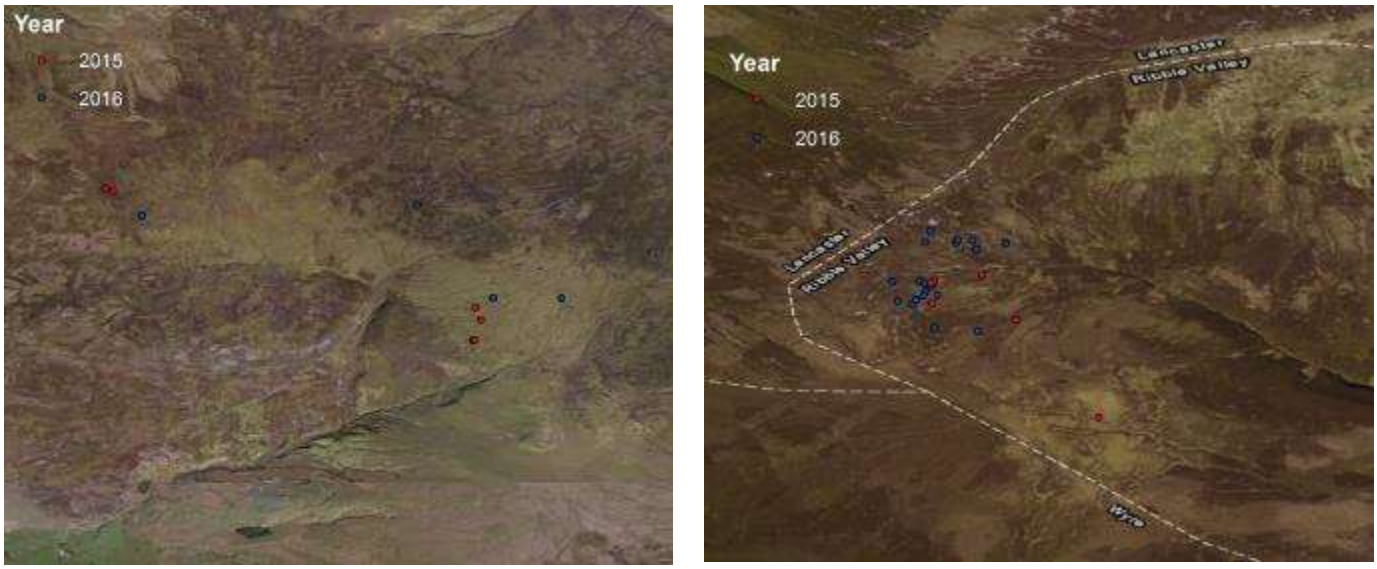



**Figure 2.2** Distribution of the nest locations of Lesser Black-backed Gulls fitted with GPS-GSM tags from the Tarnbrook colony (left) and Langden Head colony (right). Note that there are two separate points (2015 and 2016) at Tarnbrook for bird ID 034.

## 2.4 The GPS System

The GPS devices used in this study were developed by Movetech, a consortium of scientific partners (BTO, University of East Anglia, University of Lisbon and University of Porto). They include a GPS sensor, accelerometer, solar panel, battery, thermometer, a SIM card and flash drive.

The devices were programmed to collect GPS data every hour during daylight and every three hours during the night. Reduced sampling rates during the night are necessary to preserve battery life during periods of poor solar recharging conditions. Actual recording performance can vary depending on device power levels at any given time. More frequent GPS fixes are taken to prevent overcharging and the GPS is turned off entirely when the battery drops below a certain threshold to protect the device and allow continued data collection if conditions become suitable again.

These devices allow for continual data collection, potentially over long periods (e.g. up to 2 years). Data are communicated through the mobile phone network (GSM), and thus there is a continual live stream of data throughout the tag's life. GPS data are still collected in areas of no network coverage

and stored on the device to be transmitted at a later date whenever sufficient mobile network coverage is obtained again. All data were automatically forwarded to and stored on an online data repository for tracking information (2015; Fleetronic - http://rd.fleetronic.net/ 2016; Movebank - https://www.movebank.org/).

## 2.5 Data

Data from both years were downloaded from the respective repositories in comma-separated value format and combined. Analyses were restricted to the breeding and immediate post-breeding periods (i.e. excluding migration and wintering). This period was defined from the beginning of tag deployment up until the last fix obtained inside the Bowland Fells SPA and subsequently varied for each bird. Tracking data collected after the last fix within the SPA were excluded from the analyses in this report. Plotting the excluded data validated that the birds tend not to use areas immediately adjacent to the SPA for any prolonged period after their last fix inside the protected area (Appendix 2). Any records which were duplicated, contain invalid GPS fixes or were above the 99$^{th}$ percentile for GPS location error were also removed from the dataset.

When tracking the movements of breeding birds, clusters of GPS fixes around nest sites can introduce bias into analyses of foraging home ranges by increasing the indication of area usage as a result of behaviour such as incubation. To avoid such bias, all home range analyses presented here used a subset of data whereby all fixes within the colony boundaries (Fig. 2.1) were excluded. Results using data from both in and away from the colony are presented in Appendix 3. Individual birds were also excluded from the analyses if there were insufficient data (Table 2.1).

**Table 2.1** Overview of data collected from GPS-GSM tags on Lesser Black-backed Gulls over the summer period. Individuals excluded from the analyses due to insufficient or low quality data are listed at the bottom of each year and highlighted in red. Details of birds reported dead of in Appendix 4.

| Bird ID | Fixes at colony | Fixes away from colony | Total GPS fixes | Tracking period | Notes |
|---|---|---|---|---|---|
| 2015 | | | | | |
| Langden_Head_109 | 256 | 136 | 392 | 11/06/2015 - 18/07/2015 | |
| Tarnbrook_034 | 628 | 924 | 1552 | 08/06/2015 - 08/08/2015 | |
| Tarnbrook_100 | 237 | 57 | 294 | 10/06/2015 - 17/06/2015 | Truncated dataset |
| Langden_Head_28 | 0 | 0 | 0 | NA | Wintering fixes only |
| Langden_Head_68 | 36 | 9 | 45 | 09/06/2015 - 10/06/2015 | Truncated dataset |
| Langden_Head_76 | 30 | 13 | 43 | 24/06/2015 - 01/07/2015 | Truncated dataset |
| Langden_Head_101 | 8 | 20 | 28 | 12/06/2015 - 16/06/2015 | Truncated dataset |
| Langden_Head_107 | 0 | 10 | 10 | 27/06/2015 - 08/08/2015 | Truncated dataset |
| Tarnbrook_41 | 0 | 0 | 0 | NA | All excluded - Large GPS error |
| Tarnbrook_55 | 56 | 25 | 81 | 13/06/2015 - 21/07/2015 | Truncated dataset |
| Tarnbrook_104 | 0 | 0 | 0 | NA | No data transmitted |
| Tarnbrook_110 | 15 | 0 | 15 | 11/06/2015 - 23/06/2015 | Truncated dataset |
| 2016 | | | | | |
| Langden_Head_178 | 577 | 861 | 1438 | 28/05/2016 - 07/08/2016 | |
| Langden_Head_237 | 1096 | 1877 | 2973 | 25/05/2016 - 21/08/2016 | |
| Langden_Head_245 | 156 | 380 | 536 | 24/05/2016 - 13/08/2016 | |
| Langden_Head_262 | 139 | 93 | 232 | 28/05/2016 - 07/06/2016 | Truncated dataset |
| Langden_Head_269 | 182 | 280 | 462 | 28/05/2016 - 13/08/2016 | |
| Langden_Head_270 | 1005 | 908 | 1913 | 24/05/2016 - 14/08/2016 | |
| Langden_Head_277 | 123 | 155 | 278 | 25/05/2016 - 29/07/2016 | |
| Langden_Head_279 | 1052 | 1621 | 2673 | 28/05/2016 - 19/08/2016 | |
| Langden_Head_287 | 628 | 1016 | 1644 | 28/05/2016 - 02/08/2016 | |
| Langden_Head_454 | 142 | 389 | 531 | 28/05/2016 - 16/07/2016 | |
| Langden_Head_457 | 795 | 900 | 1695 | 24/05/2016 - 10/08/2016 | Truncated dataset |
| Langden_Head_459 | 475 | 936 | 1411 | 24/05/2016 - 20/08/2016 | |
| Langden_Head_460 | 346 | 187 | 533 | 05/06/2016 - 11/08/2016 | |
| Langden_Head_461 | 169 | 786 | 955 | 24/05/2016 - 18/08/2016 | |
| Langden_Head_462 | 1023 | 1051 | 2074 | 24/05/2016 - 16/08/2016 | Reported dead |
| Tarnbrook_034 | 825 | 1460 | 2285 | 14/04/2016 - 15/08/2016 | |
| Tarnbrook_226 | 92 | 281 | 373 | 22/05/2016 - 28/07/2016 | |
| Tarnbrook_452 | 195 | 365 | 560 | 30/05/2016 - 04/08/2016 | |
| Tarnbrook_453 | 151 | 212 | 363 | 27/05/2016 - 31/07/2016 | |
| Langden_Head_263 | 4 | 6 | 10 | 27/05/2016 - 11/07/2016 | Truncated dataset – Reported dead |
| Langden_Head_284 | 15 | 27 | 42 | 24/05/2016 - 06/06/2016 | Truncated dataset – Reported dead |
| Langden_Head_451 | 39 | 86 | 125 | 28/05/2016 - 01/08/2016 | |
| Langden_Head_458 | 3 | 0 | 3 | 01/07/2016 - 05/07/2016 | |

## 2.6 Analyses

### 2.6.1 Spatial analyses

***Home range***

We used time-invariant Kernel Density Estimation (KDE) (Worton 1989) to estimate the home range area usage for each bird and all birds combined. The 50%, 75% and 95% KDEs of the utilisation distribution were taken to represent the core, middle, and total areas, respectively – although in line with other studies (e.g. Soanes *et al.* 2013), here we present overlaps using the core and total area usage for simplicity. KDEs were calculated following the approach of Thaxter *et al.* (2015), using fixed smoothing parameters, deemed most appropriate through visual assessment of utilisation distributions across a range of band widths (h = 1500, resolution = 500). GPS fixes collected at irregular time intervals are not suitable for time-invariant KDEs, we therefore filtered the data, for each bird, down to a common sampling rate for day (60 minutes) and night (180 minutes) separately (allowing ± 20 minutes) even though this reduced the effective sample size.

For each individual, we calculated the total area of the 95% and 50% KDEs, as well as the percentage overlap with the Bowland Fells SPA. Boundary information for the SPA was downloaded from www.jncc.defra.gov.uk. All kernel analyses were conducted using the 'adehabitatHR' package (Calenge 2006) in R 3.3.1 (R Core Team 2016) and spatial overlaps using ArcGIS 10.3.1 (ESRI 2015).

***Foraging distance***

Individual discrete trips away from the colony were defined as consecutive GPS fixes outside of the colony boundary punctuated by fixes inside. Any trips of five points or fewer were not included. For each trip the maximum distance recorded away from the individual's nest site was calculated the R package 'geosphere' (Hijmans 2016).

### 2.6.2 Temporal analyses

For each individual, we calculated the time spent in the Bowland Fells SPA using GPS data interpolated to 10 second intervals assuming linear and constant travel between successive locations using the 'adehabitatLT' R package (Calenge 2006). Interpolated data can then be used to identify the most probable time of transition over the SPA boundary. The total time spent inside the SPA is calculated as the sum of time spent inside the boundary for each pair of consecutive GPS fixes.

# 3 RESULTS

## 3.1 Overview of Tracks

Plots of the raw GPS data give an indication of the geographic coverage and broad patterns of movements (Fig. 3.1). Generally, Lesser Black-backed Gulls from the Bowland Fells SPA foraged heavily in terrestrial environments with only a minority of birds visiting any marine areas. Predominantly, movements from the SPA were in a south or southwest direction. It was apparent that a number of sites were important to multiple birds for foraging (see 3.2.1) but that there was also individual variation. Birds tracked from the different colonies appear to have similar broad patterns of behaviour but there is a suggestion of some segregation with more movements in eastward or northward directions from Tarnbrook birds, albeit from a small sample. Example tracks are shown in Fig. 3.1; plots for all individuals are presented in Appendix 5.

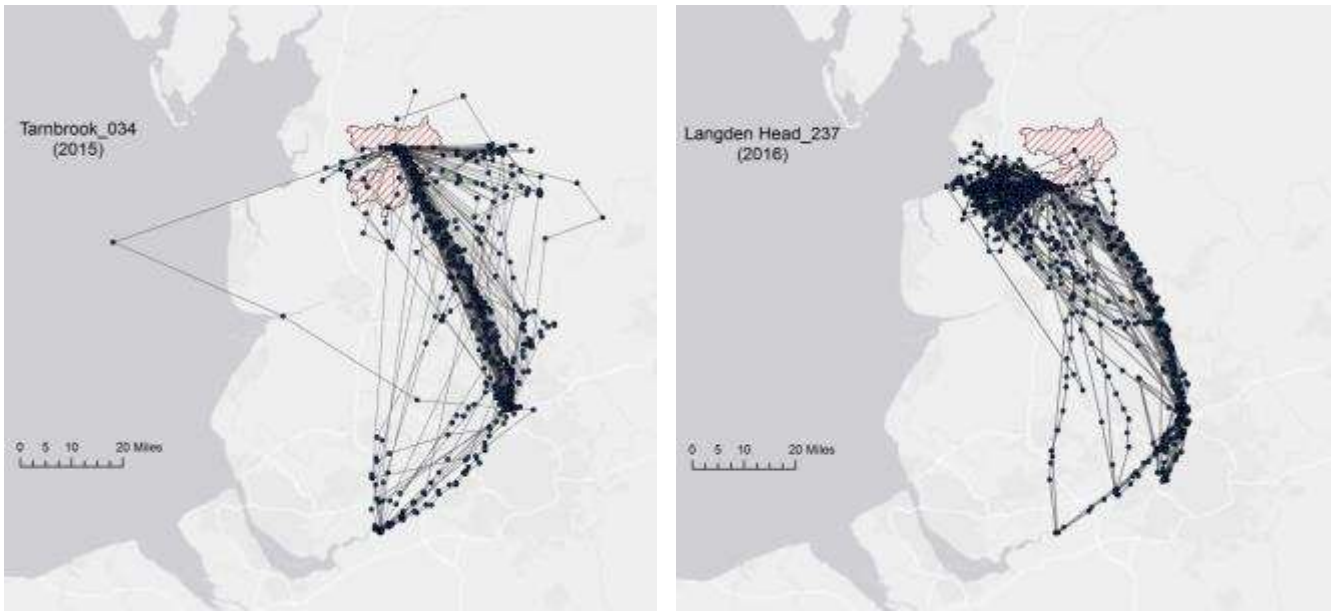



**Figure 3.1** Example tracks for two individual Lesser Black-backed Gulls from the Bowland Fells SPA across the entire summer period. The Bowland Fells SPA is indicated by the red hatched area.

## 3.2 Home Range

### 3.2.1 Day-time home ranges

Home range estimates are presented for both 2015 and 2016 (Fig. 3.2) although no general conclusions should be drawn from the 2015 data as only a very small sample of birds were suitable for inclusion in the analyses. The home ranges identify the most important areas of space use, which for the day-time subset of the data, are presumed to represent key foraging locations. The core home ranges cover several landfill sites and urban areas, particularly to the south and southwest of the SPA, as well as farmland to the east. Illustrative examples of the habitats within the core home range are shown in Fig. 3.3. There was virtually no overlap with any marine environment. The extents of the estimated home ranges and overlaps with the SPA are summarised in Table 3.1.

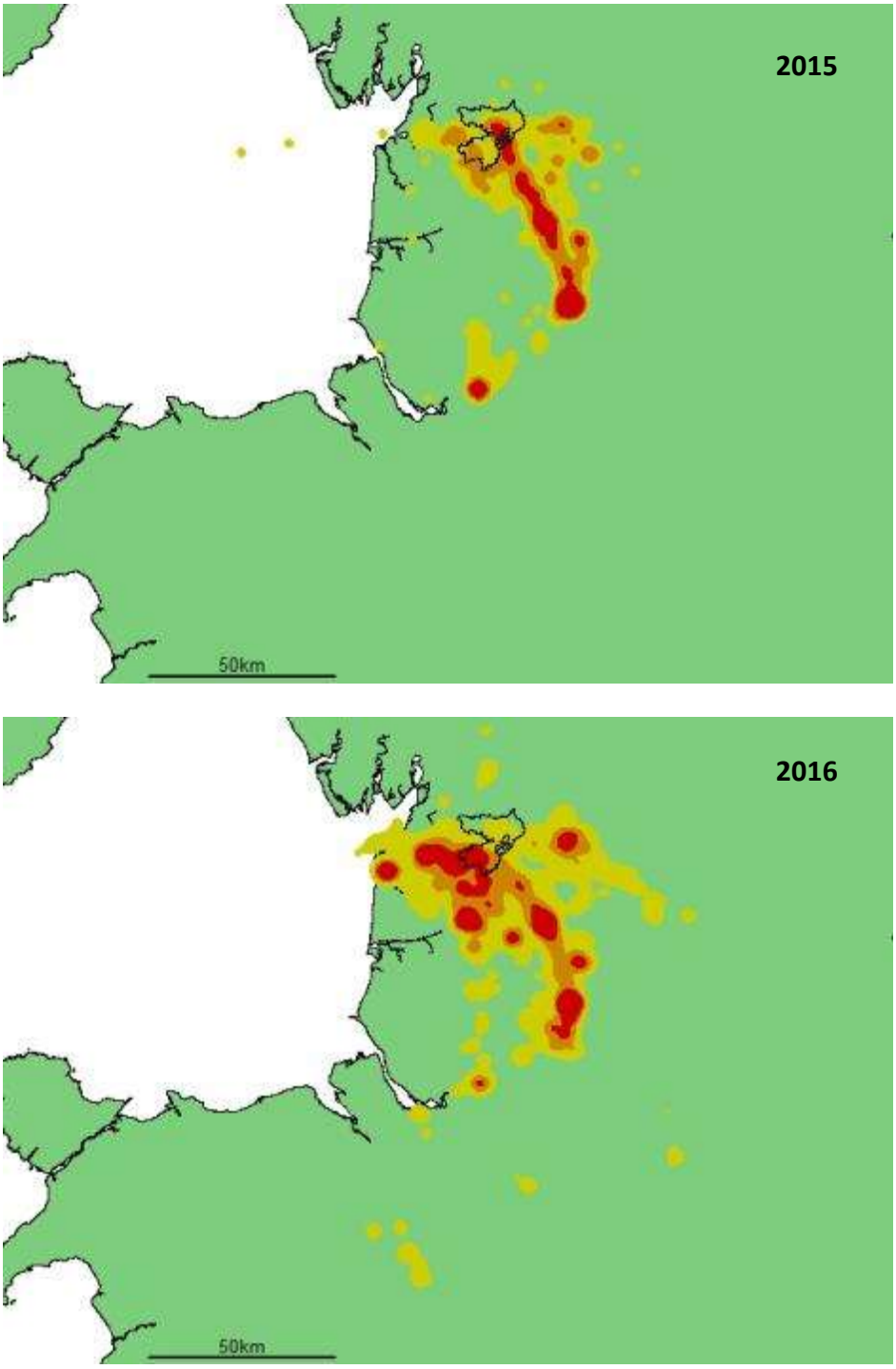



**Figure 3.2** Kernel density estimate utilisation distributions for Lesser Black-backed Gulls from the Bowland Fells SPA for 2015 (n = 2 individuals; 555 fixes) and 2016 (n = 19 individuals; 4870 fixes) using GPS fixes recorded during the day (60 minute sampling rate) outside of the main colony boundary. Red, orange and yellow illustrate the 50%, 75% and 95% utilisation distributions respectively. The Bowland Fells SPA boundary is shown in black.

**Figure 3.3** Examples of satellite imagery overlain with GPS points for Lesser Black-backed Gulls from the Bowland Fells SPA (across individuals) taken from within the main 50% utilisation distribution areas in 2016. Top left – bordering area to southwest of SPA, Top right – Fleetwood landfill site, Middle left – Preston City centre, Middle right – Bury landfill, Bottom left – farmland east of SPA.

### 3.2.2 Night-time home ranges

As the tags operated a reduced sampling rate during the night to prevent overuse of the battery, night-time home ranges could only be calculated from a reduced sample of points, and only from birds tagged in 2016. During 2016, an estimate of night-time home range could be derived using 295 GPS fixes recorded outside of the colony from a total of 1321 (Fig. 3.4). Some of the core home range areas coincide with the day estimates but other areas are also indicated, such as the Ribble Estuary, which were likely important roost sites for at least some individuals.

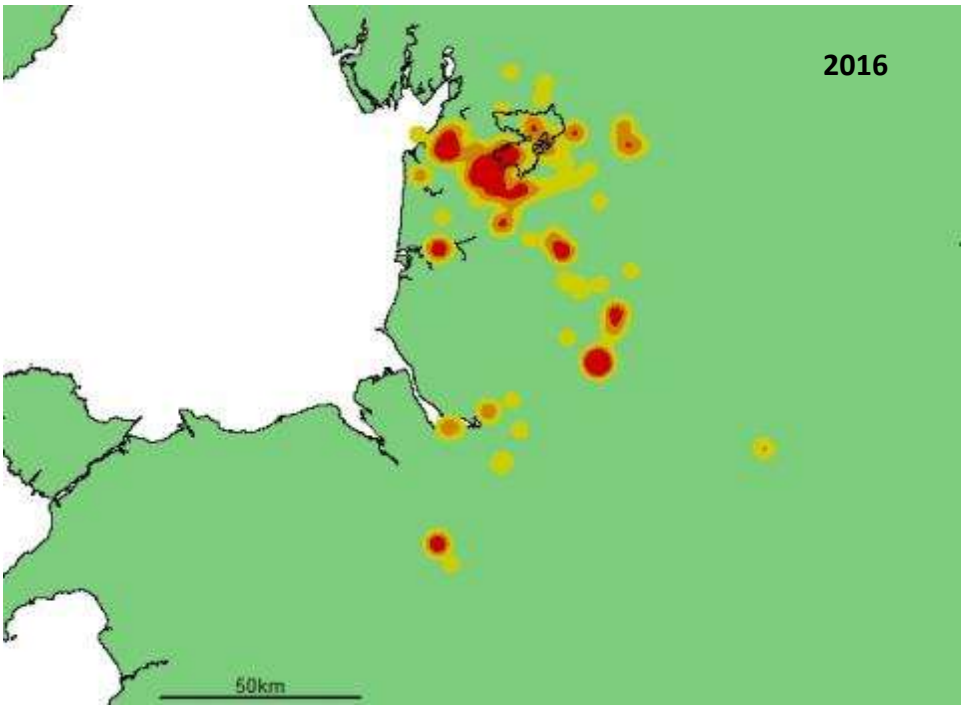



**Figure 3.4** Kernel density estimate utilisation distributions for Lesser Black-backed Gulls from the Bowland Fells SPA for 2016 (n = 19 individuals; 295 fixes) using GPS fixes recorded during the night (180 minute sampling rate) outside of the main colony boundary. Red, orange and yellow illustrate the 50%, 75% and 95% utilisation distributions respectively. The Bowland Fells SPA boundary is shown in black.

### 3.2.3 Individual home ranges in the day

Data were only sufficient to consider the home ranges of individual birds during the day. Figs. 3.5 and 3.6 provide results of these analyses for 2015 and 2016 respectively. There was some individual variation between birds in the patterns of space use detected and also between years (albeit based on data for only one individual). Bird ID 034, tagged at the Tarnbrook colony, was the only individual to transmit data for both 2015 and 2016 and while this bird used some of the landfill sites south of the SPA in both years, it also made greater use of farmland in 2016. Similarly, some of the important foraging sites identified were only covered by the core range of a subset of individual birds, for example five individuals regularly visited the landfill site in Fleetwood.

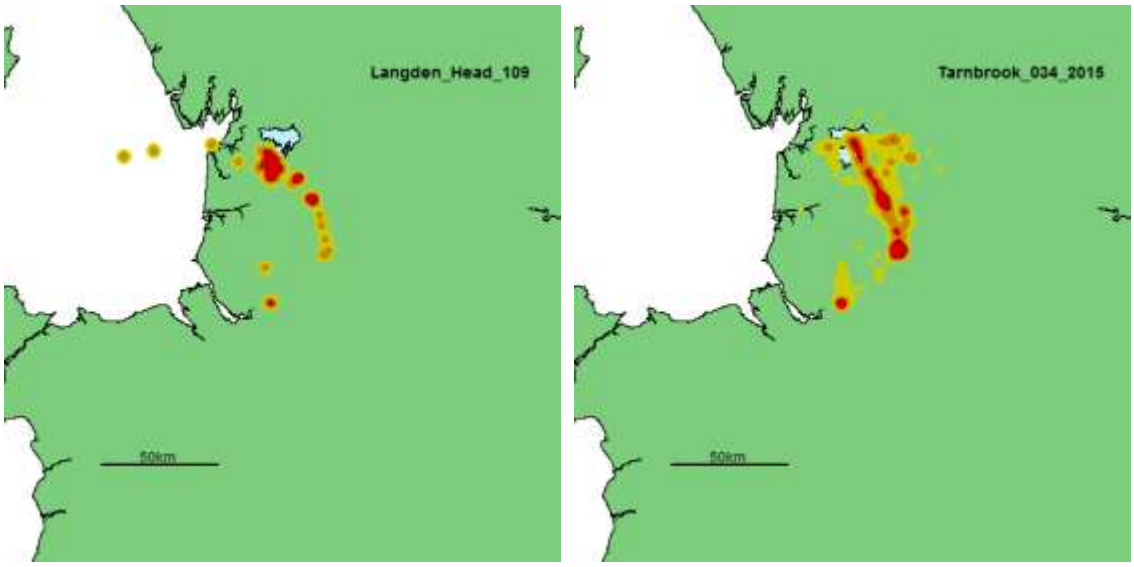
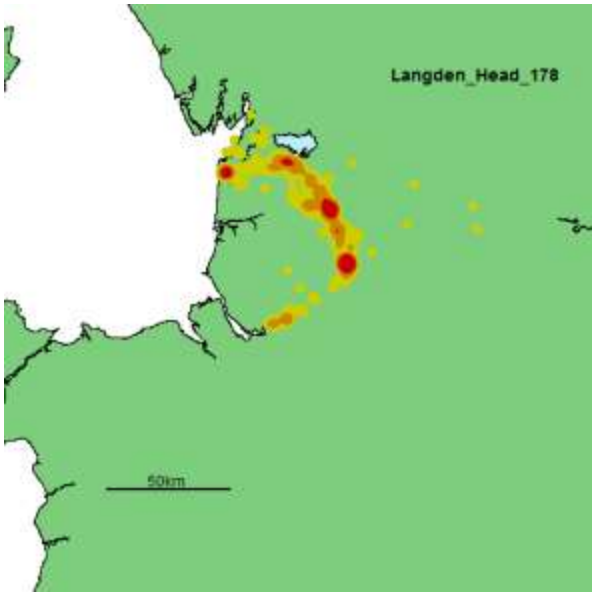
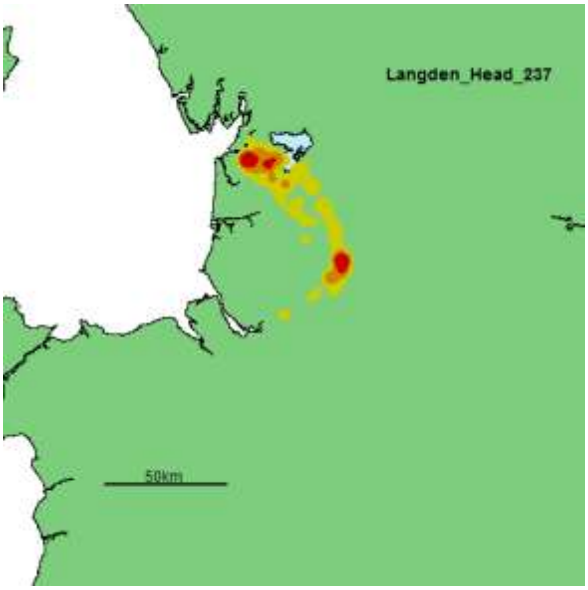



**Figure 3.5** Kernel density estimate utilisation distributions for individual Lesser Black-backed Gulls from the Bowland Fells SPA in 2015 using GPS fixes recorded during the day (60 minute sampling rate) outside of the main colony boundary. Red, orange and yellow illustrate the 50%, 75% and 95% utilisation distributions respectively. The Bowland Fells SPA indicated in blue.


Langden_Head_178
50km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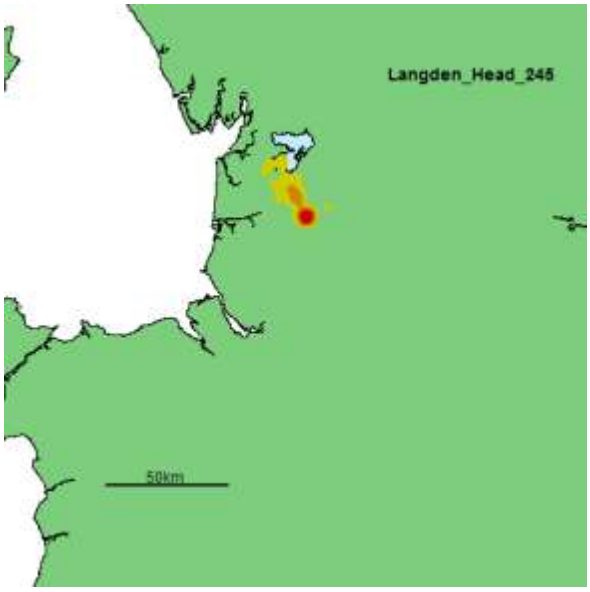
50km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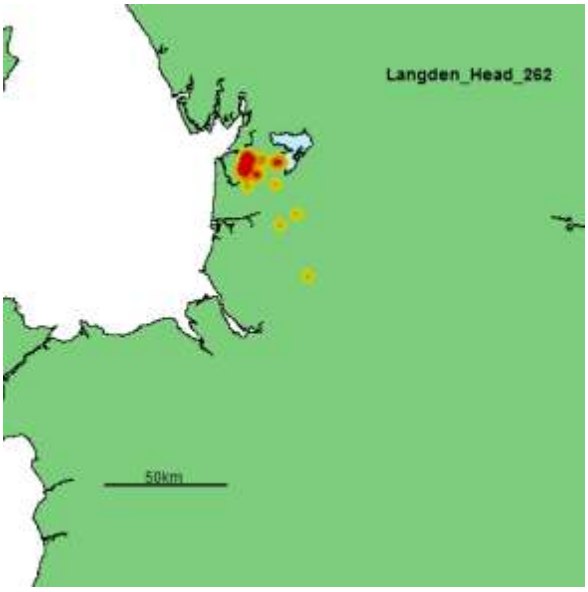
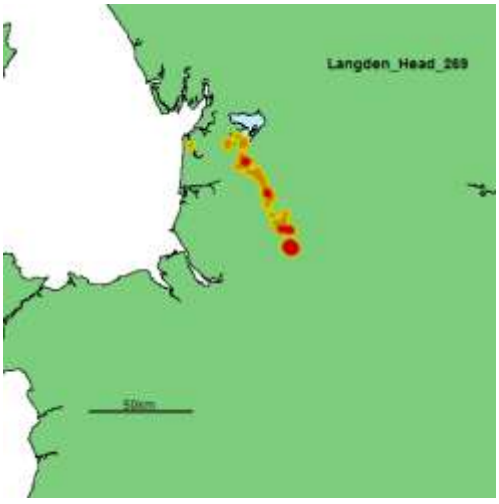
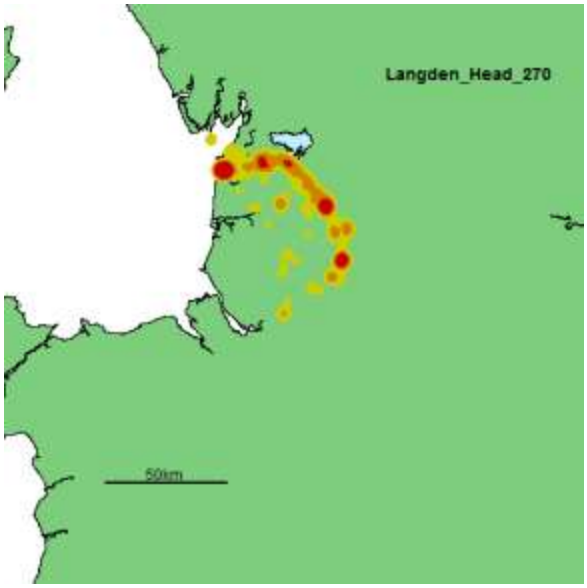
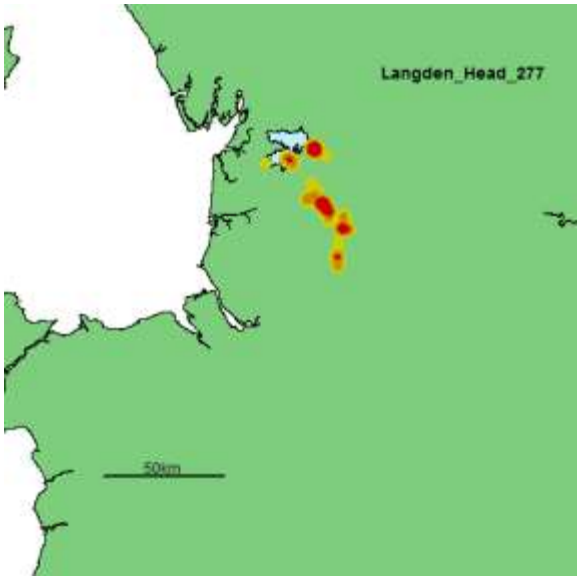
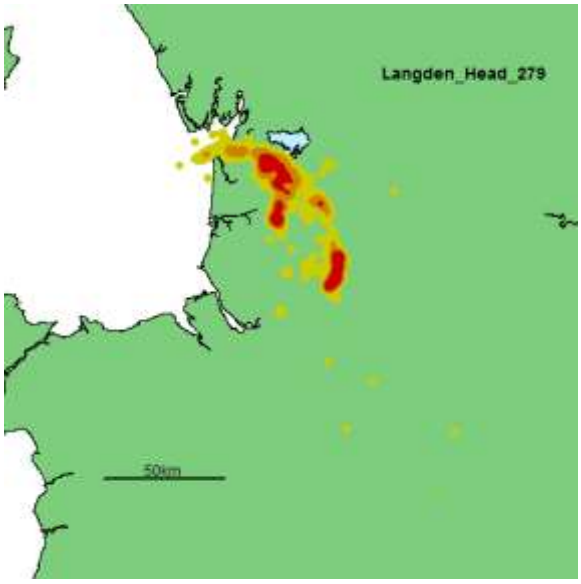
50km


Langden_Head_262
50km


Langden_Head_269


Langden_Head_270
50km


Langden_Head_277
50km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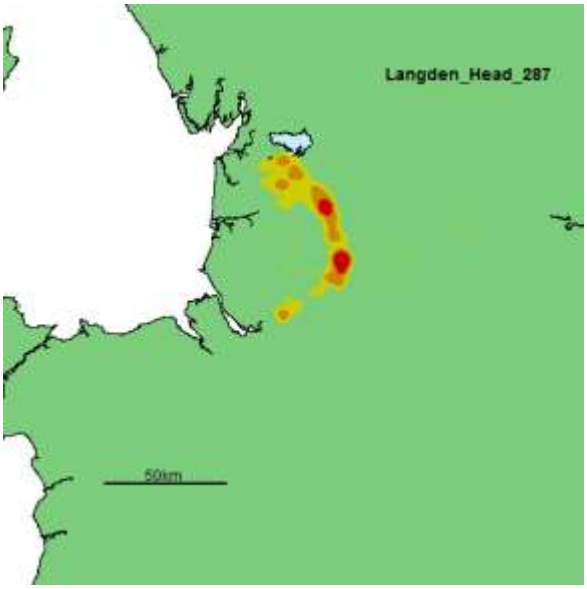
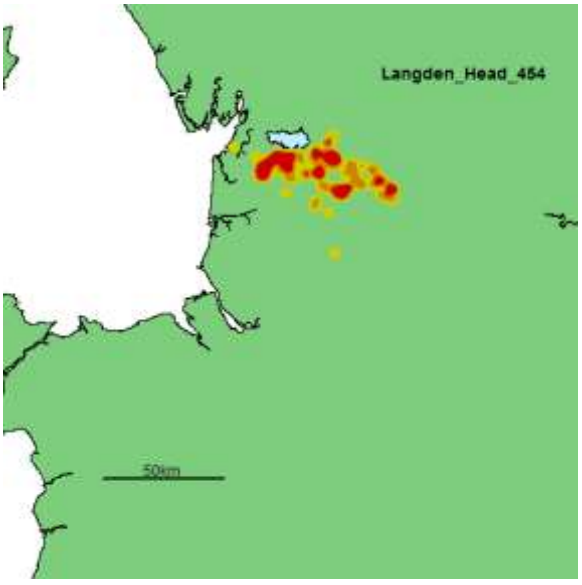
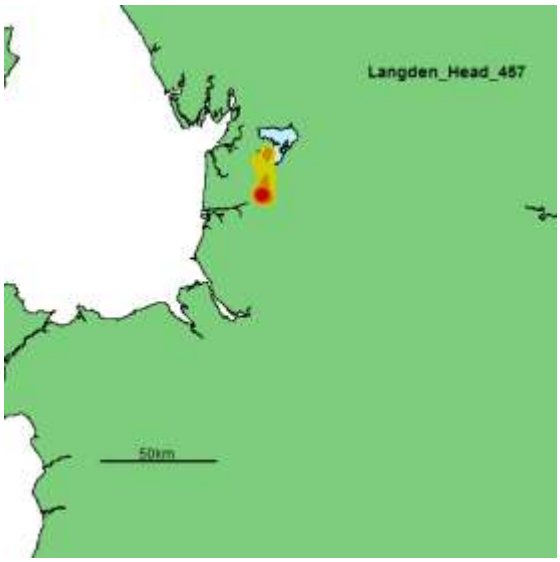
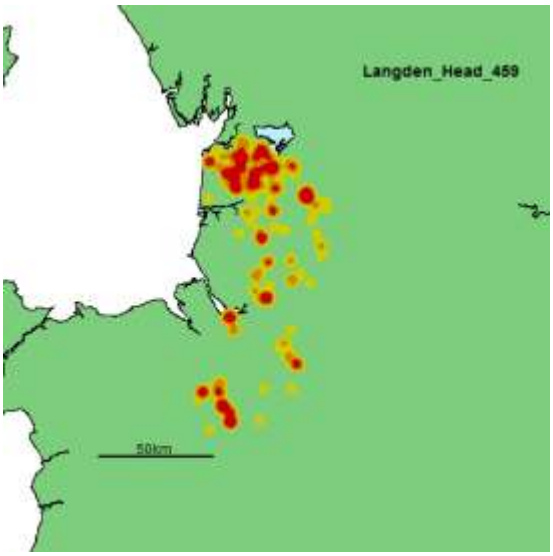
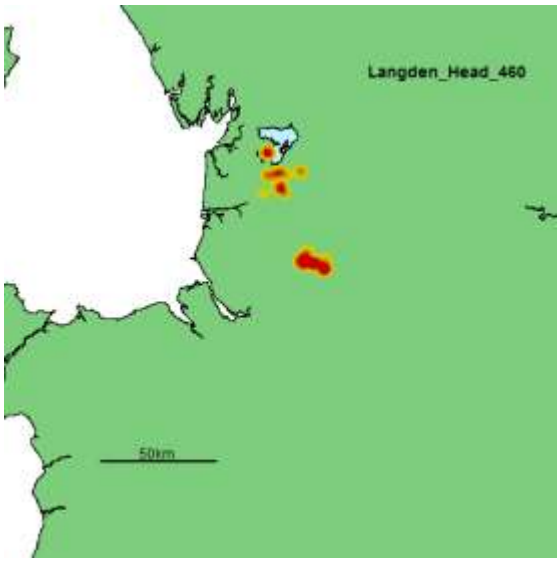
50km


Langden_Head_287
50km


Langden_Head_454
50km


Langden_Head_457
50km


Langden_Head_459
50km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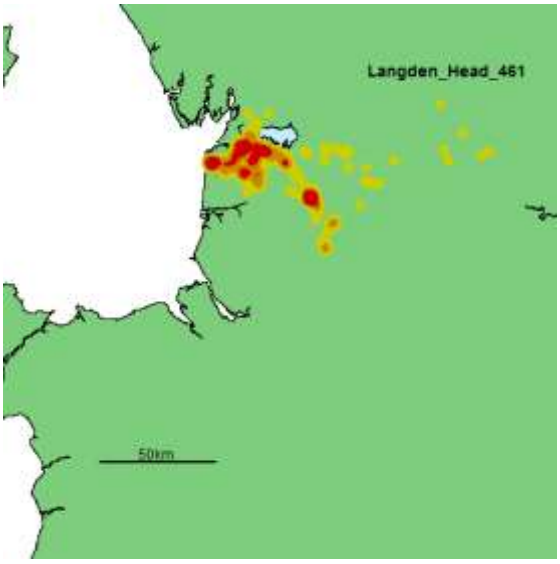
50km


Langden_Head_461
50km

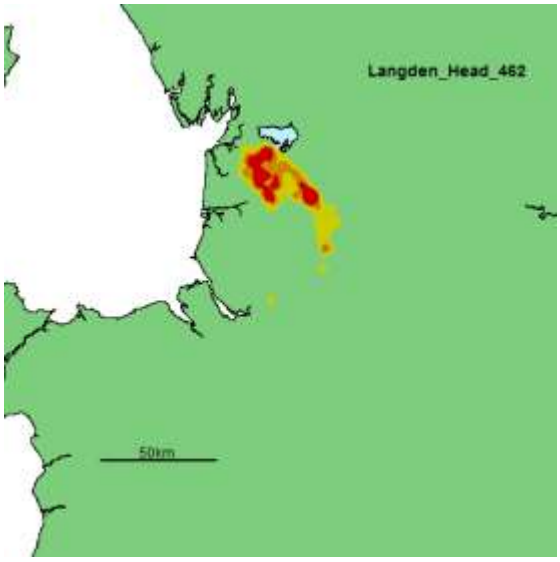

Langden_Head_462
50km


**Figure 3.6** Kernel density estimate utilisation distributions for individual Lesser Black-backed Gulls from the Bowland Fells SPA in 2016 using GPS fixes recorded during the day (60 minute sampling rate) outside of the main colony boundary. Red, orange and yellow illustrate the 50%, 75% and 95% utilisation distributions respectively. The Bowland Fells SPA boundary indicated in blue.

**Table 3.1** Summary of spatial extent and overlap between kernel density estimate utilisation distributions for movements during the day of individual Lesser Black-backed Gulls and the Bowland Fells SPA.

| Bird ID | N fixes | Area of KDE ($km^2$) | | Percentage overlap with SPA | |
|---|---|---|---|---|---|
| | | 50 | 95 | 50 | 95 |
| 2015 | | | | | |
| Langden_Head_109 | 41 | 119.86 | 615.88 | 25.03 | 8.17 |
| Tarnbrook_034 | 470 | 154.43 | 1275.85 | 8.35 | 7.1 |
| TOTAL | 511 | 274.29 | 1891.73 | 15.64 | 7.45 |
| 2016 | | | | | |
| Langden_Head_178 | 352 | 100.87 | 1210.71 | 9.87 | 4.9 |
| Langden_Head_237 | 542 | 81.20 | 832.13 | 4.73 | 4.33 |
| Langden_Head_245 | 104 | 20.60 | 282.55 | 0 | 8.45 |
| Langden_Head_262 | 33 | 54.88 | 317.24 | 8.97 | 9.65 |
| Langden_Head_269 | 55 | 81.91 | 546.57 | 0 | 7.53 |
| Langden_Head_270 | 343 | 108.04 | 1039.13 | 5.67 | 5.39 |
| Langden_Head_277 | 59 | 80.87 | 460.78 | 4.92 | 7.1 |
| Langden_Head_279 | 482 | 217.86 | 1449.51 | 8.23 | 3.77 |
| Langden_Head_287 | 434 | 68.68 | 814.39 | 0 | 6.86 |
| Langden_Head_454 | 105 | 217.10 | 953.41 | 24.57 | 7.05 |
| Langden_Head_457 | 335 | 23.94 | 221.14 | 0 | 15.8 |
| Langden_Head_459 | 297 | 388.54 | 1909.06 | 6.78 | 2.56 |
| Langden_Head_460 | 44 | 85.39 | 377.80 | 8.84 | 8.23 |
| Langden_Head_461 | 265 | 184.33 | 1185.20 | 9.73 | 5.31 |
| Langden_Head_462 | 397 | 184.04 | 812.41 | 12.8 | 6.58 |
| Tarnbrook_034 | 733 | 141.49 | 1122.66 | 0 | 7.21 |
| Tarnbrook_226 | 49 | 251.12 | 1181.79 | 5.18 | 3.16 |
| Tarnbrook_452 | 105 | 336.44 | 1558.06 | 11.77 | 5.39 |
| Tarnbrook_453 | 51 | 137.85 | 606.66 | 0.8 | 8.73 |
| TOTAL | 4785 | 2765.14 | 16881.21 | 8.29 | 5.59 |

### 3.3 Maximum Foraging Distance

Individual Lesser Black-backed Gulls varied in both the number and maximum distance of foraging trips recorded away from the colony (Table 3.2). However, for some individuals (Fig. 3.7), there were periods – linked to the stage of breeding – when foraging trips were very consistent in the maximum distance travelled. Towards the end of the tracking period, birds went on longer trips away from the colony. Foraging distance plots for all individuals are included in Appendix 6.

**Table 3.2** Summary of the maximum distance from nest reached by Lesser Black-backed Gulls from the Bowland Fells SPA during each discrete trip away from the colony during the summer period.

| Bird ID | Number of trips | Max distance (km) | Mean (± SD) maximum distance (km) |
|---|---|---|---|
| 2015 | | | |
| Langden_Head_109 | 7 | 58.94 | 45.76 ± 16.89 |
| Tarnbrook_034 | 49 | 64.59 | 19.34 ± 17.05 |
| 2016 | | | |
| Langden_Head_178 | 58 | 60.99 | 33.16 ± 17.09 |
| Langden_Head_237 | 74 | 64.82 | 30.4 ± 17.33 |
| Langden_Head_245 | 22 | 48.99 | 23.89 ± 15.64 |
| Langden_Head_262 | 5 | 57.62 | 30.1 ± 24.27 |
| Langden_Head_269 | 21 | 57.59 | 34.92 ± 22.53 |
| Langden_Head_270 | 59 | 83.40 | 37.25 ± 19.98 |
| Langden_Head_277 | 11 | 64.40 | 52.77 ± 4.51 |
| Langden_Head_279 | 74 | 94.29 | 24.93 ± 14.49 |
| Langden_Head_287 | 63 | 124.21 | 41.66 ± 33.61 |
| Langden_Head_454 | 28 | 51.87 | 30.22 ± 14.32 |
| Langden_Head_457 | 70 | 96.93 | 22.17 ± 17.94 |
| Langden_Head_459 | 42 | 71.59 | 29.27 ± 21.26 |
| Langden_Head_460 | 9 | 71.32 | 45.84 ± 18.95 |
| Langden_Head_461 | 41 | 71.69 | 39.32 ± 22.93 |
| Langden_Head_462 | 67 | 71.31 | 27.97 ± 19 |
| Tarnbrook_034 | 65 | 83.34 | 33.29 ± 18.43 |
| Tarnbrook_226 | 14 | 233.53[1] | 53.12 ± 54.06 |
| Tarnbrook_452 | 26 | 88.09 | 51.82 ± 17.53 |
| Tarnbrook_453 | 15 | 52.90 | 32.72 ± 13.66 |

[1] Note – Tarnbrook_226 trip duration from which maximum foraging distance was derived was >24hrs

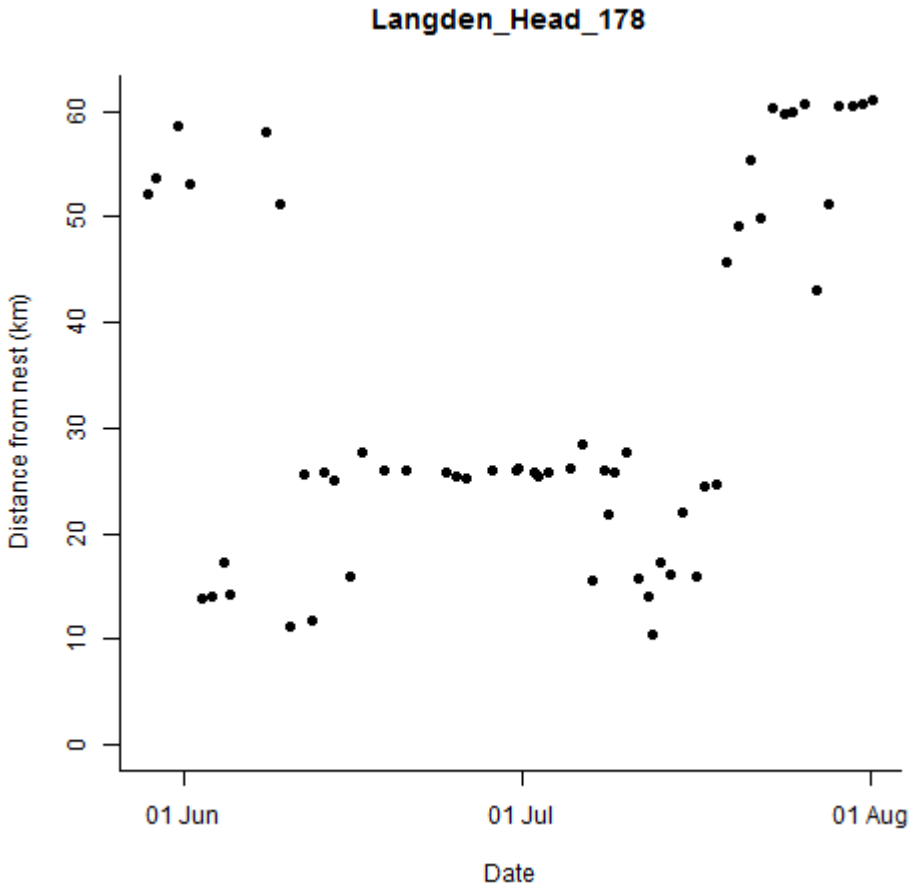



**Figure 3.7** Example for one individual Lesser Black-backed Gull (ID 178) of the maximum distance reached from the nest on each discrete trip away from the colony in the Bowland Fells SPA.

### 3.4 Time spent in Bowland Fells SPA

The estimated mean time spent inside the SPA (for both day and night periods combined but excluding time spent inside the colony boundaries) was 12% of the overall tracking period, ranging from 4 to 29% across individuals (Table 3.3). Without excluding GPS fixes recorded inside the colony the temporal overlap is much closer to 50% as would be expected from sharing of nest attendance by pairs during incubation and chick rearing.

**Table 3.3** Summary of the temporal overlap for individual Lesser Black-backed Gulls with the Bowland Fells SPA.

| | All time (incl. colony) | | | Away from colony | | |
|---|---|---|---|---|---|---|
| Bird ID | Total time (hrs) | Overlap (hrs) | % | Total time (hrs) | Overlap (hrs) | % |
| 2015 | | | | | | |
| Langden_Head_109 | 895.62 | 201.94 | 23 | 892.82 | 62.67 | 7 |
| Tarnbrook_034 | 1460.62 | 772.03 | 53 | 1425.45 | 155.33 | 11 |
| TOTAL | 2356.23 | 973.97 | 41 | 2318.27 | 218.01 | 9 |
| 2016 | | | | | | |
| Langden_Head_178 | 1708.30 | 792.54 | 46 | 1705.82 | 213.62 | 13 |
| Langden_Head_237 | 2103.50 | 943.15 | 45 | 2088.08 | 207.77 | 10 |
| Langden_Head_245 | 1951.70 | 612.79 | 31 | 1951.15 | 138.48 | 7 |
| Langden_Head_262 | 223.88 | 140.34 | 63 | 204.27 | 15.62 | 8 |
| Langden_Head_269 | 1854.68 | 714.43 | 39 | 1847.90 | 220.86 | 12 |
| Langden_Head_270 | 1957.13 | 1187.14 | 61 | 1929.25 | 284.70 | 15 |
| Langden_Head_277 | 1549.17 | 771.74 | 50 | 1470.37 | 150.52 | 10 |
| Langden_Head_279 | 1977.77 | 1116.19 | 56 | 1956.33 | 287.00 | 15 |
| Langden_Head_287 | 1572.53 | 832.16 | 53 | 1565.47 | 174.99 | 11 |
| Langden_Head_454 | 1178.02 | 562.55 | 48 | 1152.43 | 337.07 | 29 |
| Langden_Head_457 | 1857.87 | 955.26 | 51 | 1825.10 | 143.59 | 8 |
| Langden_Head_459 | 2103.03 | 828.02 | 39 | 2091.88 | 217.96 | 10 |
| Langden_Head_460 | 1612.30 | 848.28 | 53 | 1563.72 | 62.83 | 4 |
| Langden_Head_461 | 2067.07 | 547.31 | 26 | 2050.13 | 181.36 | 9 |
| Langden_Head_462 | 2006.60 | 1161.54 | 58 | 1999.37 | 287.27 | 14 |
| Tarnbrook_034 | 2960.83 | 1511.79 | 51 | 2958.82 | 404.70 | 14 |
| Tarnbrook_226 | 1599.87 | 534.49 | 33 | 1593.23 | 217.24 | 14 |
| Tarnbrook_452 | 1584.53 | 635.44 | 40 | 1533.37 | 232.34 | 15 |
| Tarnbrook_453 | 1554.62 | 683.98 | 44 | 1523.17 | 144.58 | 9 |
| TOTAL | 33423.40 | 15379.12 | 46 | 33009.85 | 3922.50 | 12 |

The results presented in this report focus on time and location information, however, some basic inferences on behaviour can also be made using the telemetry data received from the tags, even at relatively infrequent sampling rates. The tags record an estimated measure of ground speed at the time a GPS is taken. To better understand how the birds were using areas of the SPA in which GPS fixes were obtained, we also considered the distribution of estimated speed within the SPA (excluding the colonies), across all birds (Fig. 3.8). There is a high degree of uncertainty in the estimates of ground speed but they are nonetheless indicative. The majority of records indicated speeds of around 10 m/s which is consistent with flight behaviour (Shamoun-Baranes *et al.* 2011) and suggest that for the majority of time spent inside the SPA but outside of the colony, birds are commuting to other sites.

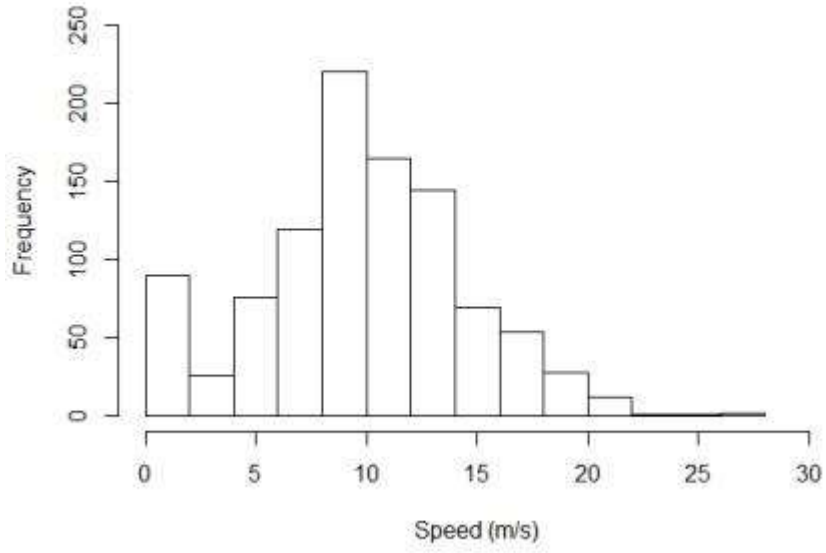



**Figure 3.8** Histogram of the estimated speed of Lesser Black-backed Gulls as recorded from the GPS-GSM devices for all GPS fixes (across individuals) recorded within the Bowland Fells SPA boundary but outside of the two colony areas.

# 4. DISCUSSION

## 4.1 Spatial assessment

Overall, the spatial overlap between day time foraging ranges of Lesser Black-backed Gulls breeding in Bowland Fells SPA and the SPA itself was low, being less than 10% for both core and total ranges in 2016 (Table 3.1). This suggests that while the SPA is clearly important as a breeding site for Lesser Black-backed Gulls, it is not important for foraging during the breeding season compared with other sites.

Nevertheless, it is important to consider the degree of individual variation in foraging strategy in assessing how representative the sample of tagged birds is of the overall population. For example, core range overlap with the SPA was highest for bird ID 454. However, when raw plotted data are viewed there is little to suggest this individual actively foraged within the SPA and the results are possible an artefact of a relatively small sample of GPS fixes. Given the total size of the colonies within the Bowland Fells SPA, if even a small percentage of the birds also adopted more local foraging then this could represent a considerable number of individuals.

In a review of previous published information, Thaxter *et al*. (2012b) reported a maximum foraging range for Lesser Black-backed Gull of 181 km. The maximum foraging distances of individual Lesser Black-backed Gulls from the Bowland colonies are typically within this range, although the maximum figure of 234 km exceeds this. However, this figure likely came after the individual's breeding attempt had finished, during the post-breeding period when birds were still attached to the colony. The studies reviewed by Thaxter *et al*. (2012b) and other recent studies (e.g. Ens *et al*. 2008, Götmark 1984, Kubetzki & Garthe 2003, Isaksson *et al.* 2016, Shamoun-Baranes *et al*. 2011) all report the importance of offshore environments during the breeding season. In contrast, the birds tracked from Bowland almost exclusively visited terrestrial sites. O'Connell (1995) highlighted the likely importance of anthropogenic food sources from landfill sites and invertebrates from agricultural areas in the diet of birds from the Tarnbrook colony, noting that earthworms were the commonest items of food fed to chicks. Use of terrestrial foraging can be expected for birds from inland colonies and there is evidence for the importance of agricultural and landfill food in urban breeding gull diet (Coulson & Coulson 2008). Future changes to current landfill regulations or urban management may influence the foraging behaviour of gulls from the Bowland Fells SPA and may affect the relative importance of use of agricultural areas near or in the SPA or the potential use of marine areas.

## 4.2 Temporal assessment

It was apparent that the tagged birds spent a small proportion of their time inside the SPA when on trips away from the main colony areas (Table 3.3) and of that time it is likely that they were mostly flying to or from other locations (Fig. 3.8). Some individuals did have higher than average temporal overlap with the SPA, for example, bird ID 454, which also showed the highest spatial overlap with the SPA. This individual was one of the few birds to make greater use of the farmland areas to the east of the SPA (Fig. 3.7) and was likely to be making use of different food resources than the majority of other birds closely linked with human environments (although it still visited urban habitat in Clitheroe on occasion).

### 4.3 Conclusions

Tracked Lesser Black-backed Gulls from the Bowland Fells SPA likely foraged almost exclusively in terrestrial habitats. Both spatial and temporal overlap with the SPA was low for most birds when away from the colony (<10% of ranges, <12% of time budgets on average). Total time within the SPA was closer to 50% when GPS data recorded from inside the colony boundary were also included, as would be expected from sharing of nest attendance by pairs during incubation and chick rearing.

It was not possible to precisely know the behaviour of the Lesser Black-backed Gulls from the tracking data; however, data on estimated ground speed suggest that most fixes within the SPA but outside the colony were obtained during active flight. It is possible to analyse telemetry data to delineate patterns of behaviour and match them to spatial use at a very fine scale, i.e. through the use of accelerometer data (Shamoun-Baranes *et al*. 2012), or at a meso-scale looking at trajectory and speed information but this was not within the scope of the present study.

The most frequently visited habitats tended to be urban areas and landfill sites to the south and southwest of the SPA but regular use of nearby agricultural land was also seen. Unfortunately it was not possible to tag an equal sample from each colony, and the sample from Tarnbrook was much smaller, but it appears that birds from each colony are highly segregated inside the SPA and may even have different foraging site preferences outside the SPA boundary.

While the SPA provides an important breeding site for the Lesser Black-backed Gulls, the tracking data indicate that it does not currently provide important foraging sites and that the gulls travel daily to other sites outside the SPA. It is likely that a small proportion of individuals spent relatively more time within the SPA and make greater use of nearby agricultural land but at present it seems profitable for most birds to continue to travel relatively long distances to forage around human occupied environments, predominantly urban areas, but also farmland.

**Acknowledgements**

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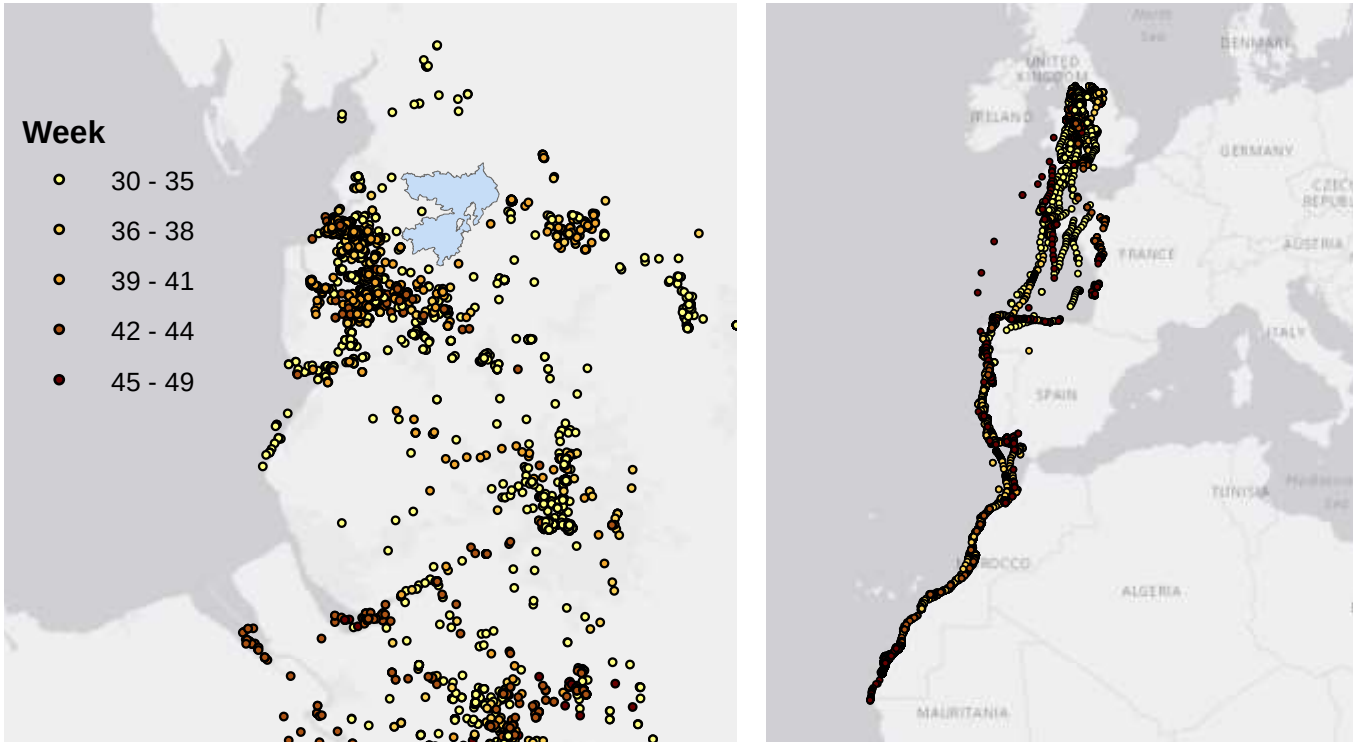
## Appendices

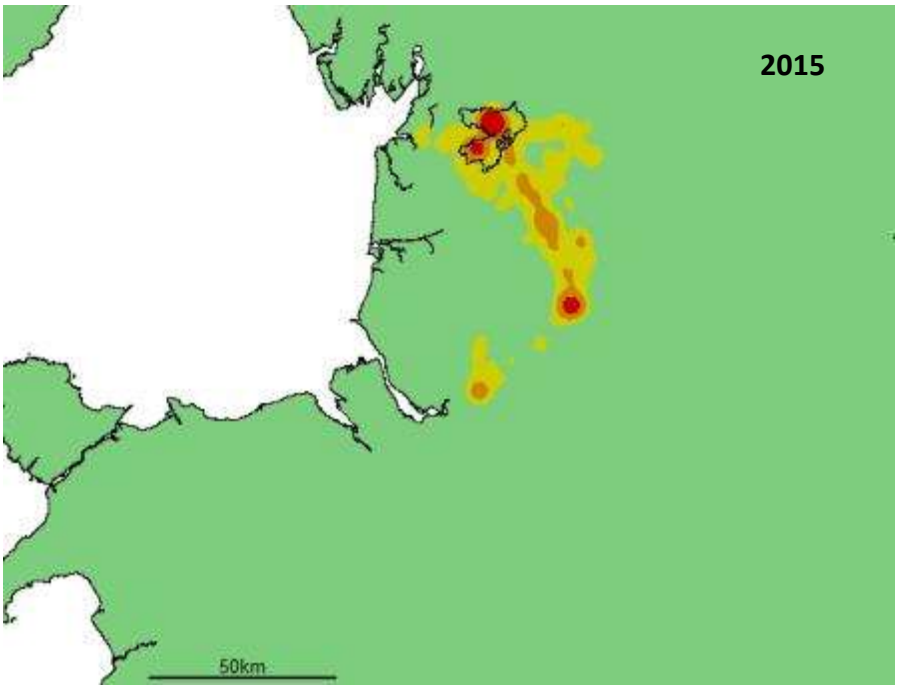
**Appendix 1** Raw capture and nest monitoring data – see file 'Bowland Fells SPA_LBBGU capture data_BTO_Feb 2017.xslx'

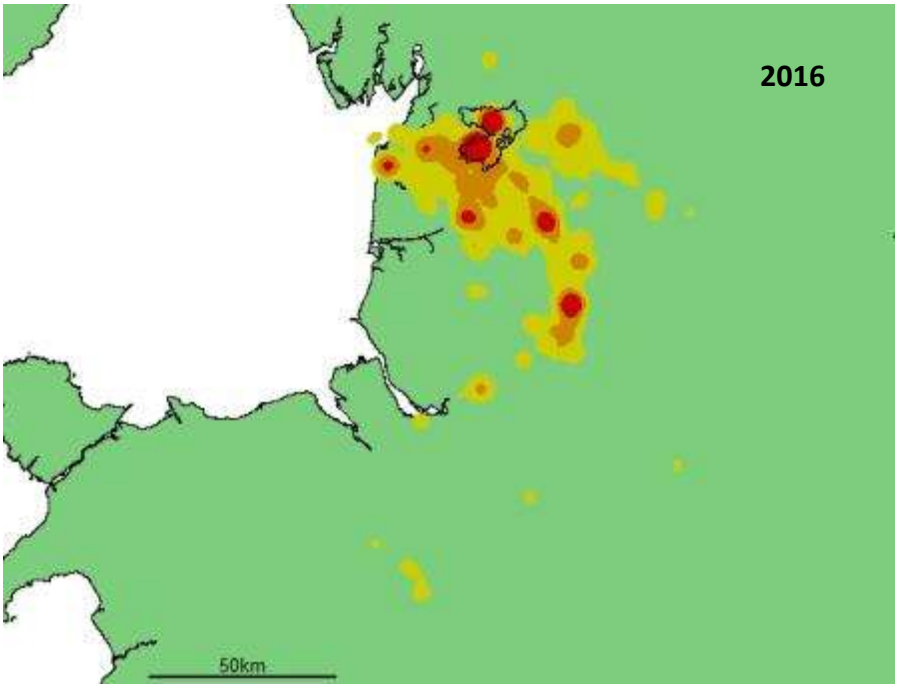
**Appendix 2** Plot of all GPS fixes for Lesser Black-backed Gulls from the Bowland Fells SPA (up until 30/11/2016) which were excluded from the analyses (after last fix was recorded inside the Bowland Fells SPA). The timing (week of year) of the GPS fix is ordered by colour with later fixes shown in darker colours.



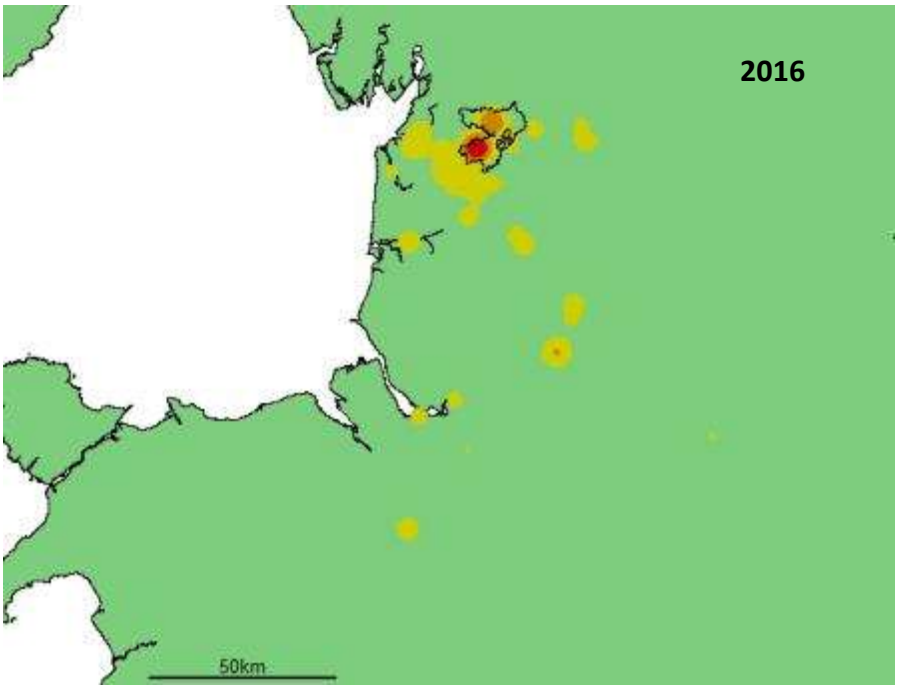
**Appendix 3** Kernel density estimate utilisation distributions for individual Lesser Black-backed Gulls from the Bowland Fells SPA and all birds combined for 2015 (n = 2 individuals) and 2016 (n = 19 individuals) using all GPS fixes (including those inside the colony) recorded during the day (60 minute sampling rate). Red, orange and yellow illustrate the 50%, 75% and 95% utilisation distributions respectively. The Bowland Fells SPA boundary is shown.

***Day foraging range***

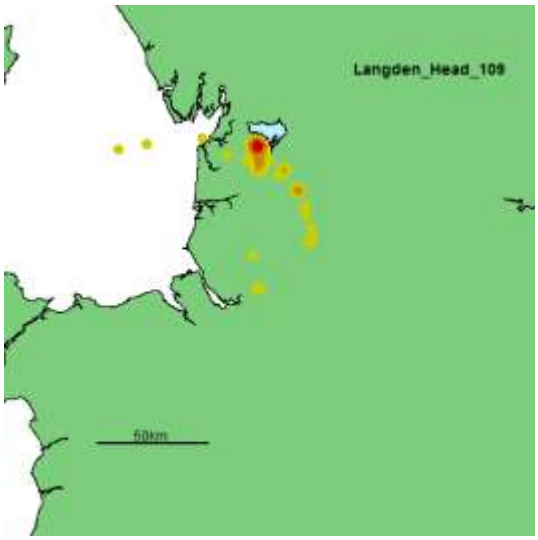


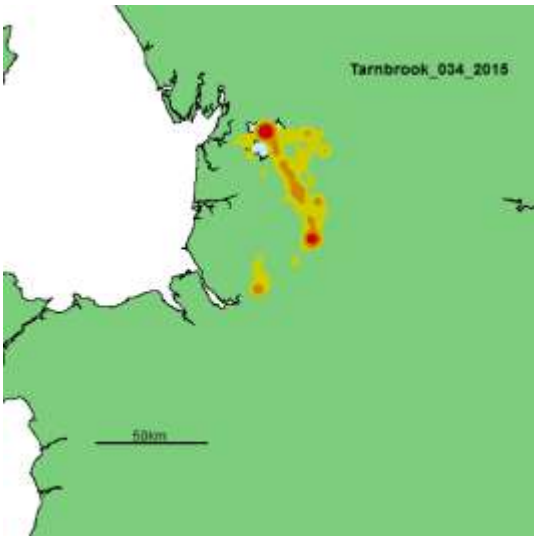



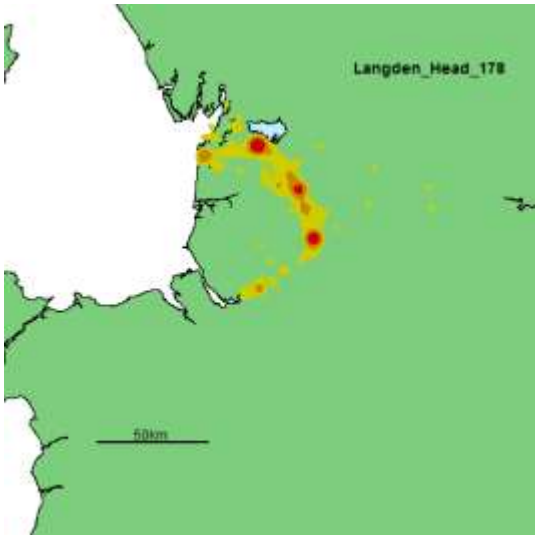
***Night foraging range***

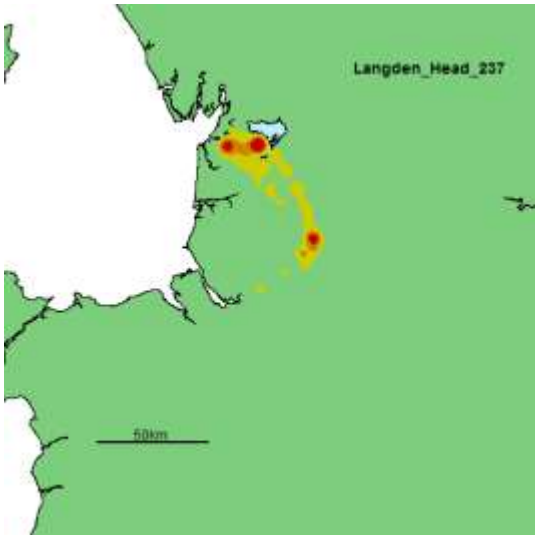


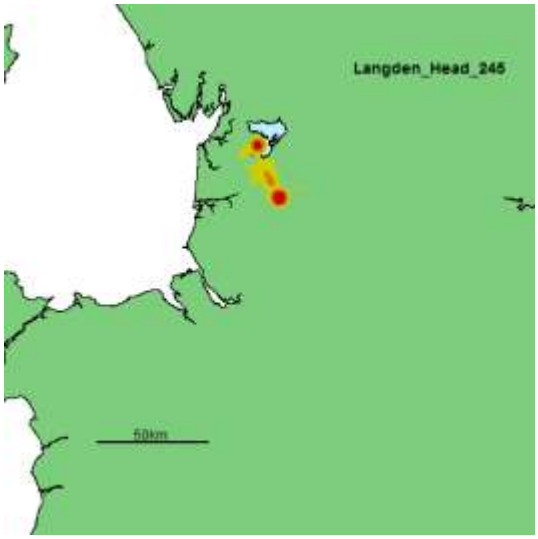

***Individual foraging ranges***

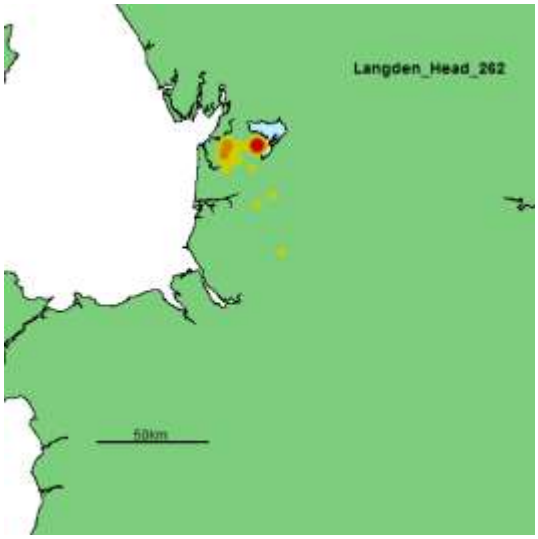


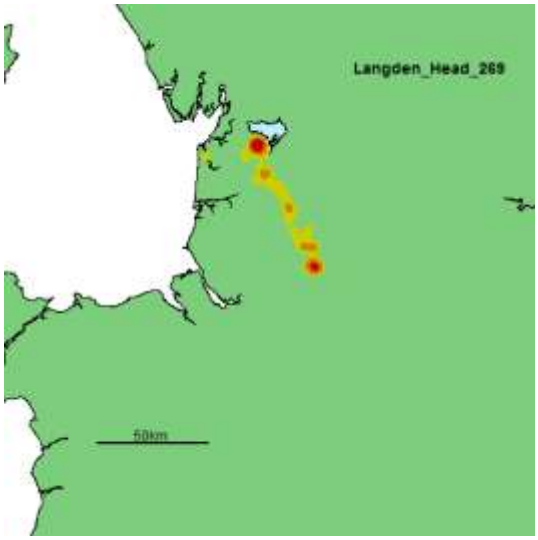



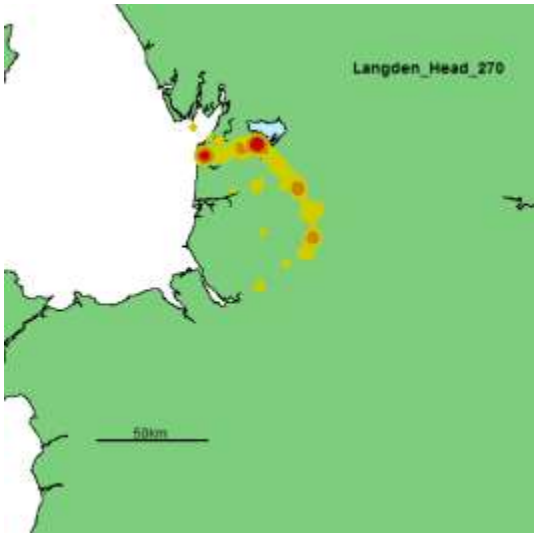

Langden_Head_178
50km


Langden_Head_237
50km


Langden_Head_245
50km


Langden_Head_262
50km


Langden_Head_269
50km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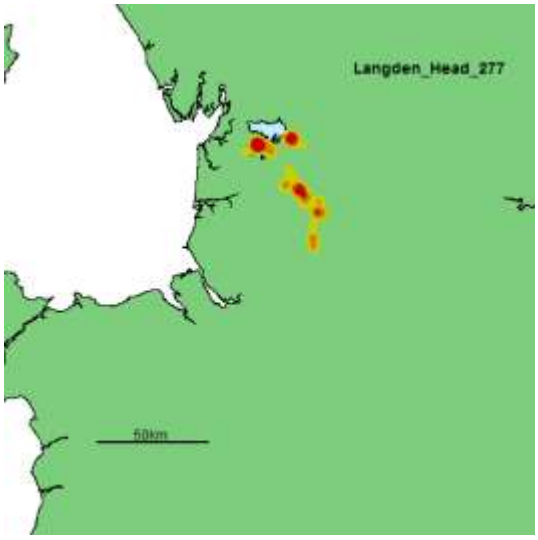
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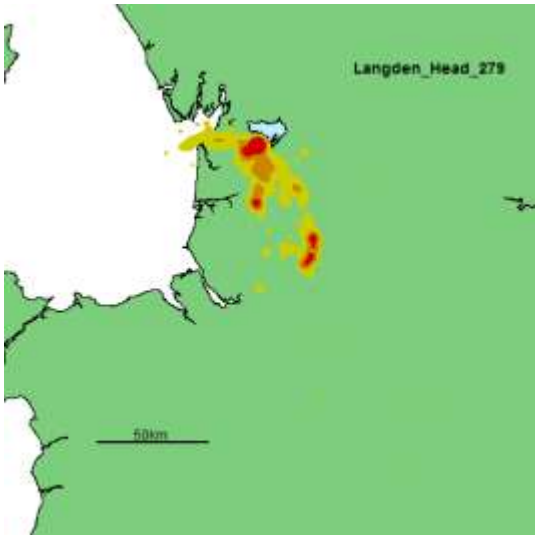
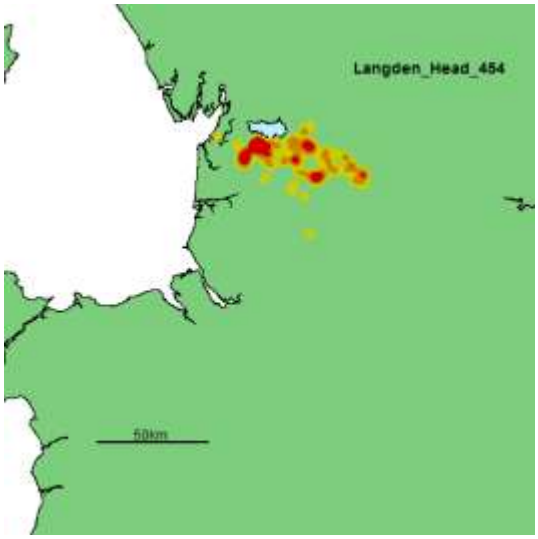

Langden_Head_279
50km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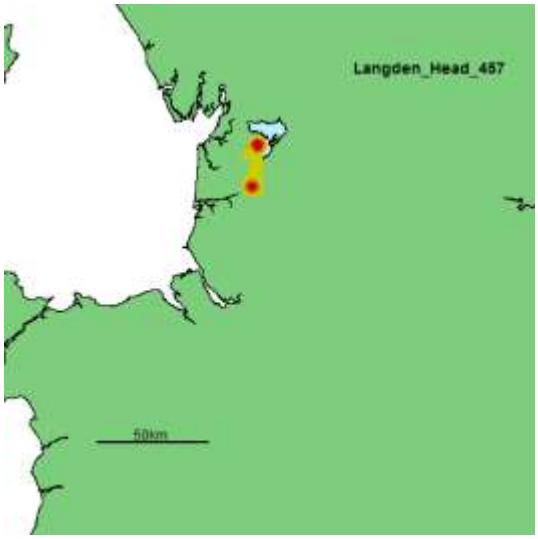
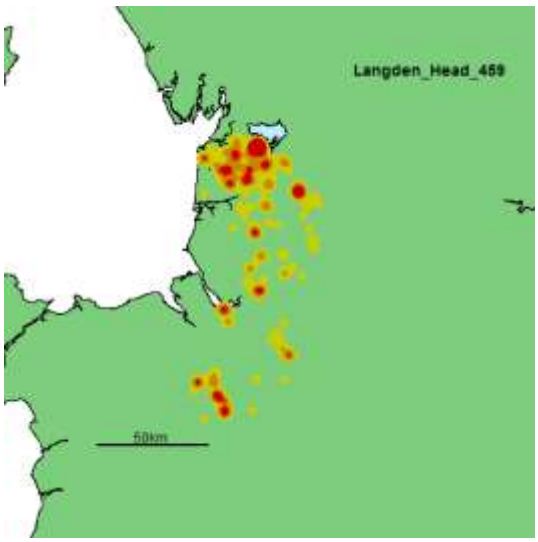

Langden_Head_457
50km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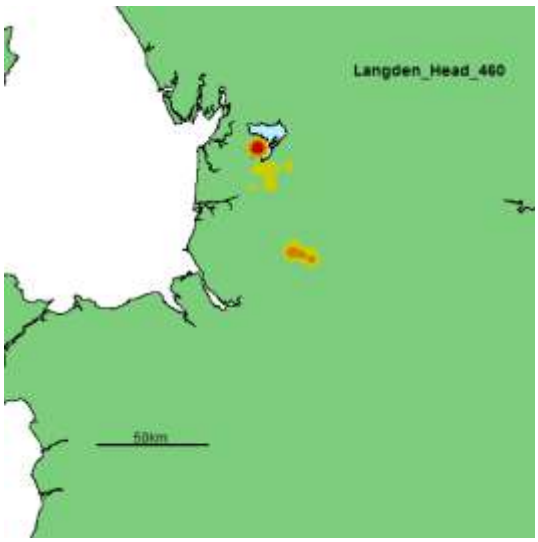
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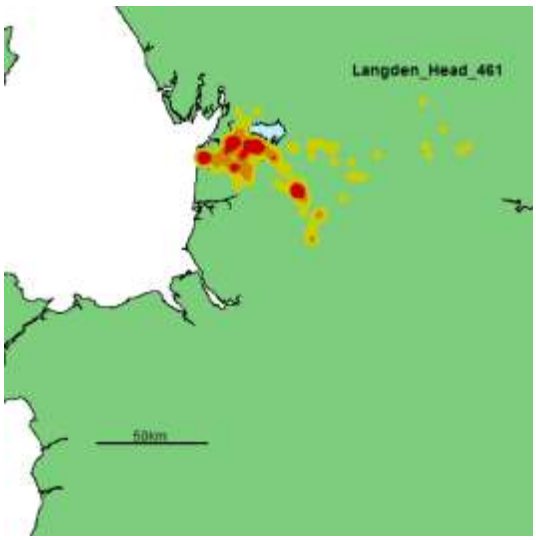
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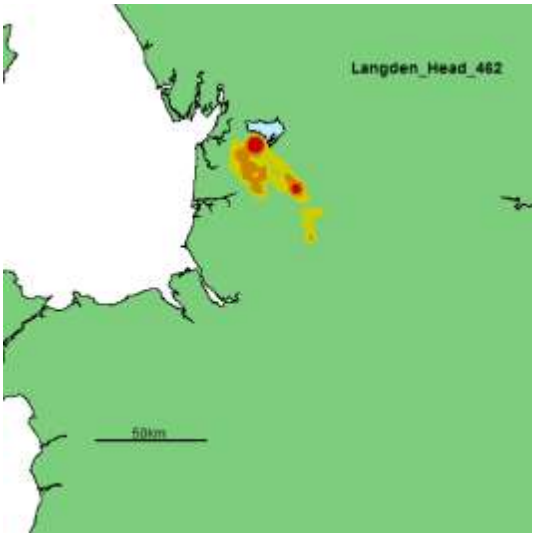
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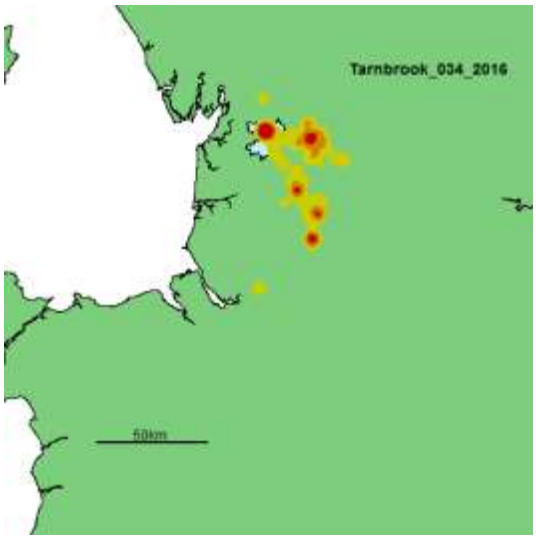
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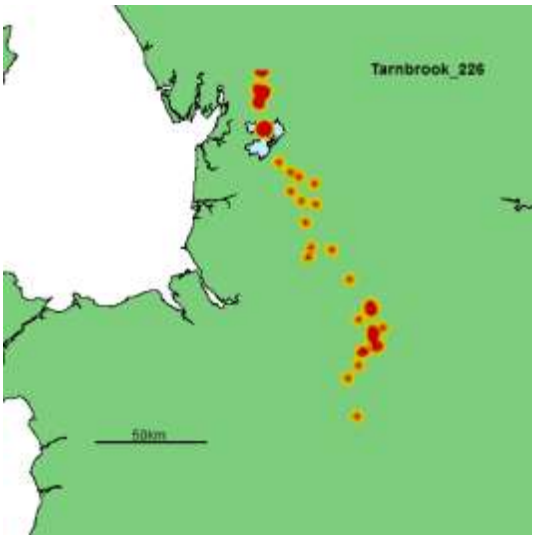
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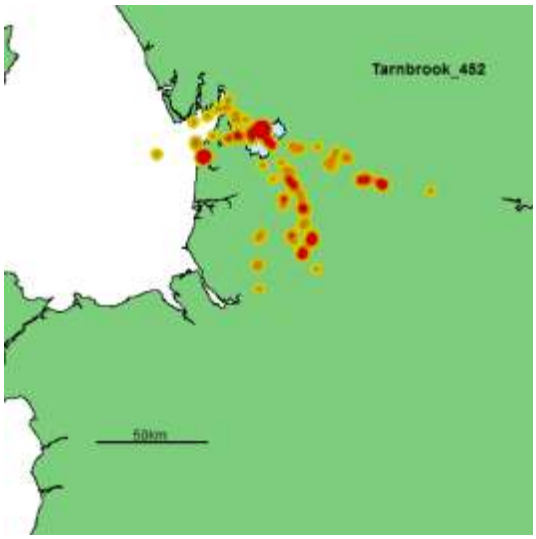
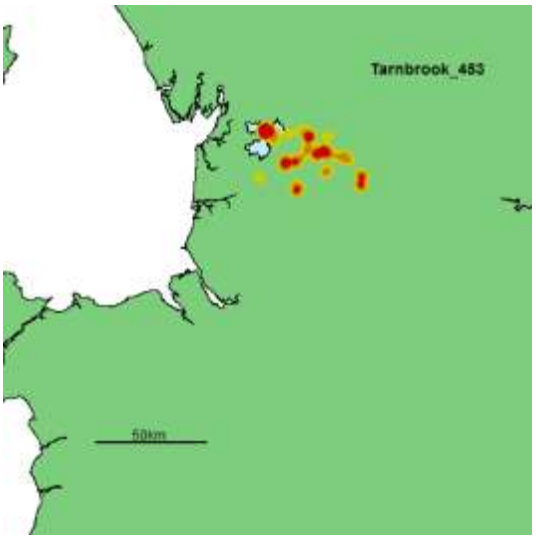
50km


Tarnbrook_452
50km


Tarnbrook_453
50km

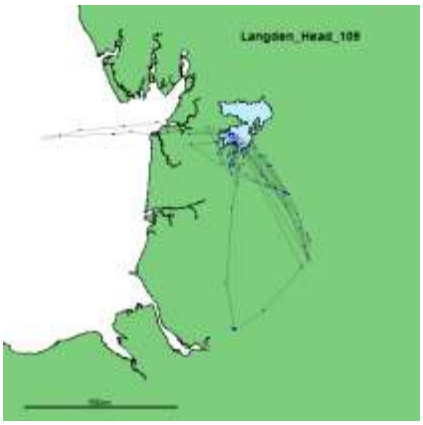
**Appendix 4** Details of tagged Lesser Black-backed Gulls from the Bowland Fells SPA reported as dead (up until 31/12/2016).

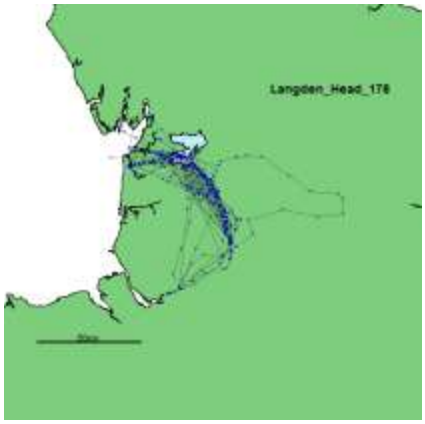
| Year caught | Year found | Tag ID | Found by | Finding circumstances |
|---|---|---|---|---|
| 2016 | 2016 | 263 | Staff | Presumed death around 28/7/16 near busy road. Tag not recovered. Would not have been known about if not for tag data. |
| 2016 | 2016 | 284 | Public | Collision with power lines reported by member of public 26/8/16 |
| 2016 | 2016 | 462 | Staff | Death around 25/8/16 near M1/M6 interchange. Scavengers took body but left tag, which was recovered. Would not have been known about if not for tag data. |

**Appendix 5** Plots of GPS tracks from individual Lesser Black-backed Gulls from the Bowland Fells SPA irrespective of data quality.

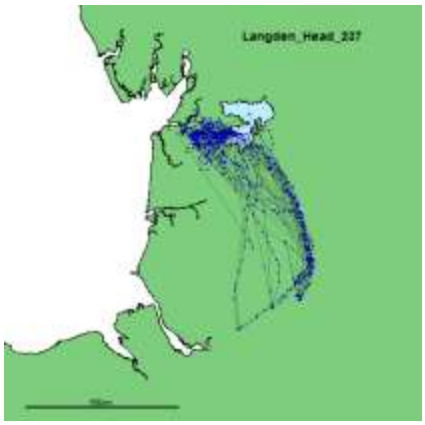






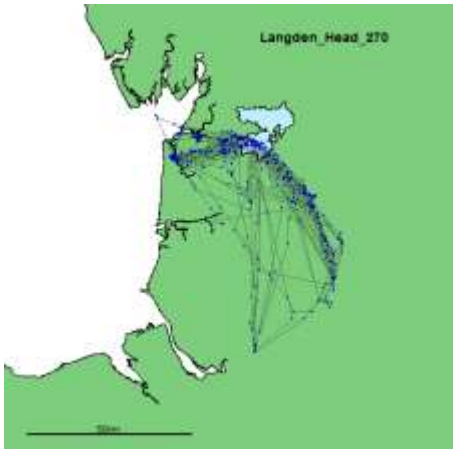




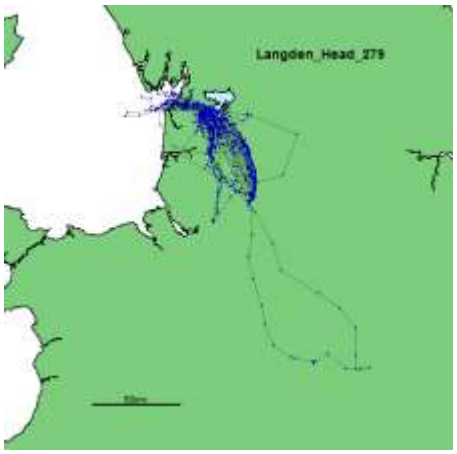

Langden_Head_282


Langden_Head_283

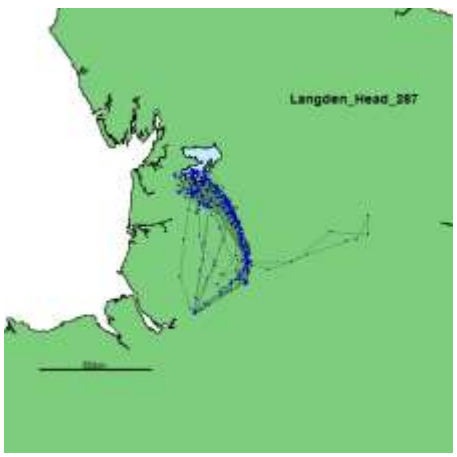

Langden_Head_269


Langden_Head_270

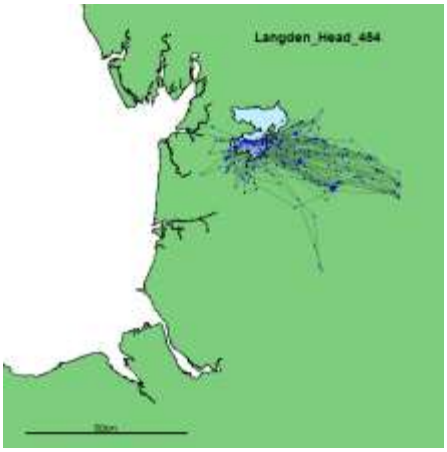

Langden_Head_277

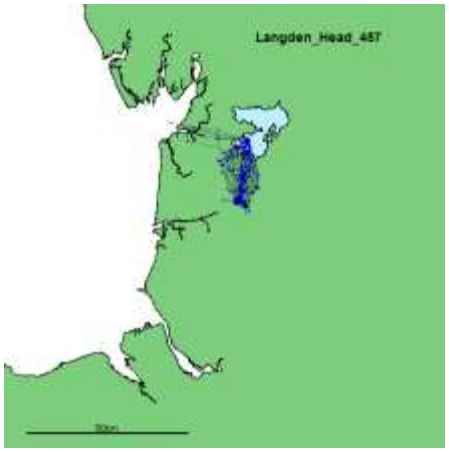

Langden_Head_279


Langden_Head_284

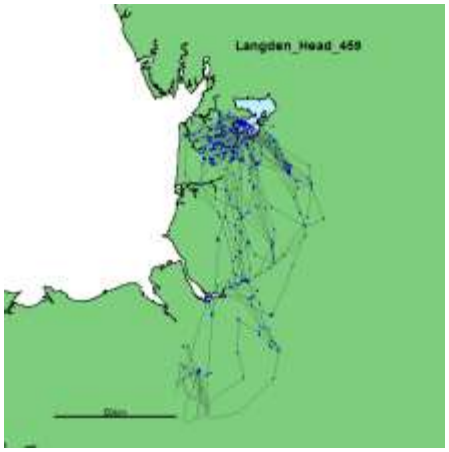

Langden_Head_287

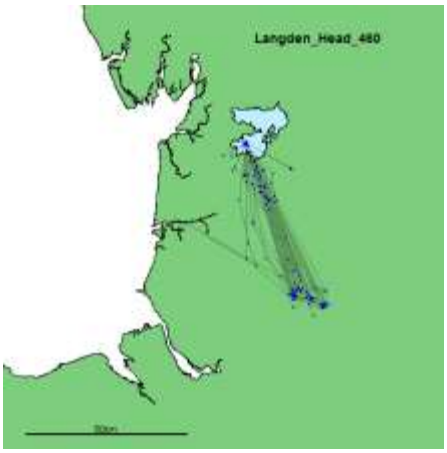

Langden_Head_451

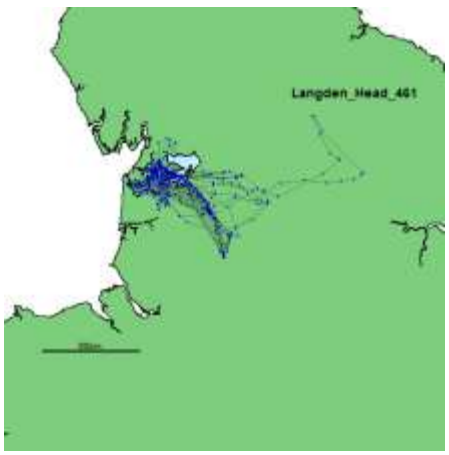

Langden_Head_454


Langden_Head_457


Langden_Head_458


Langden_Head_459


Langden_Head_460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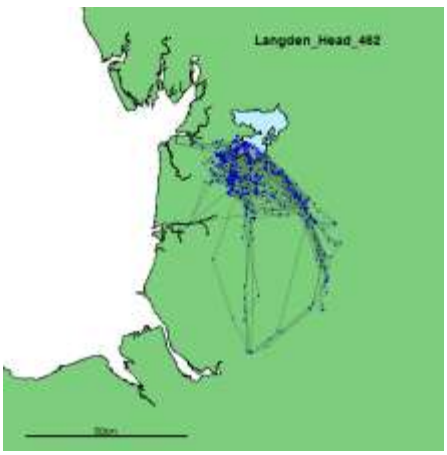
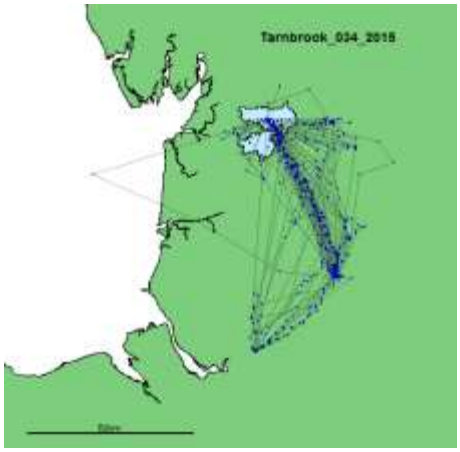
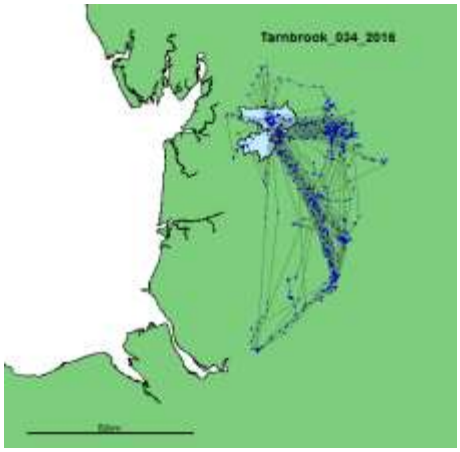
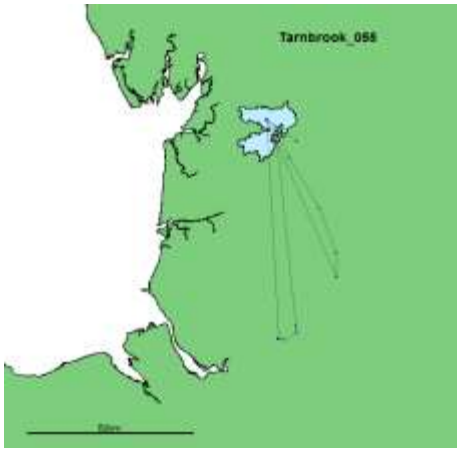
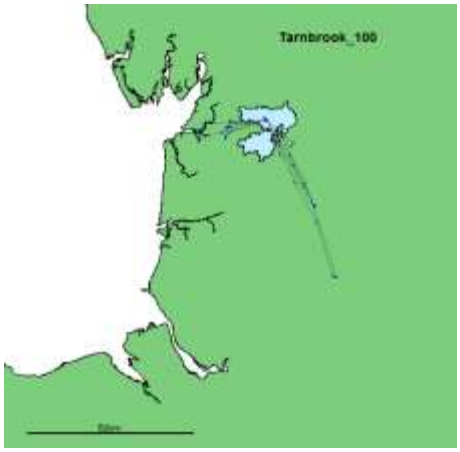
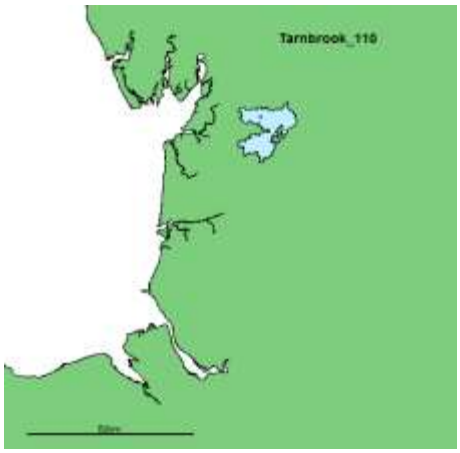

Langden_Head_462

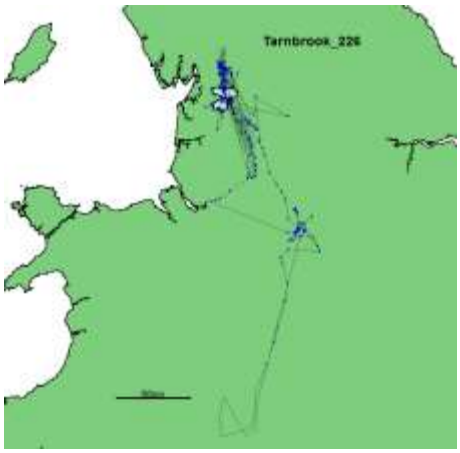

Tarnbrook_034_2015

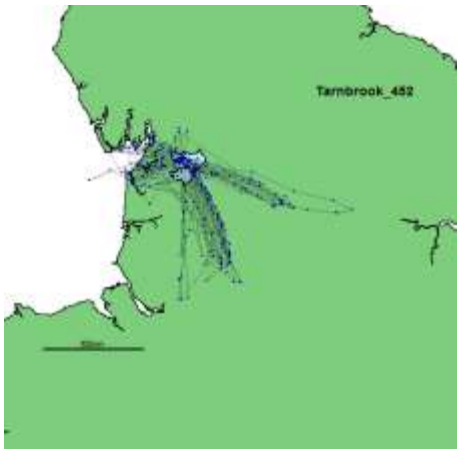

Tarnbrook_034_2016

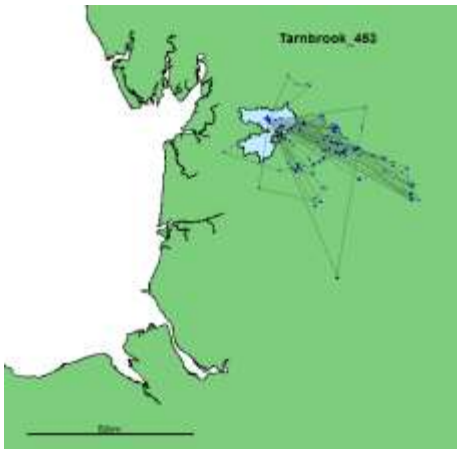

Tarnbrook_058


Tarnbrook_100

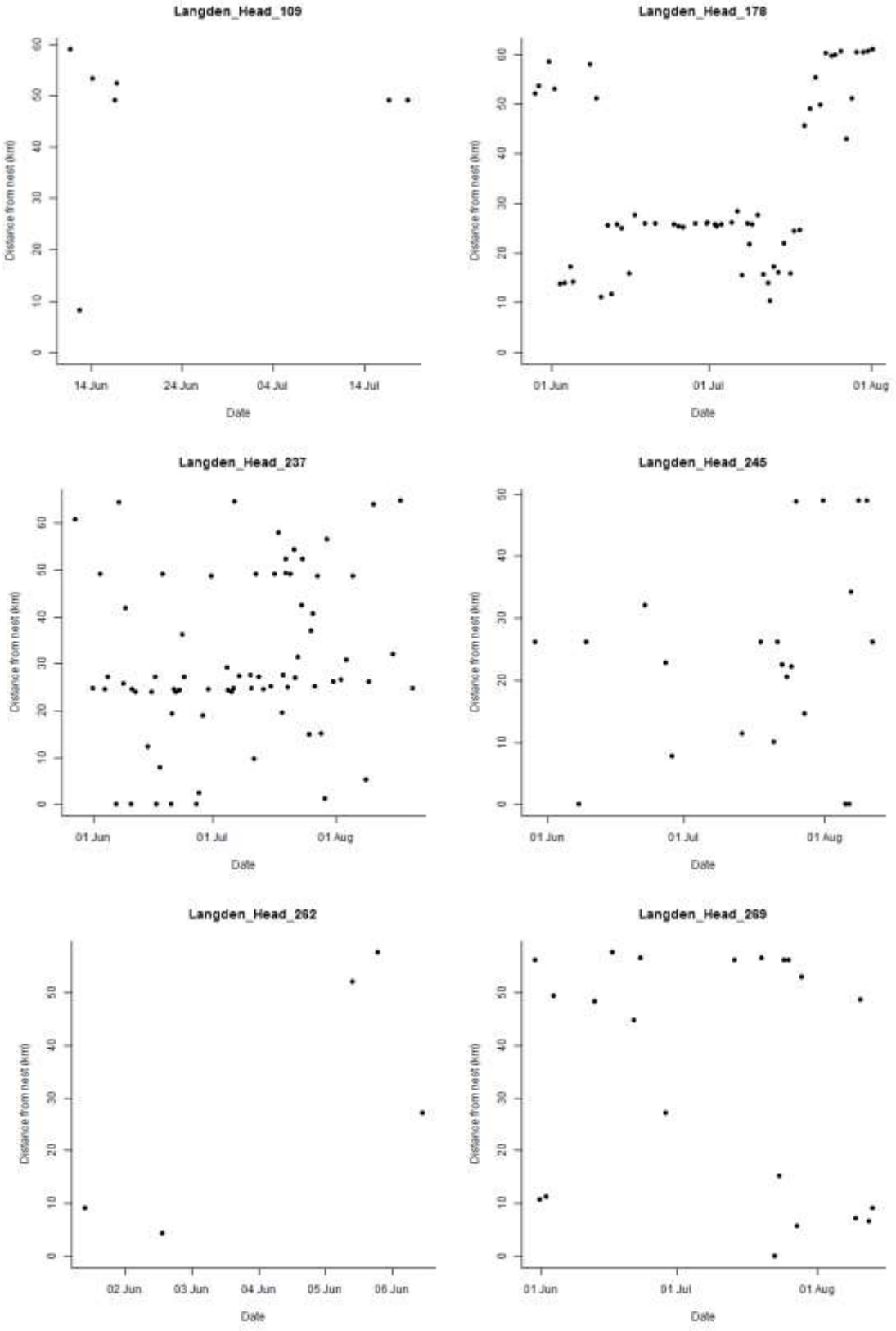

Tarnbrook_110

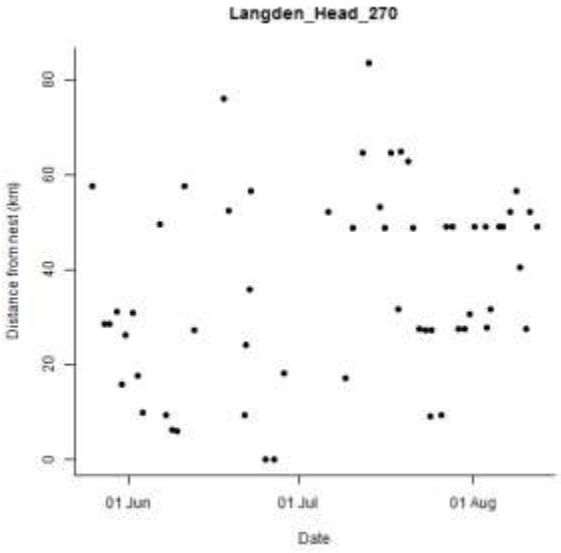

Tarnbrook_226

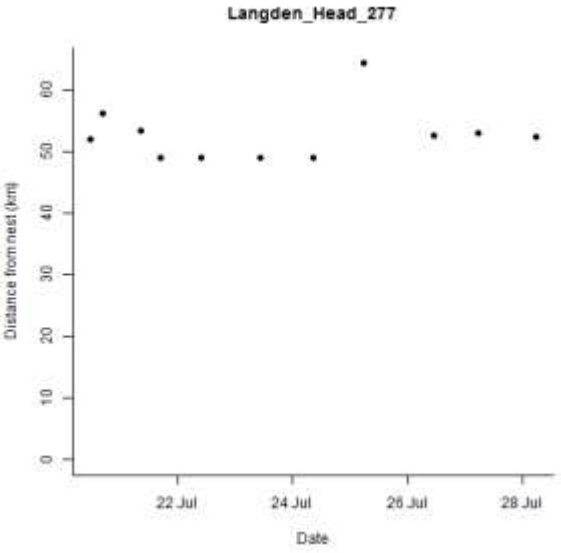

Tarnbrook_452

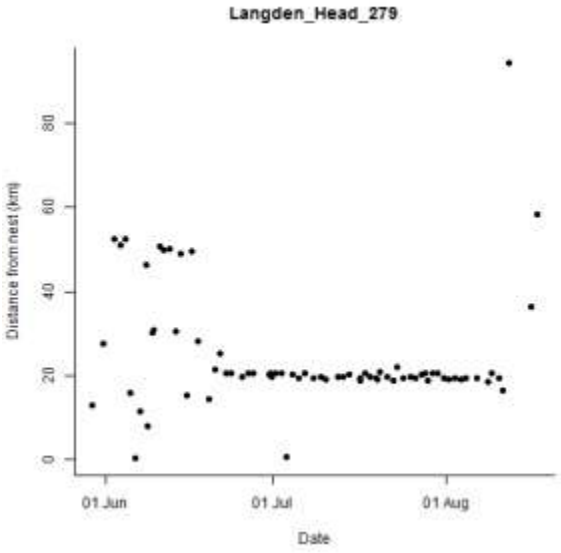

Tarnbrook_453

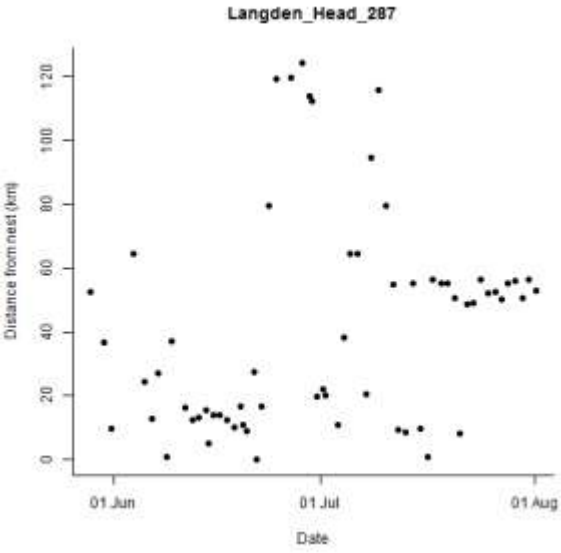
**Appendix 6** Individual plots of maximum foraging distance reached on each trip away from the colony for Lesser Black-backed Gulls fitted with GPS-GSM devices on Bowland Fells SPA.

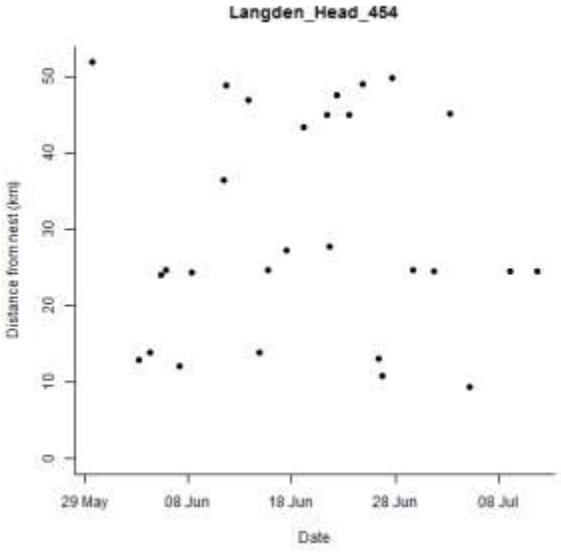


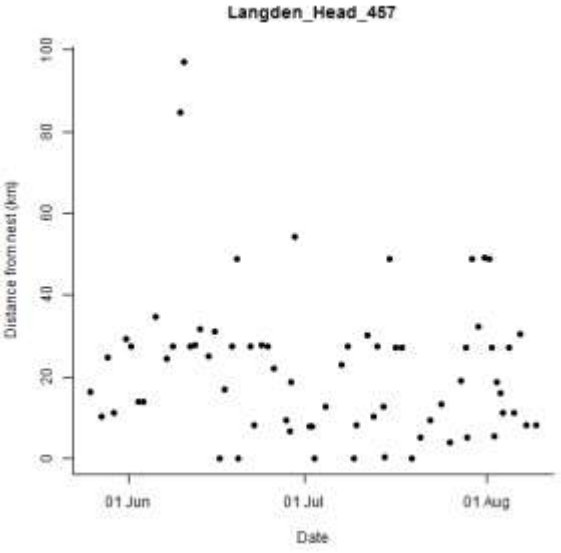

Langden_Head_270
Distance from nest (km)
0
20
40
60
80
01 Jun
01 Jul
01 Aug
Date

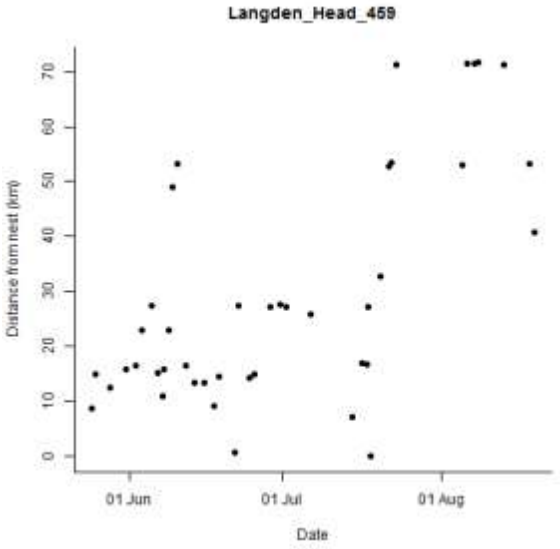

Langden_Head_277
Distance from nest (km)
0
10
20
30
40
50
60
22 Jul
24 Jul
26 Jul
28 Jul
Date

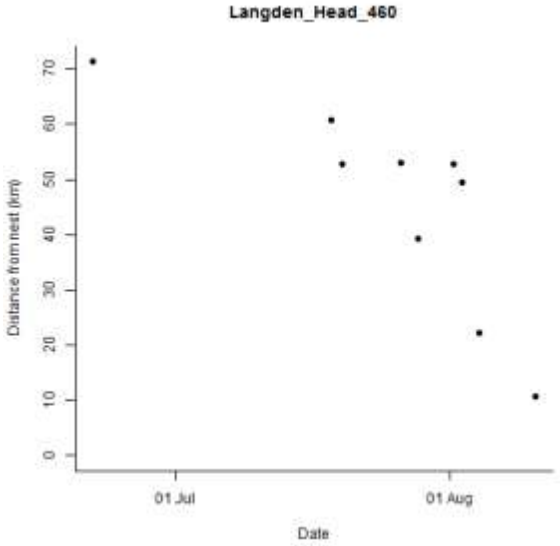

Langden_Head_279
Distance from nest (km)
0
20
40
60
80
01 Jun
01 Jul
01 Aug
Date

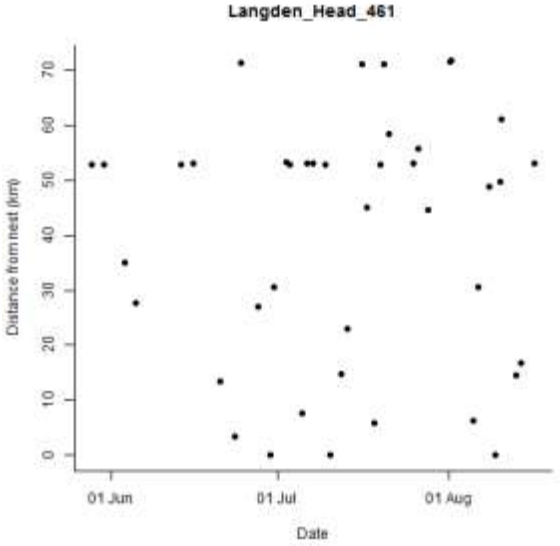

Langden_Head_287
Distance from nest (km)
0
20
40
60
80
100
120
01 Jun
01 Jul
01 Aug
Date

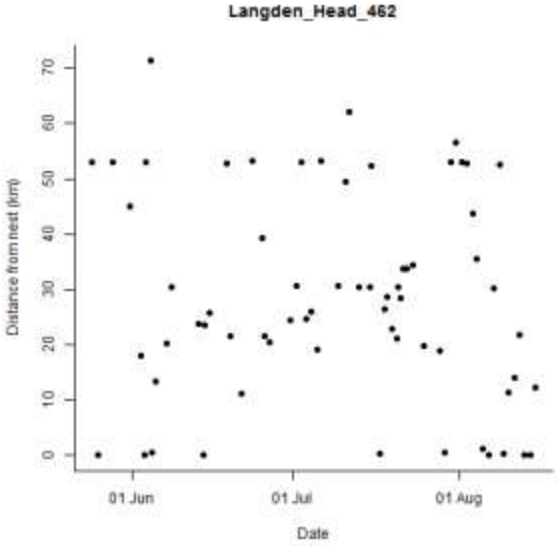

Langden_Head_454
Distance from nest (km)
0
10
20
30
40
50
29 May
08 Jun
18 Jun
28 Jun
08 Jul
Date

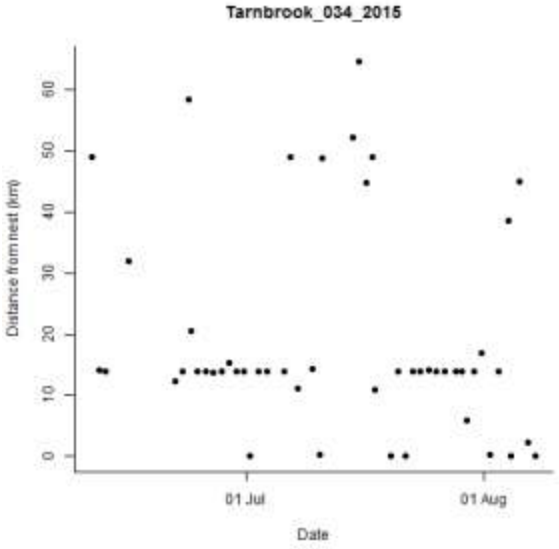

Langden_Head_457
Distance from nest (km)
0
20
40
60
80
100
01 Jun
01 Jul
01 Aug
Date

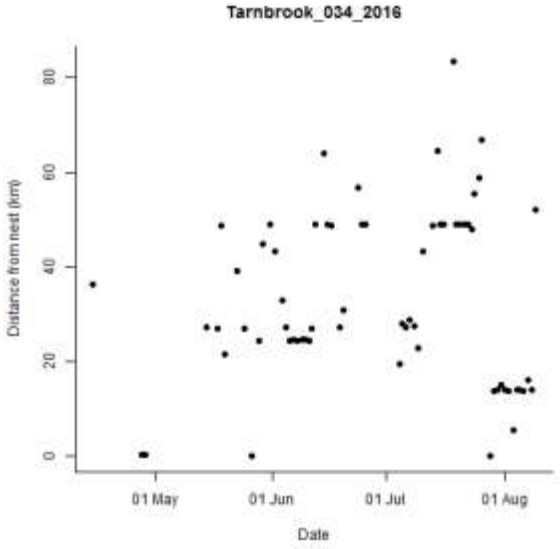

Langden_Head_459
Distance from nest (km)
0
10
20
30
40
50
60
70
01 Jun
01 Jul
01 Aug
Date

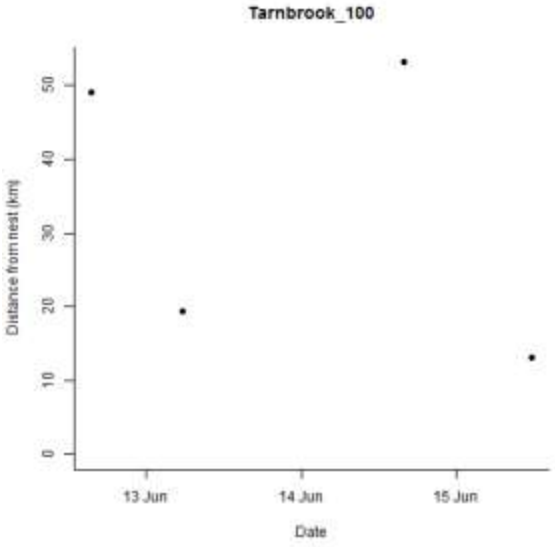

Langden_Head_460
Distance from nest (km)
0
10
20
30
40
50
60
70
01 Jul
01 Aug
Date

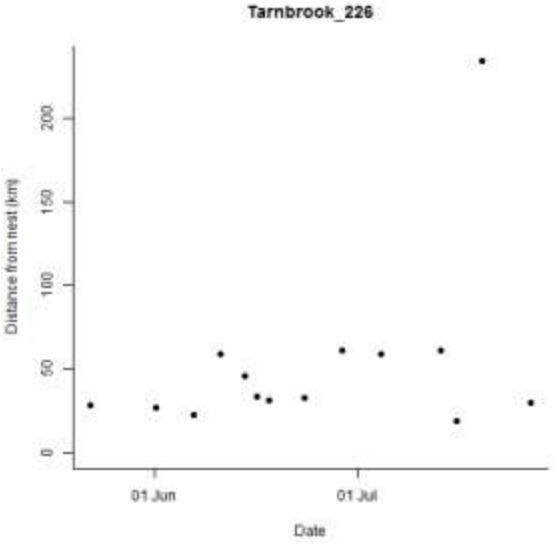

Langden_Head_461
Distance from nest (km)
0
10
20
30
40
50
60
70
01 Jun
01 Jul
01 Aug
Date

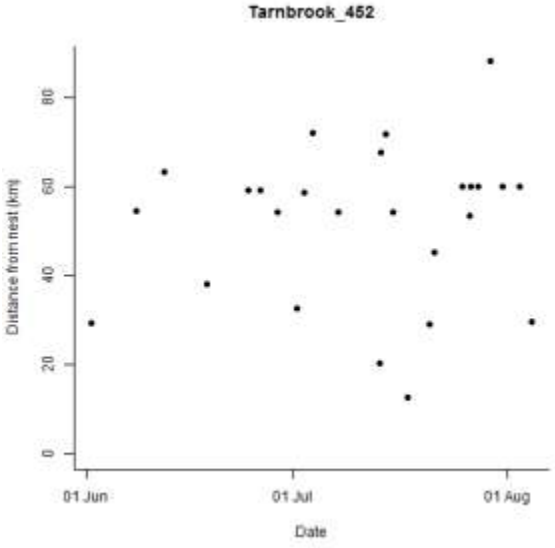

Langden_Head_462
Distance from nest (km)
0
10
20
30
40
50
60
70
01 Jun
01 Jul
01 Aug
Date

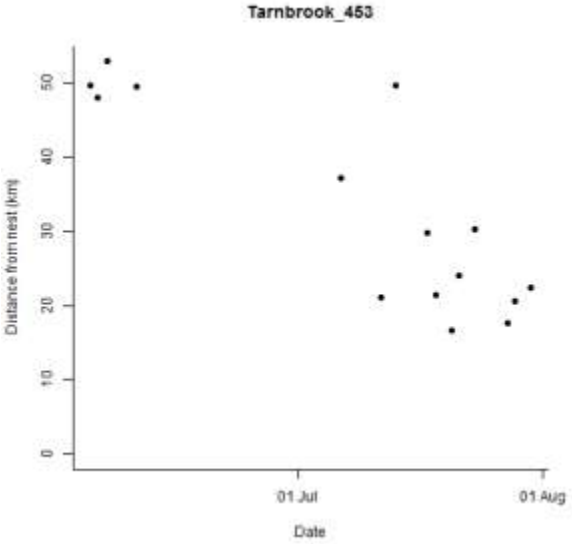

Tarnbrook_034_2015
Distance from nest (km)
0
10
20
30
40
50
60
01 Jul
01 Aug
Date


Tarnbrook_034_2016
Distance from nest (km)
0
20
40
60
80
01 May
01 Jun
01 Jul
01 Aug
Date


Tarnbrook_100
Distance from nest (km)
0
10
20
30
40
50
13 Jun
14 Jun
15 Jun
Date


Tarnbrook_226
Distance from nest (km)
0
50
100
150
200
01 Jun
01 Jul
Date


Tarnbrook_452
Distance from nest (km)
0
20
40
60
80
01 Jun
01 Jul
01 Aug
Date


Tarnbrook_453
Distance from nest (km)
0
10
20
30
40
50
01 Jul
01 Aug
Date