BTO RESEARCH REPORT 714

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Report of work carried out by the British Trust for Ornithology
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EXECTUTIVE SUMMARY

1. Findings from GPS tracking of Lesser Black-backed Gulls (*Larus fuscus*) breeding at the Bowland Fells Site of Special Scientific Interest (SSSI) and Special Protection Area (SPA) in 2017 and 2018 are presented, building on previous results from 2016. The aims of the study have been 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 within the SPA boundary.

2. Sufficient data for analyses were obtained in 2017 from 11 returning adult Lesser Black-backed Gulls tagged with GPS-GSM devices (Movetech Telemetry) in 2016 plus an additional two birds also fitted with tags in 2017. Sufficient data were obtained for eight individuals in 2018, six of which had been tracked for three consecutive years. Tags were originally deployed at two sites within the Bowland Fells SPA (Tarnbrook Fell and Langden Head). Data were analysed for the periods from when individuals were tagged or first returned to the Bowland Fells SPA at the start of the breeding season up until the last date each breeding season that they were present in the SPA.

3. Home range analyses were carried out using time invariant kernel density estimate (KDE) 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. The tracking data from Lesser Black-backed Gulls from the Bowland Fells SPA in 2017 and 2018 were consistent with previous findings for 2016 and highlighted the importance of terrestrial habitats. There was some individual variation in the extent and pattern of birds' foraging ranges. However, for all birds, home range analyses indicated that key foraging areas were outwith the SPA. The degree of overlap between individual core home ranges (50% KDEs) and the SPA was <25% (mean = 6.5%) in 2016, <18% (mean = 3.6%) in 2017 and <12% (mean = 3.4%) in 2018. Equivalent figures for total home ranges (95% KDEs) were <16% (mean = 6.7%) in 2016, <13% (mean = 6.8%) in 2017 and <10% (mean = 6.7%) in 2018. The average time spent inside the SPA boundary, but away from the breeding colony, was 11.9% of the total tracking period in 2016, 9.5% in 2017 and 6.3% in 2018.

5. The most frequently visited habitats tended to be urban areas and landfill sites to the south and southeast of the SPA but regular use of nearby agricultural land was also seen. As in 2016, marine environments were only sparsely used in 2017 and 2018.

6. The additional years of tracking data confirm the previous assessment that the SPA provides an important breeding site for Lesser Black-backed Gulls, but that their key foraging sites are outside the SPA. While many individuals were consistent in their foraging site preferences across years, there were examples of birds shifting sites. It is likely that as some preferred areas, especially landfills, become less profitable for foraging in the future, birds will shift more to more urban or agricultural foraging depending on individual preference and stage of breeding.

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.* 2016) and pSPA (potential SPA) feature.

The Lesser Black-backed Gull breeding population at the Bowland Fells SSSI/SPA has recently been growing since control measures ceased in 2012. 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 (O'Connell 1995). Some of 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 Aims

In spring 2015, initial work was undertaken to deploy 12 Global Positioning System-Global System for Mobile Communication (GPS-GSM) tags on Lesser Black-backed Gulls at the Bowland Fells SPA to investigate their movements. Unfortunately subsequent tag 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) within the SPA (Clewley *et al.* 2017a). To add to the data from birds returning for the 2017 breeding season, two additional birds were fitted with improved GPS tags in 2017 on the Tarnbrook Fell site to replace two tags which did not function as expected during 2016 (Clewley *et al.* 2017b).

The aims of the study have been 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 within the SPA boundary.

The outputs from this work can help to inform understanding of the space use of Lesser Black-backed Gulls from this breeding population in comparison to other birds that have been tracked from colonies at South Walney in the Morecambe Bay and Duddon Estuary SPA and in the Ribble and Alt Estuaries SPA, and will also help to inform understanding of the extent of interaction of the Bowland Fells population with those breeding populations at South Walney and the Ribble Estuary. The study will 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 will 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.

An evaluation of the space use of Lesser Black-backed Gulls from colonies in the Bowland Fells SPA in the 2016 breeding season was provided in Clewley *et al.* (2017a) and a summary update also provided for the 2017 breeding season in Clewley *et al.* (2017b). This report presents a comparable assessment of space use for 2017 and 2018.

2. METHODS

2.1 Focal Species

The Lesser Black-backed Gull (the UK sub-species of which is *L. fuscus graellsii*) is a breeding qualifying feature or potential qualifying feature of five SPAs in England, two in Scotland, one in Wales and two in Northern Ireland (SPA Review: Stroud *et al*. 2016). 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). Earlier research also focused particularly on the species' general breeding biology, diet, and kleptoparasitism (Camphuysen 1995, Calladine 1997, Galván 2003, Kubetzki & Garthe 2003, Kim & Monaghan 2006). Increasingly, the species has been tracked from different breeding locations across Europe, for example, in the Netherlands (Camphuysen 2011, Shamoun-Baranes *et al*. 2011, 2016, 2017, Stienen *et al.* 2016), Germany (Corman & Garthe 2014, Garthe *et al.* 2016), Belgium (Stienen *et al.* 2016), Finland (Juvaste *et al.* 2017), Sweden (Isaksson *et al.* 2016) and the UK (Thaxter *et al.* 2014a, 2015, 2018, Ross-Smith *et al.* 2016).

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 at two Lesser Black-backed Gull colonies within the Bowland Fells SPA: at Tarnbrook Fell (54.015° N, 2.59° W) and 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.

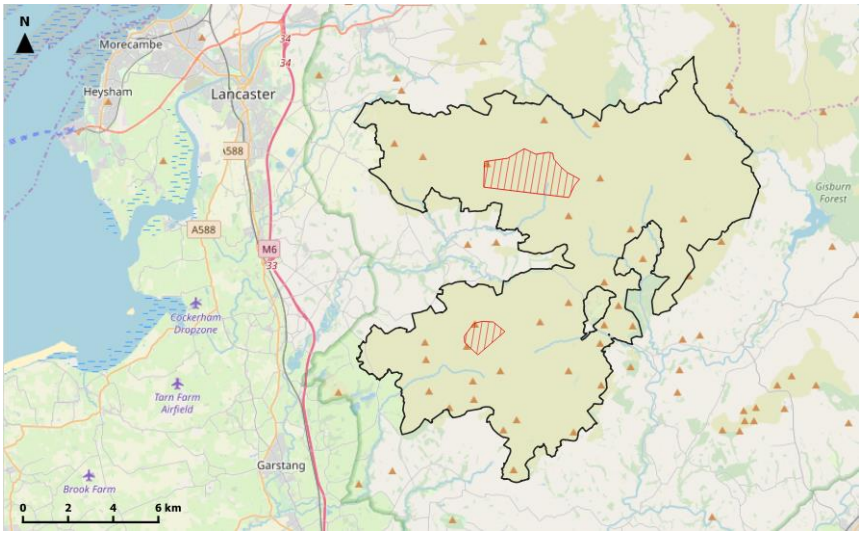


Figure 2.1 Location of each field site, Langden Head in the south and Tarnbrook Fell in the north, within the Bowland Fells SPA (black outline) and the approximate boundaries of the colonies (red). Basemap ©OpenStreetMap Contributors.

2.3 Capture and Attachment Methods in 2015, 2016 and 2017

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 and once a bird had entered and settled onto the nest, the trap could be approached and bird retrieved. If the presence of fieldworkers in direct line of sight disturbed the birds and prevented them from returning to nests immediately then the fieldworkers would conceal themselves nearby to the nest and wait for a maximum of 30 minutes before inspecting the traps. If there was any colony disturbance before the end of 30 minutes then the traps would be inspected immediately.

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.

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 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). An additional five birds were captured at Tarnbrook in 2017 in order to deploy the two final tags. All birds were weighed, measured and fitted with a unique metal leg ring. All birds tagged and a further sample of 19 'control' birds were fitted with a unique engraved colour ring for subsequent identification in the field.

GPS tags were fitted to the birds using a permanent wing loop harness made from tubular Teflon (see Thaxter *et al*. 2014b, 2016 for a detailed harness design). Tags fitted in 2016 weighed 20-25.5g, which represented <3% body mass for the birds in this study: mean ± SD: 788 ± 90g, range: 620-1040g. On average, birds caught in 2016 at Tarnbrook weighed slightly less than those caught at 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 two tags deployed at Tarnbrook in 2017 weighed c. 18.5g and were fitted to individuals weighing over 850g; three additional birds were caught but were too light (under 800g) for tagging (Appendix 1).

The mean time from capture to release (in 2016) 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.

2.4 Nest Monitoring in 2017 and 2018

Three separate nest monitoring visits were made during each of 2017 and 2018 to locate the nests of returning tagged birds and to compare their breeding success to that of a control sample of unmarked birds. Nests of tagged birds were identified by selecting the nearest nest to the centre point of stationary GPS data collected within the breeding colony; the nearest adjacent nest served as a paired control. Hatching success was defined as the proportion of eggs confirmed to hatch chicks and potential minimum nest success as the proportion of nests where chicks survived until the final visit. Due to chick movements, there was too much uncertainly after this point to assign individual chicks to nests and subsequently confirm actual fledging.

2.5 The GPS System

The GPS devices used in this study were developed by Movetech Telemetry (a consortium of scientific partners involving the University of East Anglia, cE3c from the Faculty of Sciences of the University of Lisbon, CIBIO/InBIO from the University of Porto and the BTO). 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. In areas of no network coverage, GPS data are still collected 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 (Movebank: https://www.movebank.org/).

2.6 Data

Data from 2017 and 2018 (Table 2.1) were downloaded in comma-separated value format. Analyses were restricted to the breeding season and periods immediately before and after (i.e. excluding migration and wintering). This period was defined from the first date an individual was recorded within the Bowland Fells SPA (or the beginning of tag deployment for the two additional birds tagged in 2017) up until the last fix obtained inside the Bowland Fells SPA. Any records which were duplicated, contain invalid GPS fixes or were derived from fewer than four satellites, thus likely to have a large GPS location error, were also removed from the dataset. For any individuals known or

suspected to have died, all records were excluded from analysis after the first fix when it was apparent that the bird had become stationary.

When tracking the movements of breeding birds, clusters of GPS fixes around nest sites can introduce bias into analyses of foraging home ranges. To avoid such bias and provide improved estimation of foraging home ranges, all analyses presented here used a subset of data whereby all fixes within the colony boundaries (Fig. 2.1) were excluded. Comparative results using all data from both within and away from the colony are presented in Appendix 2. Data from some individual birds were also excluded from the analyses if their tags provided insufficient data (Table 2.1); however, plots of raw tracking data for all birds are presented in Appendix 3. Comparative results from 2015 and 2016 (Clewley *et al.* 2017a) are also presented in Appendix 4.

Table 2.1 Overview of data collected from GPS-GSM tags deployed on Lesser Black-backed Gulls at the Bowland Fells SPA over the 2017 and 2018 breeding seasons. Individuals excluded from the analyses due to insufficient or low quality data are listed at the bottom for each respective year and highlighted in orange. Yellow highlighting indicates data of medium quality, where the sampling rate was lower than expected or where there was only partial coverage of the breeding season; green highlighting indicates data of high quality. Details of birds reported dead during the study are provided in Appendix 5.

Bird ID	Total GPS Fixes	Fixes Away From Colony	Tracking Period	Notes
2017				
Langden Head_237	4901	2545	19/03/2017 – 19/08/2017	
Langden Head_245	3338	2261	03/05/2017 – 19/08/2017	
Langden Head_269	3129	1607	21/04/2017 – 20/08/2017	
Langden Head_279	3441	1550	03/05/2017 – 04/08/2017	
Langden Head_287	3000	1669	01/04/2017 – 23/07/2017	
Langden Head_461	2231	1910	13/03/2017 – 16/07/2017	
Tarnbrook_226	3603	2315	07/04/2017 – 04/08/2017	
Tarnbrook_697	865	581	21/05/2017 – 14/08/2017	Tagged in 2017
Tarnbrook_728	1365	934	21/05/2017 – 14/08/2017	Tagged in 2017
Langden Head_178	616	267	31/03/2017 – 02/07/2017	Truncated data – bird died & reduced sampling rate
Langden Head_270	2805	1215	15/03/2017 – 16/07/2017	Truncated data – bird died
Langden Head_277	1085	339	29/03/2017 – 06/07/2017	Reduced sampling rate
Langden Head_459	857	460	09/04/2017 – 31/07/2017	Reduced sampling rate
Langden Head_451	99	14	31/03/2017 – 24/05/2017	Excluded – small sample
Langden Head_457	292	100	12/03/2017 – 24/05/2017	Excluded – small sample
Langden Head_460	261	170	05/05/2017 – 21/06/2017	Excluded – small sample
Langden Head_262	-	-	NA	Reported dead in 2017
Langden Head_263	-	-	NA	Reported dead in 2016
Langden Head_284	-	-	NA	Reported dead in 2016
Langden Head_454	-	-	NA	Did not transmit during breeding season
Langden Head_458	-	-	NA	Did not transmit during breeding season
Langden Head_462	-	-	NA	Reported dead in 2016
Tarnbrook_452	-	-	NA	Did not transmit during breeding season
Tarnbrook_453	-	-	NA	Did not transmit during breeding season
2018				
Langden Head_245	1815	774	17/04/2018 - 26/06/2018	
Langden Head_269	1568	780	06/04/2018 - 14/08/2018	
Tarnbrook_226	3039	1368	03/04/2018 - 24/07/2018	
Tarnbrook_728	1949	991	09/04/2018 - 08/08/2018	
Langden Head_237	2705	1175	14/03/2018 - 06/06/2018	Truncated data – bird died
Langden Head_459	811	398	03/04/2018 - 25/07/2018	Reduced sampling rate
Langden Head_461	866	698	12/03/2018 - 02/05/2018	Truncated data – bird died
Tarnbrook_697	357	198	04/04/2018 - 03/05/2018	Truncated data – bird died or harness failure
Langden Head_460	96	41	21/06/2018 - 10/08/2018	Excluded – small sample

2.7 Analyses

2.7.1 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 3.4.1 (R Core Team 2017) and spatial overlaps using QGIS (QGIS Development Team 2018).

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).

2.7.2 Temporal Analyses

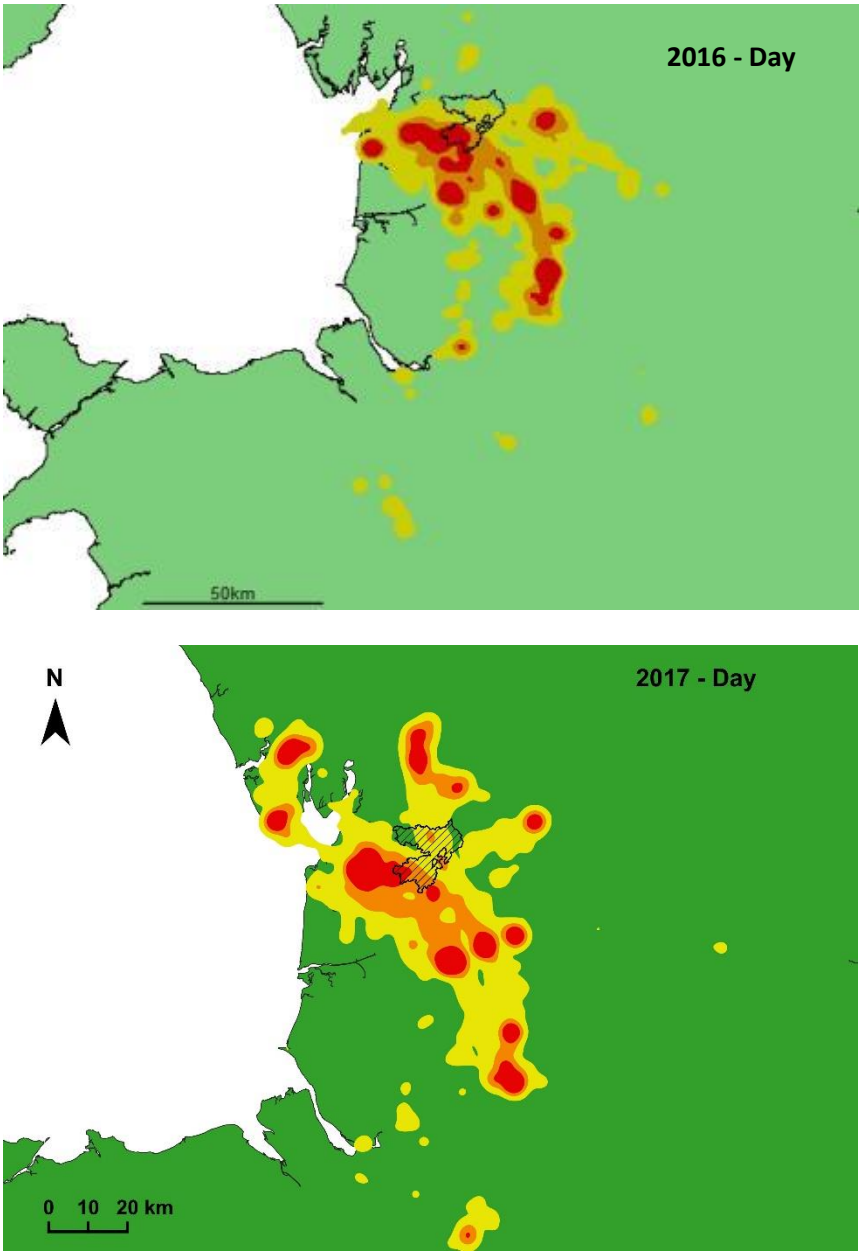
For each individual, we calculated the time spent in the Bowland Fells SPA using GPS data interpolated to 10 second intervals assuming linear and constant travel between successive locations using the 'adehabitatLT' R package (Calenge 2006). Interpolated data can then be used to identify the most probable 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 Home Range

3.1.1 Day-time home range

Home range estimates are presented in Figure 3.1 for 2016 (results taken from Clewley *et al.* 2017a), 2017 and 2018. The home ranges identify the most important areas of space use, which for the day-time subset of the data, represent key foraging locations. The core home ranges cover several landfill sites and urban areas, particularly to the south and southeast of the Bowland Fells SPA, as well as farmland to the west and north. There was virtually no overlap with any marine environment in any of the years. The extents of the estimated home ranges and overlaps with the SPA are summarised in Table 3.1.



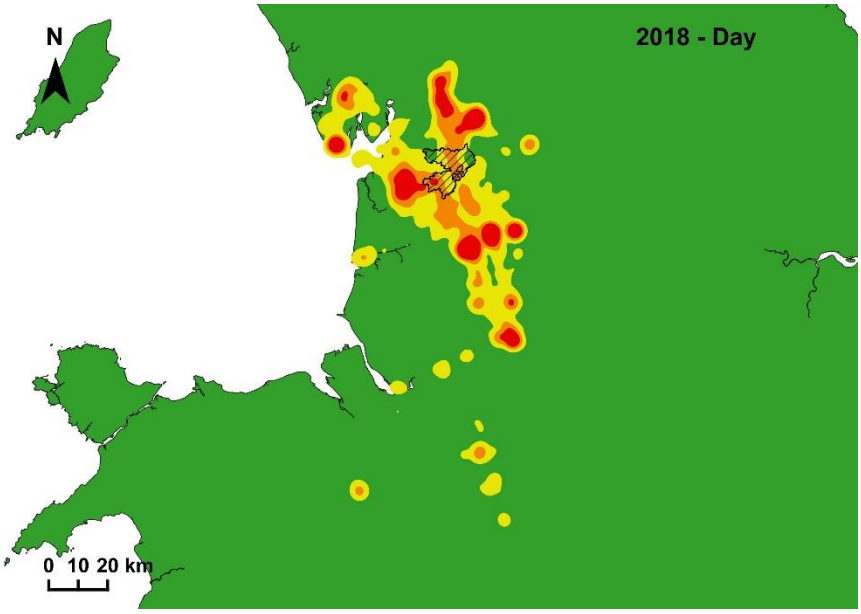
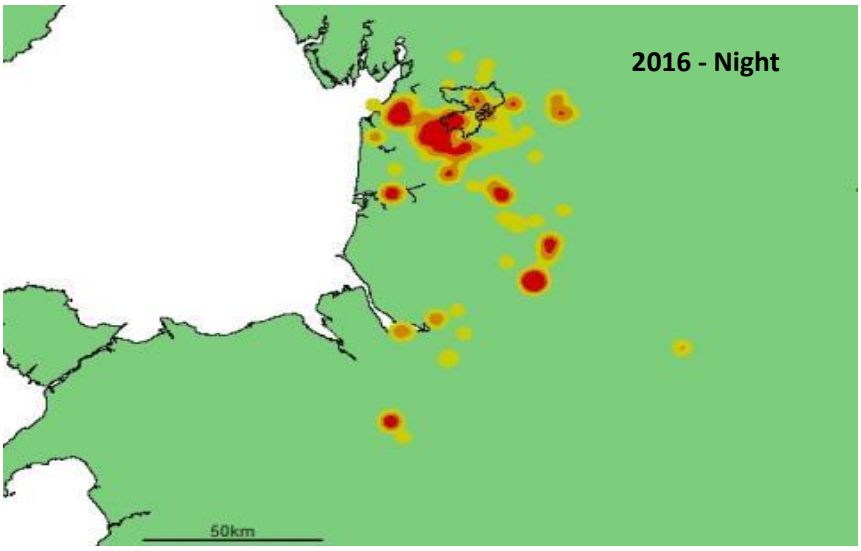


Figure 3.1 Kernel density estimate utilisation distributions for Lesser Black-backed Gulls from the Bowland Fells SPA for 2016 (taken from Clewley *et al.* 2017a*;* n = 19 individuals; 4870 fixes), 2017 (n = 13 individuals; 6710 fixes) and 2018 (n = 7 individuals; 2929 fixes). Estimated using GPS fixes 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.

3.1.2 Night-time home range

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 fixes. Much of the core home range areas coincide with the day estimates (Fig 3.2).



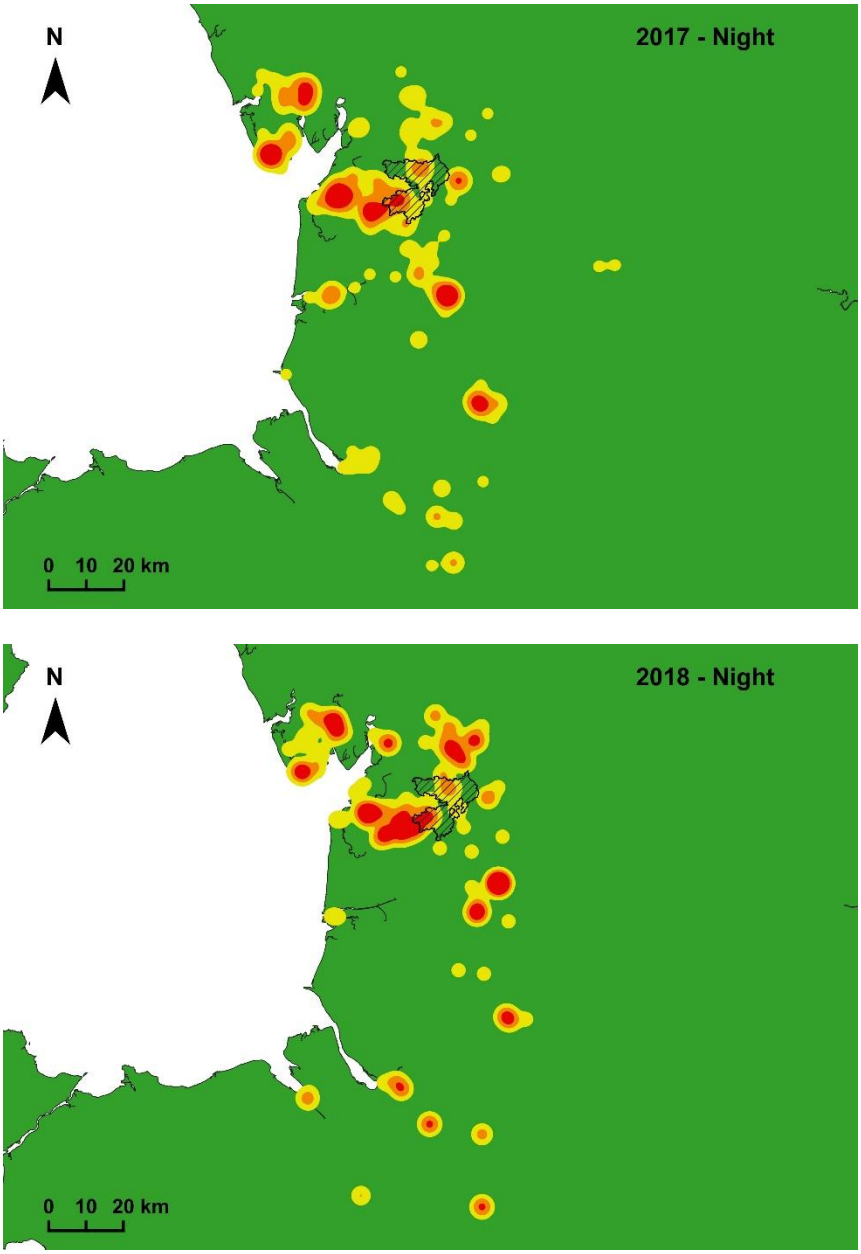
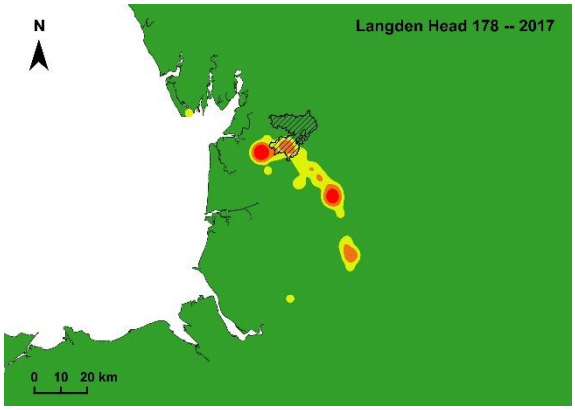


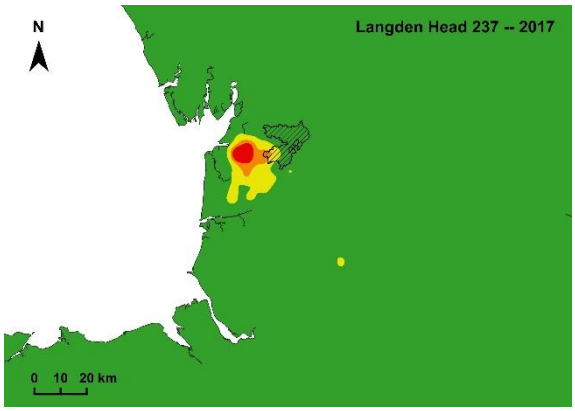
Figure 3.2 Kernel density estimate utilisation distributions for Lesser Black-backed Gulls from the Bowland Fells SPA for 2016 (taken from Clewley *et al.* 2017a*;* n = 19 individuals; 295 fixes), 2017 (n = 12 individuals; 561 fixes) and 2018 (n = 7 individuals; 267 fixes). Estimated using GPS fixes 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.

3.1.3 Individual home ranges in the day

Data were only sufficient to consider the home ranges of individual birds during the day. Home ranges are presented for individuals in 2017 and 2018 separately (Figs. 3.3 and 3.4 respectively), with a satellite imagery screenshot covering the area of each individual's core home range, where fix density was highest, to illustrate habitat use. Individual sample sizes used for calculating home ranges are presented in Table 3.1.


N
Langden Head 178 -- 2017
0 10 20 km


0 2 km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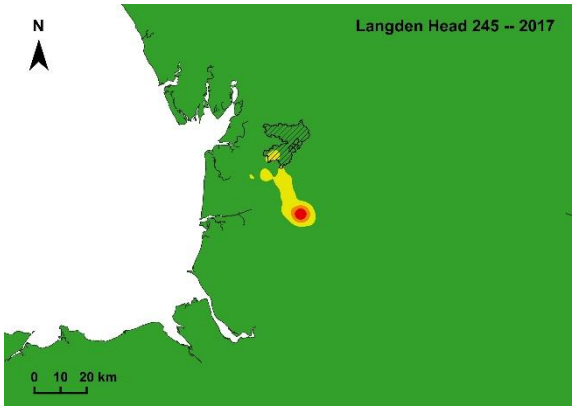
Langden Head 237 -- 2017
0 10 20 km


0 1 2 km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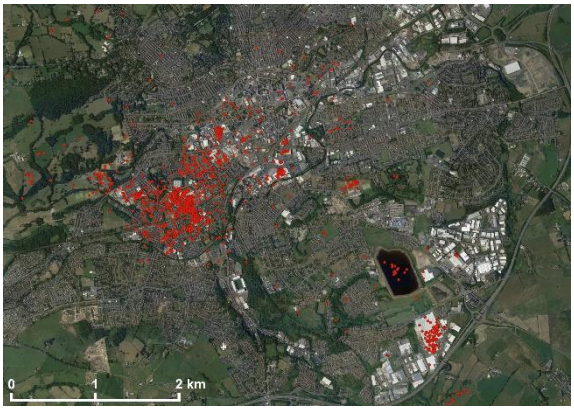
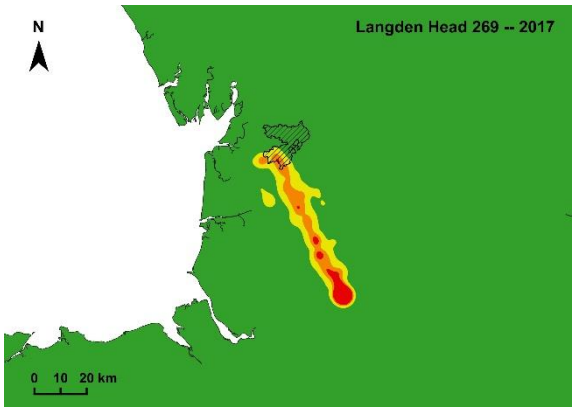
Langden Head 245 -- 2017
0 10 20 km


0 1 2 km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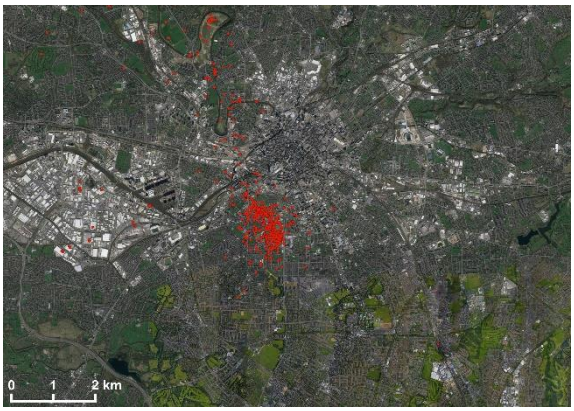
Langden Head 269 -- 2017
0 10 20 km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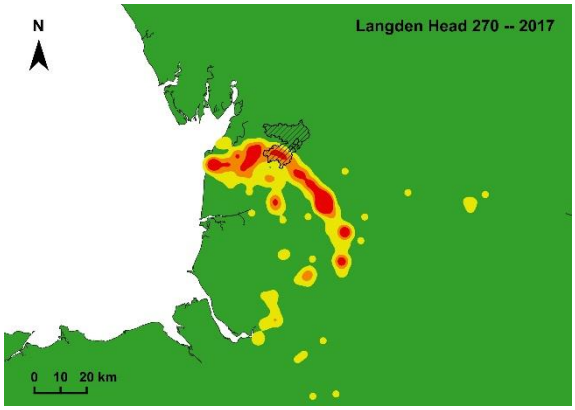
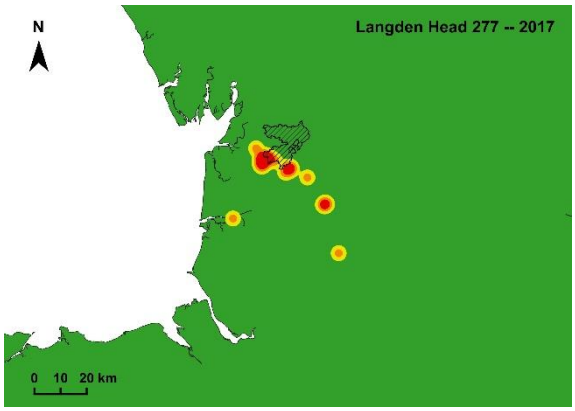

N
Langden Head 270 -- 2017
0 10 20 km


0 1 2 km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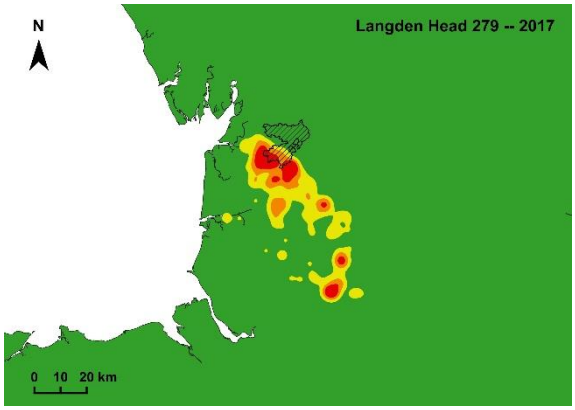
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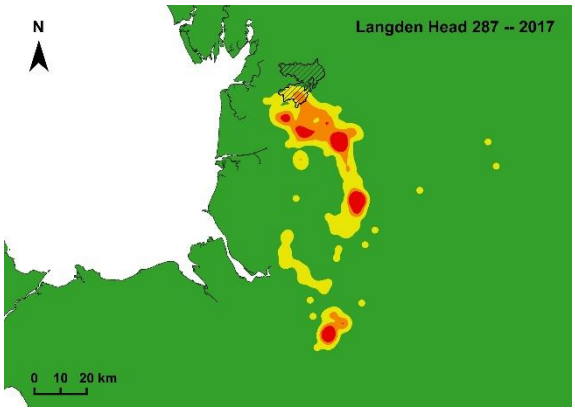
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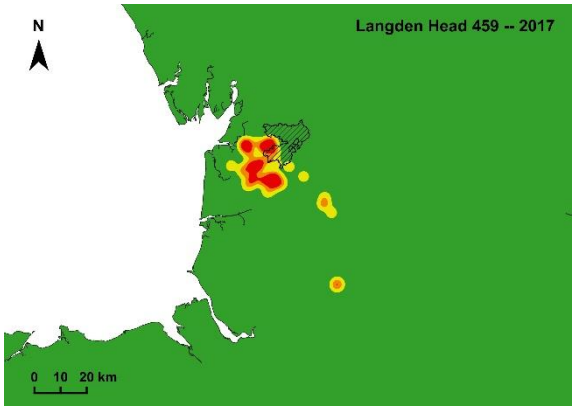
0 1 2 km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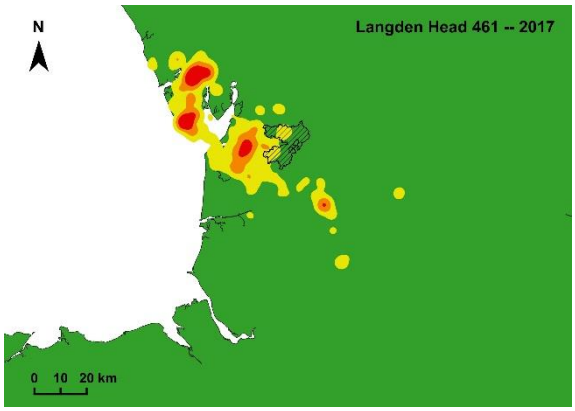
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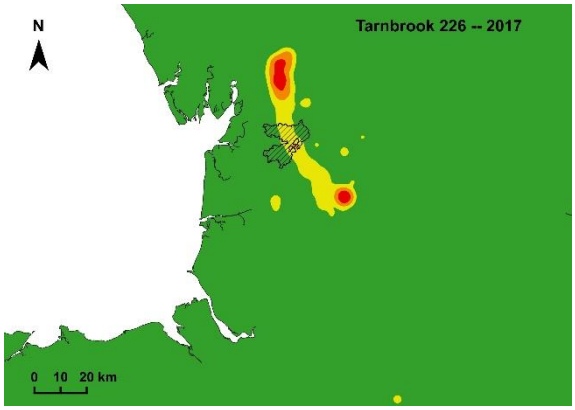
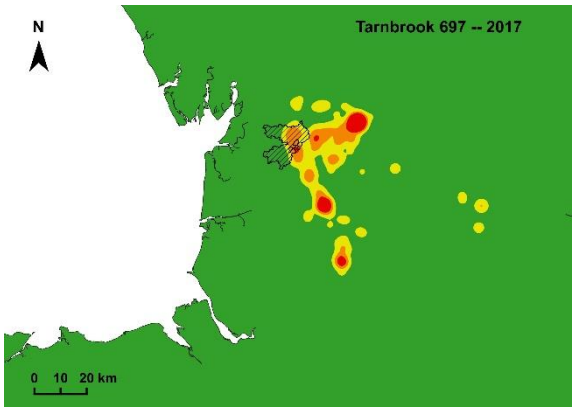
0 10 20 km


0 1 2 km


N
Tarnbrook 226 -- 2017
0 10 20 km


0 1 2 km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Tarnbrook 697 -- 2017
0 10 20 km


0 1 2 km

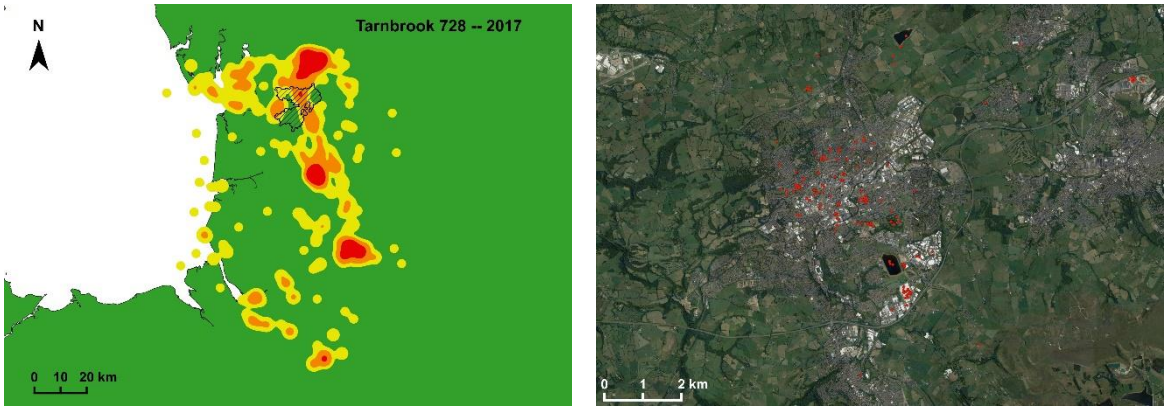
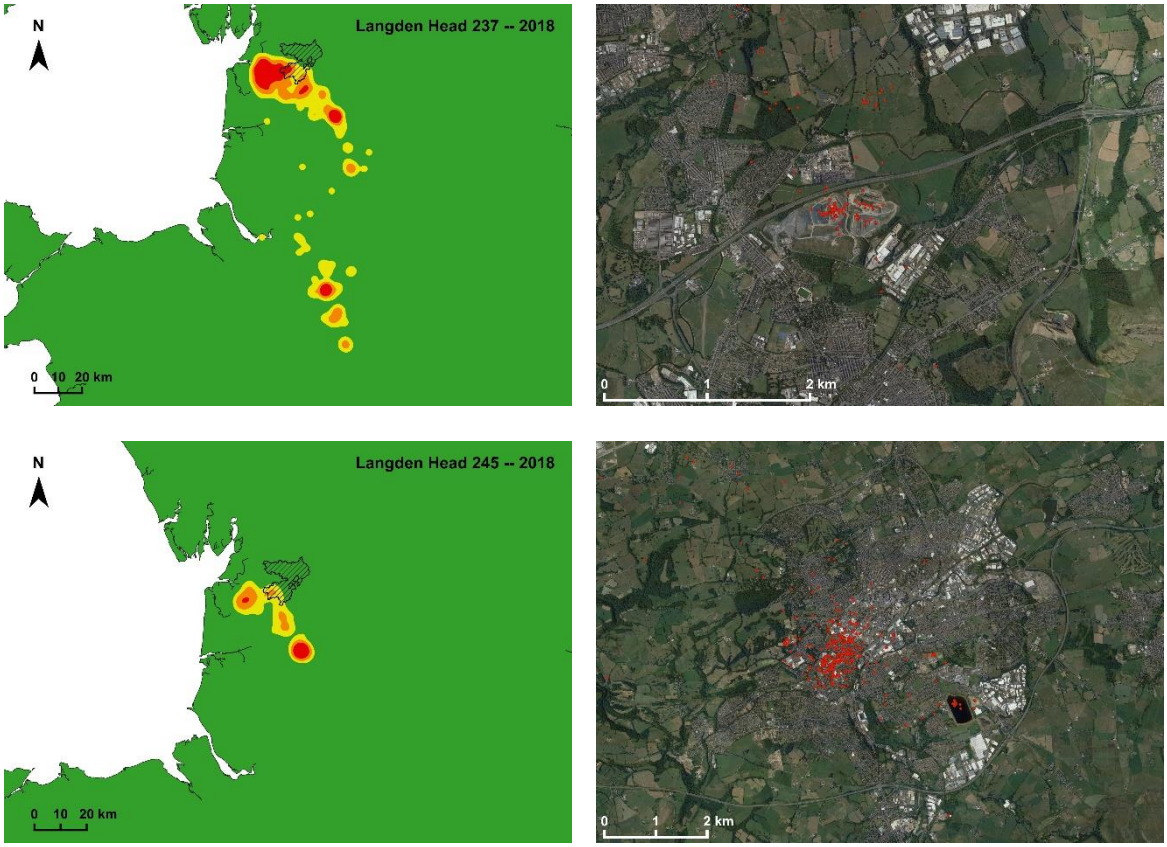
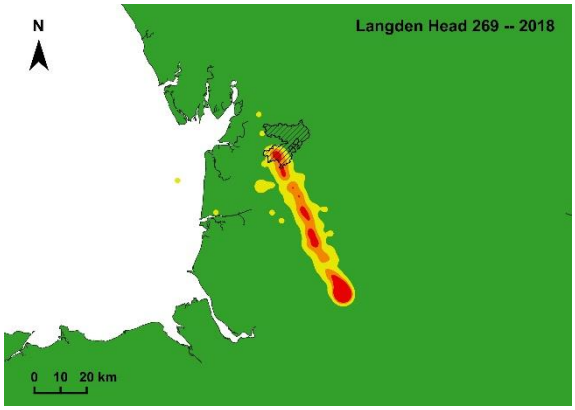
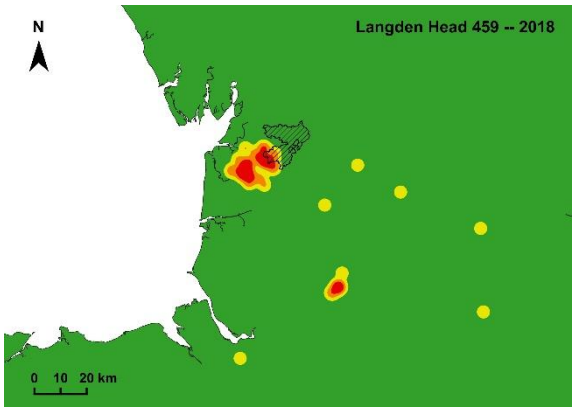


Figure 3.3 Kernel density estimate utilisation distributions for individual Lesser Black-backed Gulls from the Bowland Fells SPA in 2017 using GPS fixes recorded during the day (60 minute sampling rate) outside of the main colony boundary. Individuals 178, 277 and 459 had reduced sampling rates, so home ranges are based on 180 minute and 240 minute sampling rates respectively. Red, orange and yellow illustrate the 50%, 75% and 95% utilisation distributions respectively. The Bowland Fells SPA boundary indicated in black. Imagery ©2018 Google.




N
Langden Head 269 -- 2018
0 10 20 km


0 1 2 km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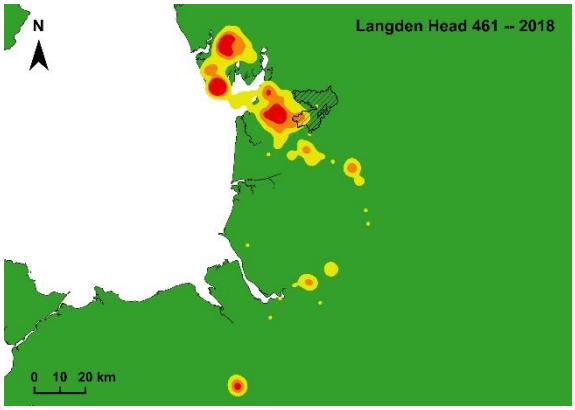
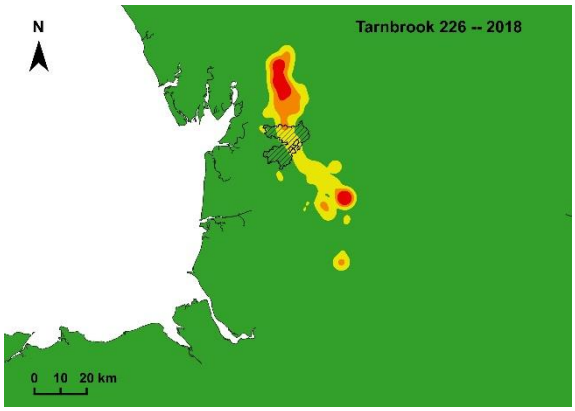
Langden Head 459 -- 2018
0 10 20 km


0 1 2 km


N
Langden Head 461 -- 2018
0 10 20 km


0 1 2 km


N
Tarnbrook 226 -- 2018
0 10 20 km


0 1 2 km

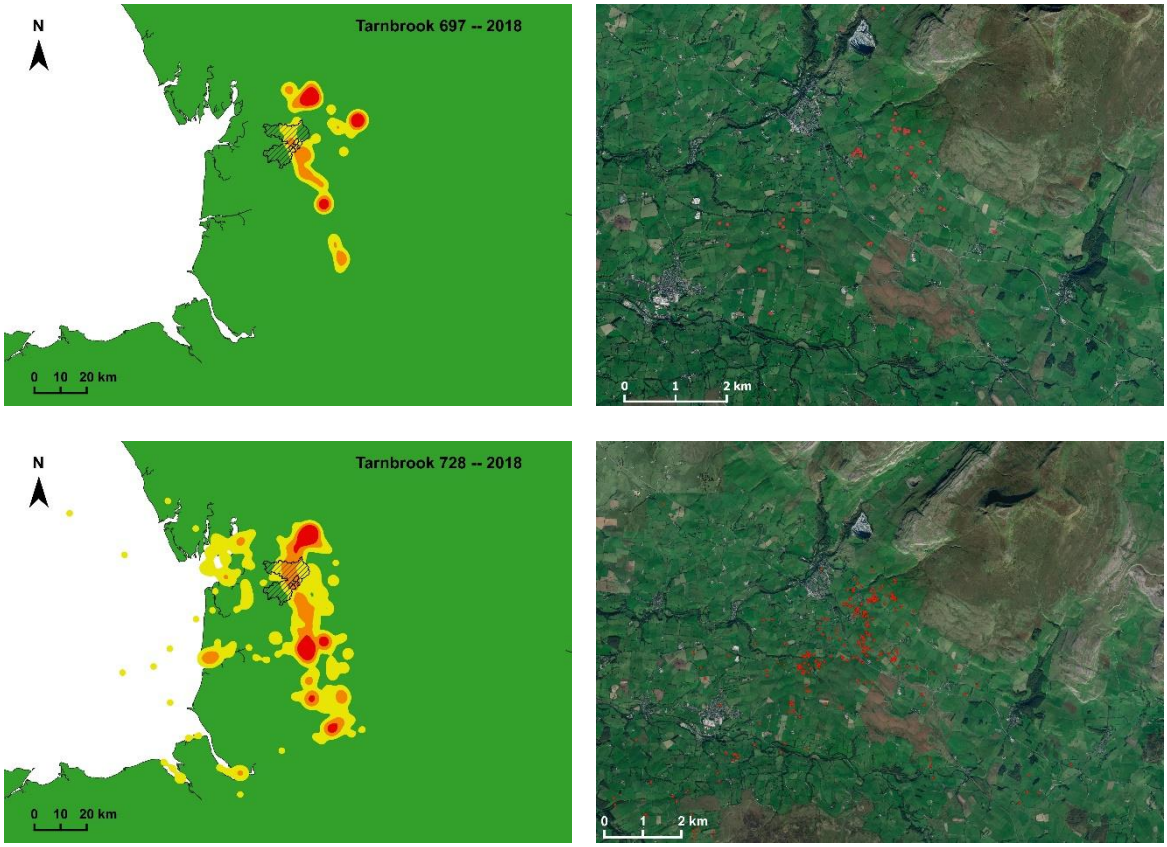


Figure 3.4 Kernel density estimate utilisation distributions for individual Lesser Black-backed Gulls from the Bowland Fells SPA in 2018 using GPS fixes recorded during the day (60 minute sampling rate) outside of the main colony boundary. Individual 459 had a reduced sampling rate, so home range was based on a 240 minute sampling rate. Red, orange and yellow illustrate the 50%, 75% and 95% utilisation distributions respectively. The Bowland Fells SPA boundary indicated in black. Imagery ©2018 Google.

Table 3.1 Summary of Kernel Density Estimation (KDE) utilisation distributions for individual Lesser Black-backed Gulls from the Bowland Fells SPA in 2016, 2017 and 2018 and their overlap with the SPA.

	2016[1]					2017					2018				
		Area of KDE (km^2)		% overlap with SPA			Area of KDE (km^2)		% overlap with SPA			Area of KDE (km^2)		% overlap with SPA	
ID	**N**	**50**	**95**	**50**	**95**	**N**	**50**	**95**	**50**	**95**	**N**	**50**	**95**	**50**	**95**
Langden Head 178	352	100.9	1210.7	9.9	4.9	133	45.0	439.6	0	12.4	-	-	-	-	-
Langden Head 237	542	81.2	832.1	4.7	4.3	773	48.5	380.3	0	7.0	355	175.7	1091.8	6.88	5.2
Langden Head 245	104	20.6	282.6	0	8.5	696	15	212.3	0	7.9	307	34.3	344.1	0	9.3
Langden Head 262	33	54.9	317.2	9.0	9.7	-	-	-	-	-	-	-	-	-	-
Langden Head 269	55	81.9	546.6	0	7.5	611	80.3	669.8	1.4	6.5	268	103.0	670.1	11.08	7.5
Langden Head 270	343	108.0	1039.1	5.7	5.4	438	190.1	1268.2	7.2	4.6	-	-	-	-	-
Langden Head 277	59	80.9	460.8	4.9	7.1	27	69.2	430.2	17.2	8.1	-	-	-	-	-
Langden Head 279	482	217.9	1449.0	8.2	3.8	442	141.3	959.1	13.0	5.5	-	-	-	-	-
Langden Head 287	434	68.7	814.4	0	6.9	587	142.0	1410.8	0	3.8	-	-	-	-	-
Langden Head 454	105	217.1	953.4	24.6	7.1	-	-	-	-	-	-	-	-	-	-
Langden Head 457	335	23.9	221.1	0	15.8	-	-	-	-	-	-	-	-	-	-
Langden Head 459	297	388.5	1909.1	6.8	2.6	71	113.7	471.3	6.3	7.2	56	102.5	511.3	9.04	6.3
Langden Head 460	44	85.4	377.8	8.8	8.2	-	-	-	-	-	-	-	-	-	-
Langden Head 461	265	184.3	1185.2	9.7	5.3	1225	110.7	1231.1	0	4.3	509	139.0	1021.6	0	3.0
Langden Head 462	397	184.0	812.4	12.8	6.6	-	-	-	-	-	-	-	-	-	-
Tarnbrook 034	733	141.5	1122.7	0	7.2	-	-	-	-	-	-	-	-	-	-
Tarnbrook 226	49	251.1	1181.8	5.2	3.2	819	63.9	653.5	0	9.0	533	95.1	790.9	0	7.8
Tarnbrook 452	105	336.4	1558.1	11.8	5.4	-	-	-	-	-	-	-	-	-	-
Tarnbrook 453	51	137.9	606.7	0.8	8.7	-	-	-	-	-	-	-	-	-	-
Tarnbrook 697	-	-	-	-	-	372	88.2	918.2	0.6	8.4	135	73.8	643.8	0	9
Tarnbrook 728	-	-	-	-	-	735	202.7	2675.9	1.1	3.7	822	135.5	1943.2	0	5.4
Mean				**6.5**	**6.7**				**3.6**	**6.8**				**3.4**	**6.7**

[1] 2016 data taken from Clewley *et al.* (2017a).

3.2 Maximum Foraging Distance

There was variation recorded in the number of discrete trips away from the colony and the maximum distance travelled both between individuals and between years (Table 3.2). Some individuals were recorded making extended trips away from the colony for 24-48 hours, reaching as far as Somerset in the most extreme example, before returning to the Bowland Fells area. Longer trips were likely to be made by individuals post-breeding (success or failure).

3.3 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 colony boundaries) was 9.5% of the overall tracking period in 2017 reducing to 6.6% in 2018 (Table 3.3). Without excluding GPS fixes recorded inside the colony, the average percentage of time spent by individuals within the SPA was close to 50%, as would be expected from sharing of nest attendance by pairs during incubation and chick rearing (Appendix 6).

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

ID	2016[1]			2017			2018		
	N	Max distance (km)	Mean (± SD) maximum distance (km)	N	Max distance (km)	Mean (± SD) maximum distance (km)	N	Max distance (km)	Mean (± SD) maximum distance (km)
Langden Head 178	58	60.99	33.16 ± 17.09	7	57.53	29.39 ± 14.15			
Langden Head 237	74	64.82	30.4 ± 17.33	153	64.45	14.96 ± 6.7	83	123.12[1]	22.09 ± 19.25
Langden Head 245	22	48.99	23.89 ± 15.64	77	31.34	26.1 ± 3.34	74	29.22	22.42 ± 6.07
Langden Head 262	5	57.62	30.1 ± 24.27	-	-	-	-	-	-
Langden Head 269	21	57.59	34.92 ± 22.53	155	64.46	57.67 ± 9.58	82	61.07	57.03 ± 9.07
Langden Head 270	59	83.40	37.25 ± 19.98	109	99.84	30.08 ± 15.58	-	-	-
Langden Head 277	11	64.40	52.77 ± 4.51	21	275.07[1]	45.66 ± 54.46	-	-	-
Langden Head 279	74	94.29	24.93 ± 14.49	90	64.04	23.53 ± 19.36	-	-	-
Langden Head 287	63	124.21	41.66 ± 33.61	93	320.25[1]	42.94 ± 37.26	-	-	-
Langden Head 454	28	51.87	30.22 ± 14.32	-	-	-	-	-	-
Langden Head 457	70	96.93	22.17 ± 17.94	10	32.31	23.14 ± 6.23	-	-	-
Langden Head 459	42	71.59	29.27 ± 21.26	34	94.29	23.84 ± 18.69	28	79.71	28.15 ± 20
Langden Head 460	9	71.32	45.84 ± 18.95	14	58.3	50.77 ± 10.32	2	55.67	52.49 ± 4.5
Langden Head 461	41	71.69	39.32 ± 22.93	49	87.55	34.86 ± 17.37	28	109.4	35.58 ± 20.11
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	172	111.6[2]	29.13 ± 9.11	122	53.68	26.59 ± 8.37
Tarnbrook 452	26	88.09	51.82 ± 17.53	-	-	-	-	-	-
Tarnbrook 453	15	52.90	32.72 ± 13.66	-	-	-	-	-	-
Tarnbrook 697	-	-	-	50	93.36	39.42 ± 16.87	19	55.48	29.16 ± 12.74
Tarnbrook 728	-	-	-	67	88.25	30.7 ± 19.14	96	91	35.25 ± 19.09

[1] 2016 data taken from Clewley *et al.* (2017a);

[2] Derived from trips away from colony >24 hours**.**

Table 3.3 Summary of the percentage of time spent by individual Lesser Black-backed Gulls within the Bowland Fells SPA, excluding time spent inside colony boundaries.

ID	2016[1]			2017			2018		
	Total time (hrs)	Overlap (hrs)	%	Total time (hrs)	Overlap (hrs)	%	Total time (hrs)	Overlap (hrs)	%
Langden Head 178	1705.82	213.62	13	2243.07	130.27	5.81	-	-	-
Langden Head 237	2088.08	207.77	10	3674.17	422.77	11.51	2018.82	269.08	13.33
Langden Head 245	1951.15	138.48	7	2593.85	127.02	4.9	1667.52	113.55	6.81
Langden Head 262	204.27	15.62	8	-	-	-	-	-	-
Langden Head 269	1847.90	220.86	12	2901.72	295.7	10.19	3117.15	145.07	4.65
Langden Head 270	1929.25	284.70	15	2954.47	436.89	14.79	-	-	-
Langden Head 277	1470.37	150.52	10	2377.27	278.36	11.71	-	-	-
Langden Head 279	1956.33	287.00	15	2228.97	424.2	19.03	-	-	-
Langden Head 287	1565.47	174.99	11	2713.82	345.78	12.74	-	-	-
Langden Head 454	1152.43	337.07	29	-	-	-	-	-	-
Langden Head 457	1825.10	143.59	8	-	-	-	-	-	-
Langden Head 459	2091.88	217.96	10	2718.3	150.22	5.53	2704.03	63.47	2.35
Langden Head 460	1563.72	62.83	4	-	-	-	-	-	-
Langden Head 461	2050.13	181.36	9	2993.25	99.24	3.32	1225	33.63	2.75
Langden Head 462	1999.37	287.27	14	-	-	-	-	-	-
Tarnbrook 034	2958.82	404.70	14	-	-	-	-	-	-
Tarnbrook 226	1593.23	217.24	14	2857.9	202.21	7.08	2699.55	210.11	7.78
Tarnbrook 452	1533.37	232.34	15	-	-	-	-	-	-
Tarnbrook 453	1523.17	144.58	9	-	-	-	-	-	-
Tarnbrook 697	-	-	-	2029.25	159.78	7.87	699.52	44.98	6.43

[1] 2016 data taken from Clewley *et al.* (2017a).

3.4 Nest Monitoring

It was possible to identify the likely nests of 12 returning tagged adults from 2016 at the Langden Head colony in 2017, but unfortunately none at Tarnbrook Fell (there was a sampling bias in 2016 and few birds were marked at Tarnbrook Fell). During 2018, the nests of a further two tagged birds at Tarnbrook and four tagged birds at Langden Head were monitored. An additional bird (ID 226) was present regularly in the same location within Tarnbrook Fell but there was no evidence that the bird was breeding and it was most likely attending a loafing area. Estimates of nest success (Table 3.4) represent a minimum as it was not always apparent whether nest had failed or whether eggs had hatched and chicks had already dispersed from the nest site. There were few cases of confirmed failure: one chick was found dead a few days old in a tagged bird's nest (the remaining chicks survived until the end of monitoring) and one egg was predated from a control nest.

Table 3.4 Results of nest monitoring of tagged and control Lesser Black-backed Gulls from within the Bowland Fells SPA during 2017 and 2018

	Mean clutch size (± SD)	**Minimum hatching success**	**Potential minimum nest success**
2017[1]			
Tagged birds' nests	2.58 ± 0.64	0.75	0.58
Control birds' nests	2.75 ± 0.43	0.83	0.67
2018			
Tagged birds' nests	2.83 ± 0.37	0.71	0.50
Control birds' nests	2.50 ± 0.76	0.67	0.33

[1] from Clewley *et al.* (2017b).

4. DISCUSSION AND CONCLUSIONS

This work has extended the GPS tracking of Lesser Black-backed Gulls from the Bowland Fells SPA to three years, enabling annual variation in space use to be evaluated. Further to the results for 2016 presented in Clewley *et al.* (2017a), there were sufficient suitable data from 13 individuals for analysis of space use in 2017 and for eight individuals in 2018. Six of these birds had been tracked for three consecutive years.

There was some individual variation in the extent and pattern of birds' foraging ranges. However, for all birds, home range analyses indicated that key foraging areas were outwith the SPA. The degree of overlap between individual core home ranges (50% KDEs) and the SPA was <25% (mean = 6.5%) in 2016, <18% (mean = 3.6%) in 2017 and <12% (mean = 3.4%) in 2018. Equivalent figures for total home ranges (95% KDEs) were <16% (mean = 6.7%) in 2016, <13% (mean = 6.8%) in 2017 and <10% (mean = 6.7%) in 2018.

It was apparent from the overall home ranges that broad patterns of foraging where consistent across years. Urban areas and landfill sites to the south of the SPA, notably around Manchester and Blackburn, were key foraging locations for the majority of individuals in all years. Agricultural areas, often closer to the SPA but outside its boundary were also widely used but to a lesser extent. In contrast to studies of birds from breeding colonies elsewhere (e.g. studies reviewed by Thaxter *et al*. 2012 and also Ens *et al*. 2008, Götmark 1984, Kubetzki & Garthe 2003, Isaksson *et al.* 2016, Shamoun-Baranes *et al*. 2011), marine environments were only sparsely used.

Some new areas were utilised in 2017 and 2018 compared with 2016 and conversely some areas were lost from the core home range estimates. This is most likely a result of differences in the individuals present in each year cohort. Several of the birds tracked in 2016 were lost to the project through mortality or tag failure and two new birds were added in 2017 from Tarnbrook Fell which tended to make more use of areas north of the SPA.

It was not possible to contrast results between the two colonies with the Bowland Fells SPA due to an unbalanced sample between the two sites. Individuals from one colony did not visit the other, and remained largely faithful to their breeding sites. Outside the SPA, some of the tracks of Tarnbrook birds overlapped with the key foraging sites of Langden Head birds to the south, but they also made more use of agricultural land to the north compared with birds from Langden Head. The only individual from Langden Head to use areas north of the SPA was bird 461, which visited the Furness Peninsula from 2017; however, tracks for this bird did not overlap the areas used by Tarnbrook birds. The apparent partial segregation of foraging between colonies suggested for 2016 data (Clewley *et al.* 2017a) thus remained the case for 2017 and 2018.

For the majority of individual birds, key foraging sites remained consistent between years with only a couple of individuals switching to new foraging locations. Each bird travelled considerable distances on their trips from the colonies, passing other apparently suitable habitat. Thus, if one foraging location becomes unprofitable it is likely they would be able to take advantage of another quickly.

The overall home ranges of individual birds and their foraging distances showed more variation between years, however. For example, bird 459 had a markedly reduced home range in 2017 and 2018 compared with 2016; this individual was one of the few to make extended use of landfill sites near the Mersey or even further south in 2016. Changes at some of these sites over the winter of 2016/17 meant that they became less favourable for foraging gulls, leading bird 459 to switch to predominantly agricultural foraging in 2017, before it then began to use a new landfill site during the 2018 breeding season. O'Connell (1995), through dietary studies, previously established the

importance of terrestrial foraging for gulls breeding in Bowland. It is likely that as landfill site management changes, breeding gulls will increasingly use agricultural and other urban habitats to forage, depending on individual preference.

Consistent with the home range analyses, the average time spent by individual birds in the SPA away from the colony was also limited – 11.9% % of the total tracking period in 2016, 9.5% in 2017 and 6.3% in 2018 – declining over the three study years. However, this decline may partly be an artefact of the fact that birds were tracked from the beginning of the breeding season in both 2017 and 2018, prior to incubation and chick rearing. There was no evidence that the gulls spent extended periods of time in the SPA outside of the colony boundaries. One individual at the Tarnbrook colony in 2018 was consistently recorded within a few hundred metres of other breeding birds; however, when this area was visited, it appeared to be a loafing site, rather than a foraging or breeding site and no nests could be found in the vicinity. It might be expected that birds such as this that frequent the area, but which are not attending nests, may be most likely to forage within the SPA. However, if this were the case, we would expect this to be apparent in the birds' estimated core home ranges, which was not the case for this individual. If future conflict remains between the presence of gulls and other upland interests, a focus on investigating the role of non-breeding birds would be beneficial as known breeders do not appear to utilise the SPA in any meaningful way other than breeding.

Acknowledgements

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References

Bub, H. 1991. Bird trapping and bird banding. Cornell University, Ithica, New York, USA.

Calenge, C. 2006. The package adehabitat for the R software: a tool for the analysis of space and habitat use by animals. *Ecological Modelling*, **197**, 516-519.

Calladine, J. 1997. A comparison of Herring Gull Larus argentatus and Lesser Black-backed Gull *Larus fuscus* nest sites: their characteristics and relationships with breeding success. *Bird Study*, **44**, 318-326.

Camphuysen, C.J. 1995. Herring Gull *Larus argentatus* and Lesser Black-backed Gulls *Larus fuscus* feeding at fishing vessels in the breeding season: competitive scavenging versus efficient flying. *Ardea*, **83**, 365-380.

Camphuysen, C.J. 2011. *Lesser Black-backed Gulls nesting at Texel: foraging distribution, diet, survival, recruitment and breeding biology of birds carrying advanced GPS loggers*. Royal Netherlands Institute for Sea Research, Texel, NIOZ-Report 2011-05.

Camphuysen, C.J. & Webb, A. 1999. Multi-species feeding associations in North Sea seabirds: jointly exploiting a patchy environment. *Ardea*, **87**, 177-198.

Clewley, G.D., Scragg, E.S., Thaxter, C.B. & Burton, N.H.K. 2017a. Assessing the habitat use of Lesser Black-backed Gulls (*Larus fuscus*) from the Bowland Fells SPA. BTO Research Report 694. BTO, Thetford.

Clewley, G.D., Scragg, E.S., Thaxter, C.B. & Burton, N.H.K. 2017b. Assessing the habitat use of Lesser Black-backed Gulls (*Larus fuscus*) from the Bowland Fells SPA. ANNEX 1 – 2017 update. BTO Research Report 694. BTO, Thetford.

Corman, A.M. & Garthe, S. 2014. What flight heights tell us about foraging and potential conflicts with wind farms: a case study in Lesser Black-backed Gulls (*Larus fuscus*). *Journal of Ornithology*, **155**, 1037-1043.

Ens, B.J., Barlein, F., Camphuysen, C.J., Boer, P. de, Exo, K.-M., Gallego, N., Hoye, B., Klaassen, R., Oosterbeek, K., Shamoun-Baranes, J., Jeugd, H. van der & Gasteren, H. van 2008. *Tracking of individual birds. Report on WP 3230 (bird tracking sensor characterization) and WP 4130 (sensor adaptation and calibration for bird tracking system) of the FlySafe basic activities project*. SOVON-onderzoeksrapport 2008/10. SOVON Vogelonderzoek Nederland, Beek-Ubbergen.

Galván, I. 2003. Intraspecific kleptoparasitism in Lesser Black-backed Gulls wintering inland in Spain. *Waterbirds,* **26**, 325-330.

Garthe S., Schwemmer, P., Paiva, V.H., Corman, A-M., Fock, H.O., Voigt, C.C. & Adler, S. 2016. Terrestrial and marine foraging strategies of an opportunistic seabird species breeding in the Wadden sea. *PLoS ONE,* **11**, e0159630.

Götmark, F. 1984. Food and foraging in five European *Larus* gulls in the breeding season: a comparative review. *Ornis Fennica*, **61**, 9-18.

Hijmans, R.J. 2016. geosphere: Spherical Trigonometry. R package version 1.5-5. https://CRAN.R-project.org/package=geosphere

Isaksson, N., Evans, T.J., Shamoun-Baranes, J. & Åkesson, S. 2016. Land or sea? Foraging area choice during breeding by an omnivorous gull. *Movement Ecology*, **4**, 11.

Juvaste, R., Arriero, E., Gagliardo, A., Holland, R., Huttenen, M.J., Mueller, I., Thorup, K., Wikelski, M., Hannila, J., Penttinen, M-L. & Wistbacka, R. 2017. Satellite tracking of red-listed nominate Lesser Black-backed Gulls (*Larus f. fuscus*): Habitat specialisation in foraging movements raises novel conservation needs. *Global Ecology and Conservation*, **10**, 220-230.

Kim, S.Y. & Monaghan, P. 2006. Interspecific differences in foraging preferences, breeding performance and demography in Herring (*Larus argentatus*) and Lesser Black-backed Gulls (*Larus fuscus*) at a mixed colony. *Journal of Zoology*, **270**, 664-671.

Kubetzki, U. & Garthe, S. 2003. Distribution, diet and habitat selection by four sympatrically breeding gull species in the south-eastern North Sea. *Marine Biology*, **143**, 199-207.

O'Connell, M. 1995. *An ecological approach to the management of gulls, in particular the Lesser Black-backed Gull,* Larus fuscus *(L. 1758)*. PhD Thesis, University of Durham.

QGIS Development Team (2018). QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.osgeo.org

R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. http://ww.r-project.org

Ross-Smith, V.H., Thaxter, C.B., Masden, E.A., Shamoun-Baranes, J., Burton, N.H.K., Wright, L.J., Rehfisch, M.M. & Johnston, A. 2016. Modelling flight heights of Lesser Black-backed Gulls and Great Skuas from GPS: a Bayesian approach. *Journal of Applied Ecology*, **53**, 1676-1685.

Schwemmer, P. & Garthe, S. 2008. Regular habitat switch as an important feeding strategy of an opportunistic seabird species at the interface between land and sea. *Estuarine Coastal and Shelf Science*, **77**, 12-22.

Shamoun-Baranes, J., Bouten, W., Camphuysen, C.J. & Baaj, E. 2011. Riding the tide: intriguing observations of gulls resting at sea during breeding. *Ibis*, **153**, 411-415.

Shamoun-Baranes J., Bouten W., van Loon E.E., Meijer C., Camphuysen C.J. 2016. Flap or soar? How a flight generalist responds to its aerial environment. *Philosophical Transactions of the Royal Society B* **371:** 2015039.

Shamoun-Baranes, J., Burant, J.E., van loon, E., Bouten, W. & Camphuysen, C.J. 2017. Short distance migrants travel as far as long distance migrants in Lesser Black-backed Gulls *Larus fuscus*. *Journal of Avian Biology*, **48**, 49-57.

Stienen, E.W.M., Desmet, P., Aelterman, B., Courtens, W., Feys, S., Vanermen, N., Verstraete, H., Van de walle, M., Deneudt, K., Hernandez, F., Houthoofdt, R., Vanhoorne, B., Bouten, W., Buijs, R.-J., Kavelaars, M., Müller, W., Herman, D., Matheve, H., Sotillo, A. & Lens, L. 2016. GPS tracking data of Lesser Black-backed Gulls and Herring Gulls breeding at the southern North Sea coast. *ZooKeys*, **555**, 115-124.

Soanes, L. M., Arnould, J. P. Y., Dodd, S. G., Sumner, M. D. and Green, J. A. 2013. How many seabirds do we need to track to define home-range area? *Journal of Applied Ecology*, **50**, 671-679.

Stroud, D.A., Bainbridge, I.P., Maddock, A., Anthony, S., Baker, H., Buxton, N., Chambers, D., Enlander, I., Hearn, R.D., Jennings, K.R, Mavor, R., Whitehead, S. & Wilson, J.D., on behalf of the UK SPA & Ramsar Scientific Working Group (eds.) 2016. *The status of UK SPAs in the 2000s: the Third Network Review*. JNCC, Peterborough.

Thaxter, C.B., Humphreys, E.M., Ross-Smith, V.H., Clark, N.A., Barber, L., Clewley, G., Conway, G.J., Harris, S.J., Masden, E.A., Bouten, W. & Burton, N.H.K. 2018. *Measuring the interaction between Lesser Black-backed Gulls and Herring Gulls from the Skokholm and Skomer SPA and Morecambe Bay and Duddon Estuary SPA and Offshore Wind Farm Development Sites: Final report*. BTO Research Report No. 702, BTO, Thetford.

Thaxter, C.B., Lascelles, B., Sugar, K., Cook, A.S.C.P., Roos, S., Bolton, M., Langston, R.H.W. & Burton, N.H.K. 2012. Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas. *Biological Conservation*, **156**, 53-61.

Thaxter, C.B., Ross-Smith, V.H., Bouten, W., Rehfisch, M.M., Clark, N.A., Conway, G.J. & Burton, N.H.K. 2015. Seabird-wind farm interactions during the breeding season vary within and between years. *Biological Conservation*, **186**, 347-358.

Thaxter, C.B., Ross-Smith, V.H., Clark, J.A., Clark, N.A., Conway, G.J., Marsh, M., Leat, E.H.K. & Burton, N.H.K. 2014b. A trial of three harness attachment methods and their suitability for long-term use on Lesser Black-backed Gulls and Great Skuas. *Ringing & Migration*, **29**, 65-76.

Thaxter, C.B., Ross-Smith, V.H., Clark, J.A., Clark, N.A., Conway, G.J., Masden, E.A., Wade, H.M., Leat, E.H.K., Gear, S.C., Marsh, M., Booth, C., Furness, R.W., Votier, S.C. & Burton, N.H.K. 2016. Contrasting effects of GPS device and harness attachment on adult survival in the Lesser Black-backed Gull *Larus fuscus* and Great Skua *Stercorarius skua*. *Ibis*, **158**, 279-290.

Thaxter, C.B., Ross-Smith, V.H., Clark, N.A., Conway, G.J., Johnston, A., Wade, H.M., Masden, E.A., Bouten, W. & Burton, N.H.K. 2014a. *Measuring the interaction between marine features of Special Protection Areas with offshore wind farm development zones through telemetry: final report.* BTO Research Report No. 649. BTO, Thetford.

Wernham, C.V., Toms, M.P., Marchant, J.H., Clark, J.A., Siriwardena, G.M. & Baillie, S.R. (eds.) 2002. *The Migration Atlas: movements of the birds of Britain and Ireland*. T. & A.D. Poyser, London.

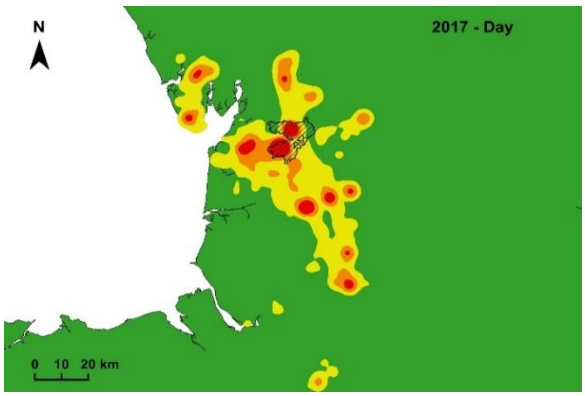
Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology*, **70**, 164-168.

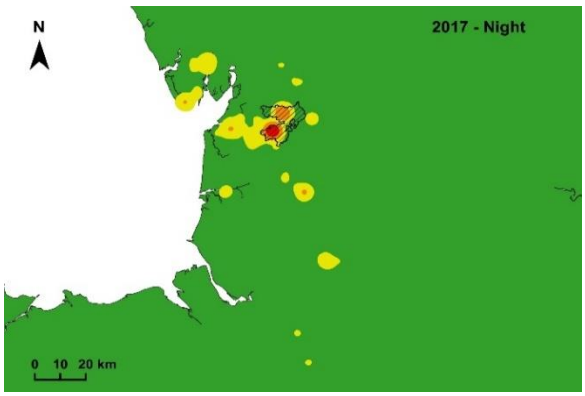
APPENDICES

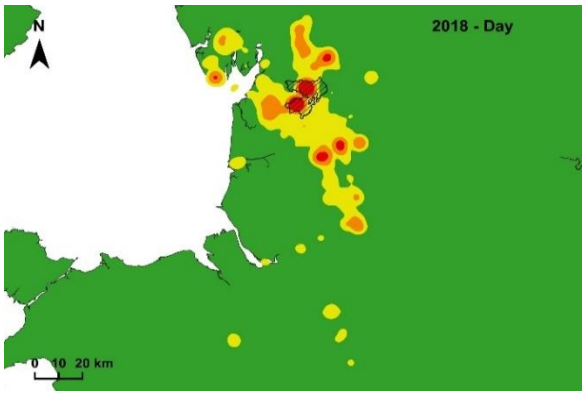
Appendix 1 Raw capture and nest monitoring data – see files "Bowland LBBGU tracking data 2017_2018.csv" "Bowland 2017_2018 Nest monitoring and ringing data.xlsx".

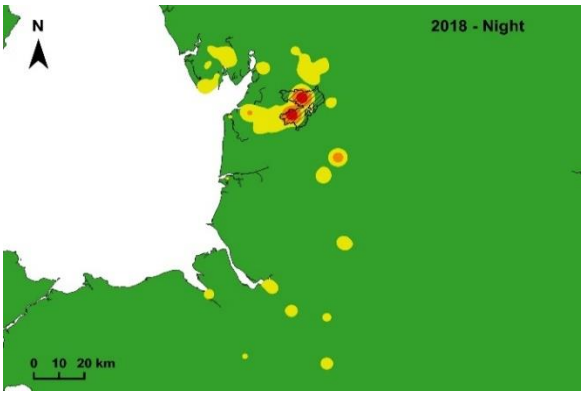
Appendix 2 Kernel Density Estimation (KDE) utilisation distributions for Lesser Black-backed Gulls from the Bowland Fells SPA using all GPS fixes (including those inside the colony). Combined KDEs for 2017 derived from: 13 individuals and 10370 fixes (day) and 12 individuals and 2382 fixes (night). Combined KDEs for 2018 calculated from 7 individuals and 5327 fixes (day) and 7 individuals and 1098 fixes (night). All day KDEs were calculated using data filtered to 60 minute sampling rates, except for birds 178 and 277, for which data were filtered to 180 minutes and bird 459 for which data were filtered to240 minutes. Red, orange and yellow illustrate the 50%, 75% and 95% utilisation distributions respectively. The Bowland Fells SPA boundary is shown in black.

Combined KDEs

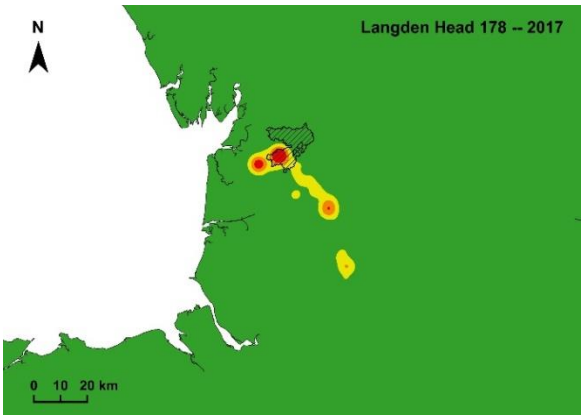


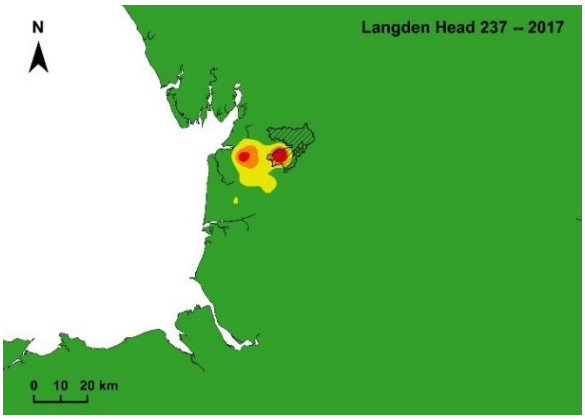


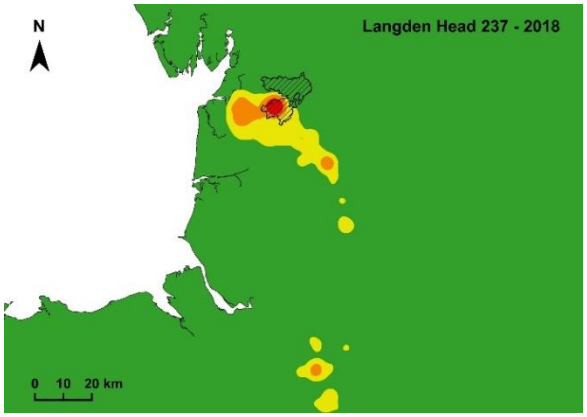




Individual KDEs



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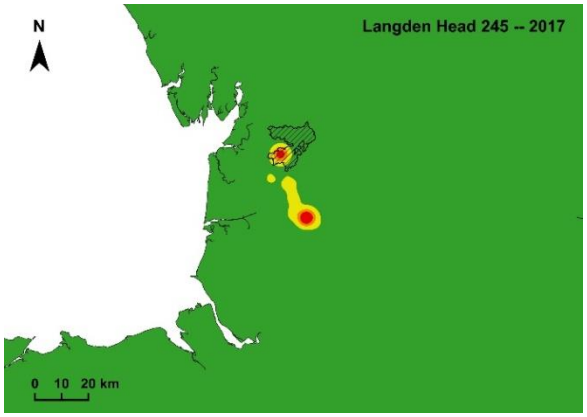
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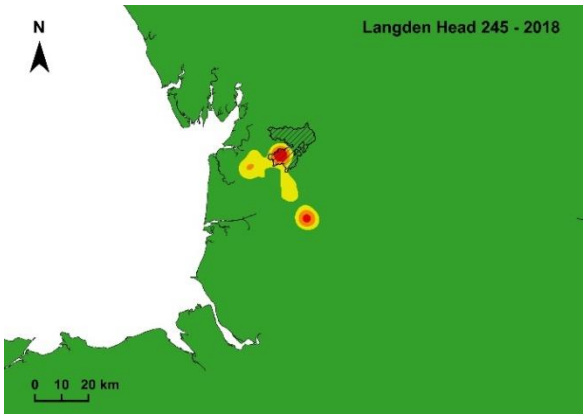
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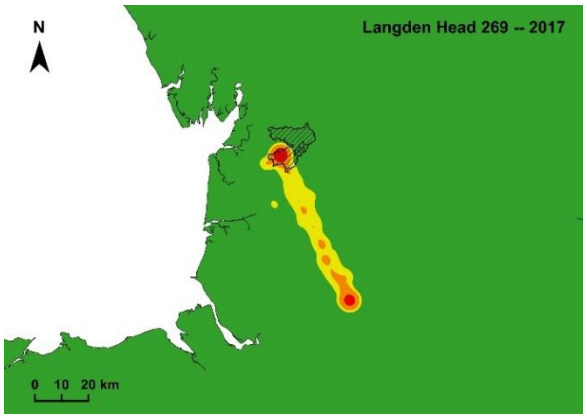
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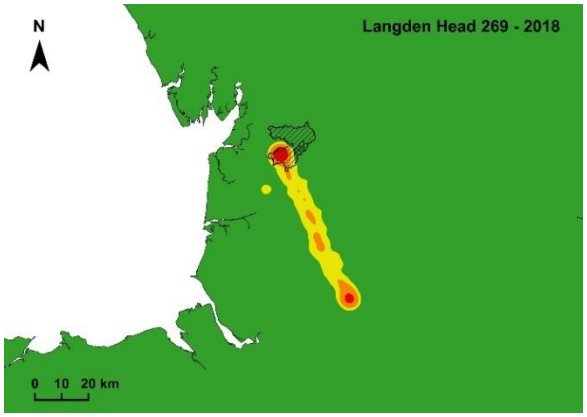
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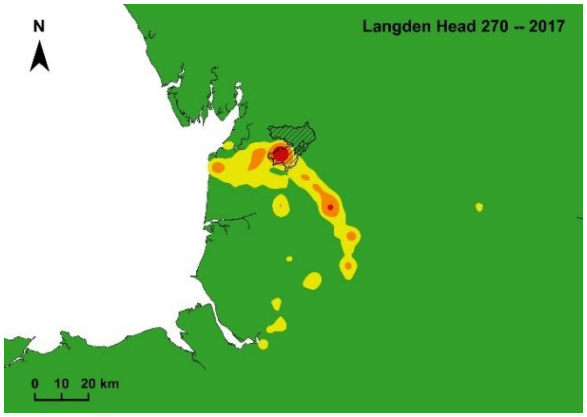
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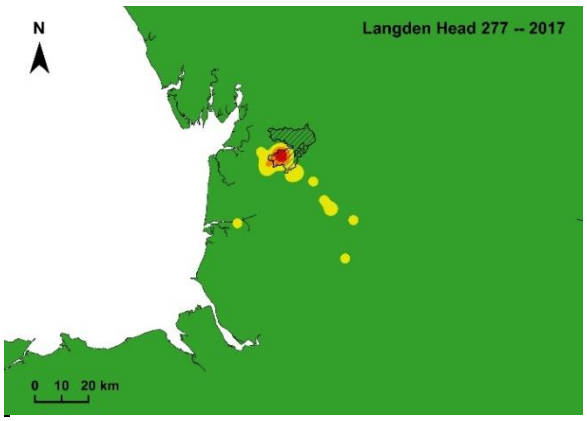
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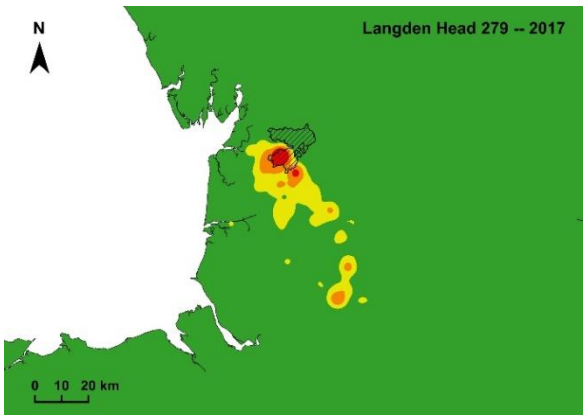
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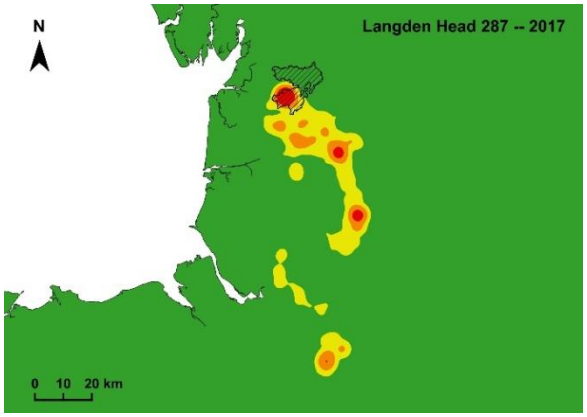
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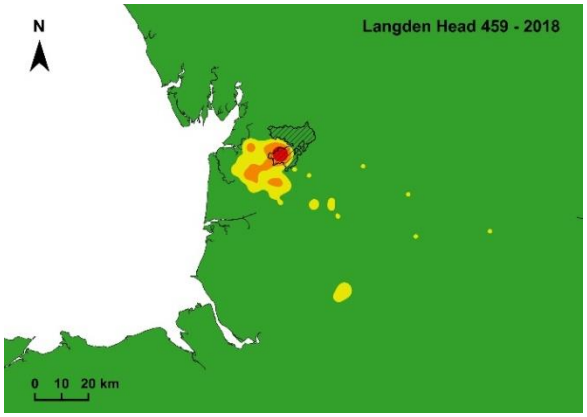
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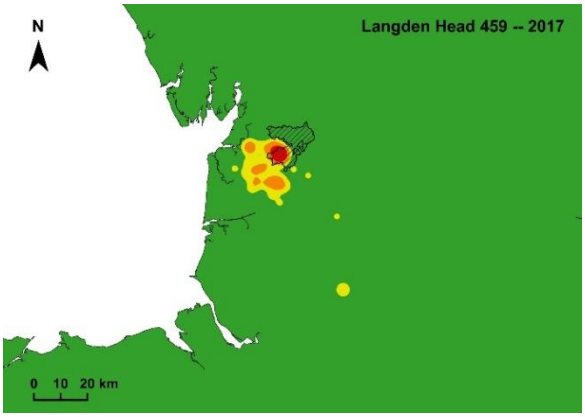
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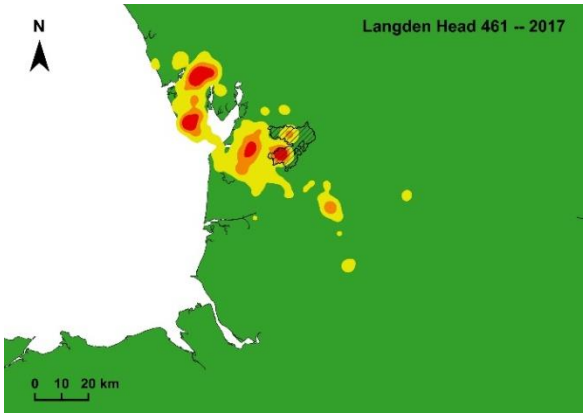
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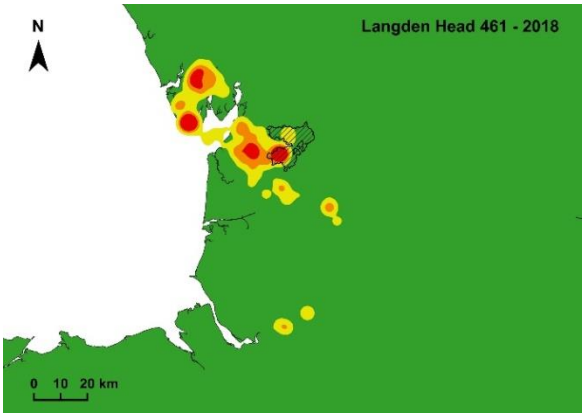
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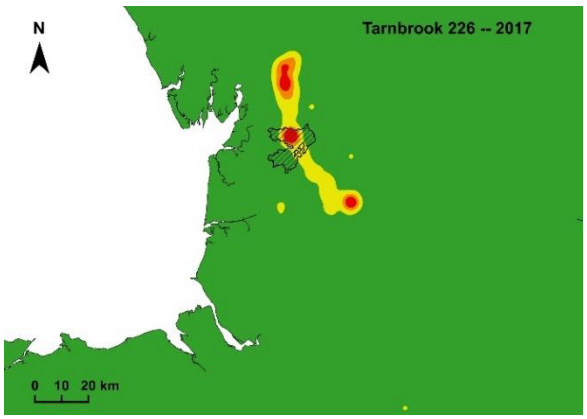
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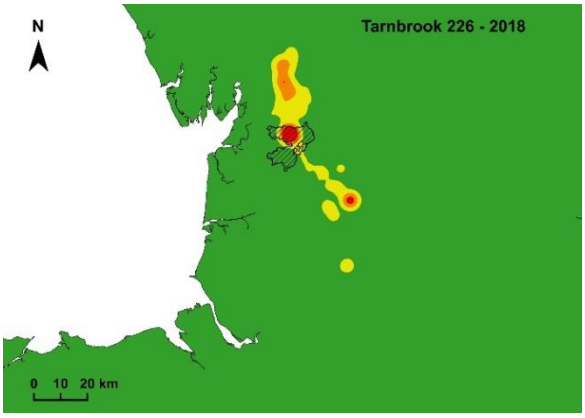
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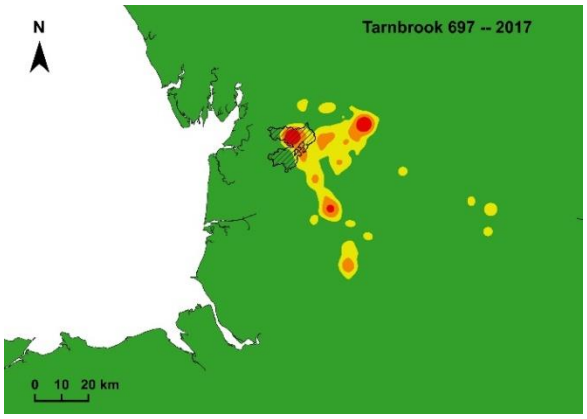
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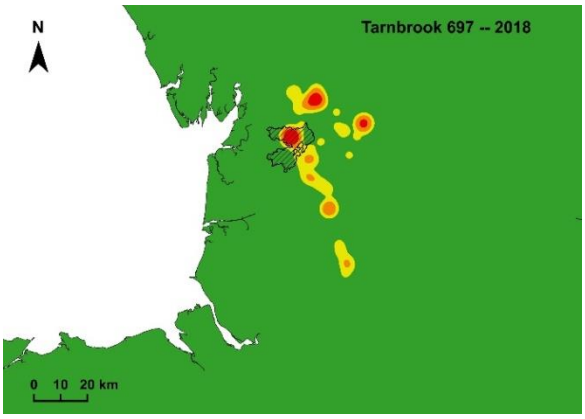
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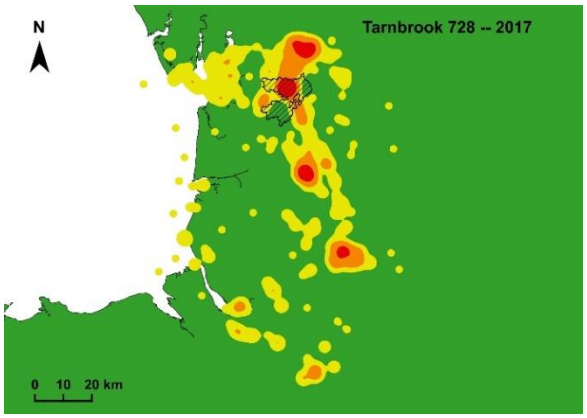
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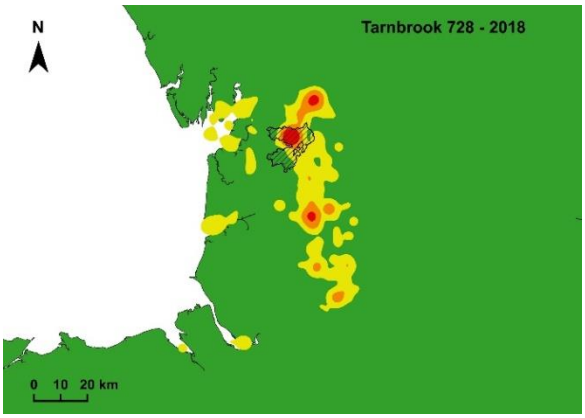
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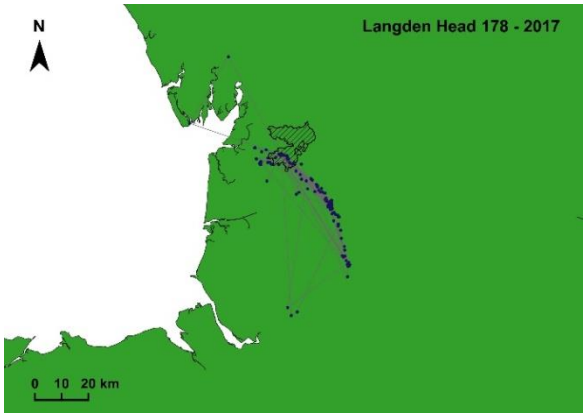
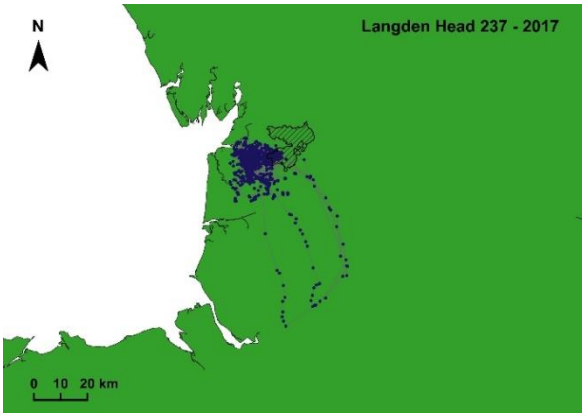
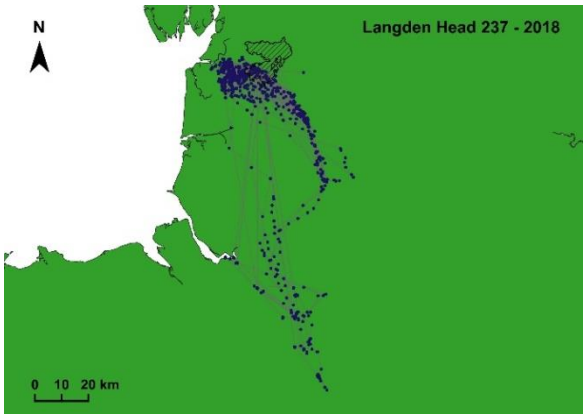
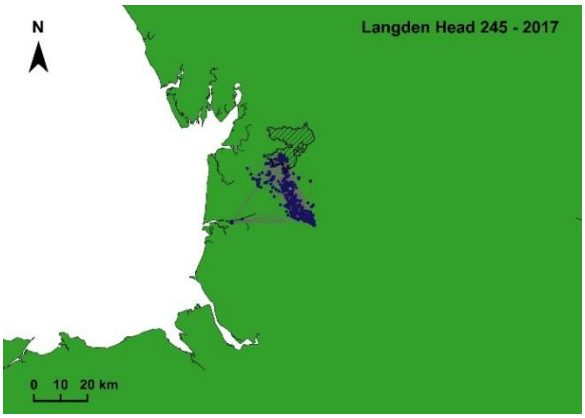
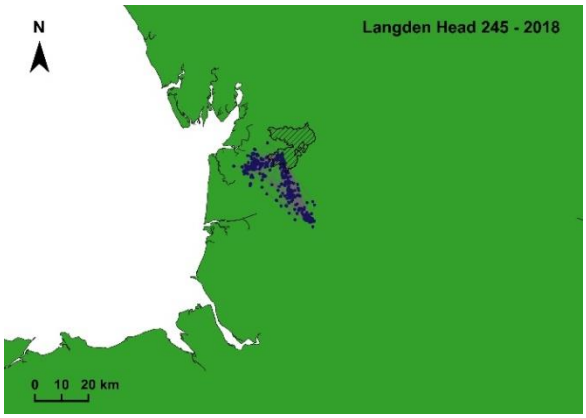
Appendix 3 Plots of raw tracking data for all individuals irrespective of quality.

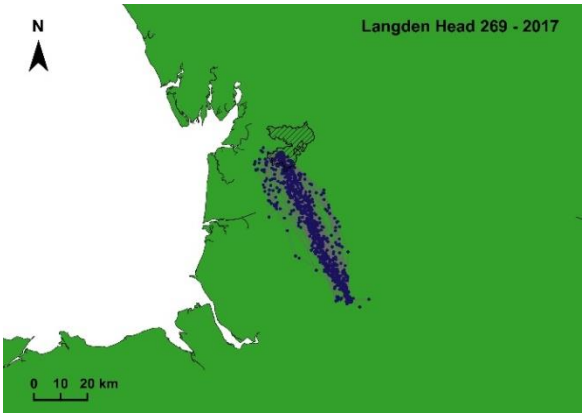


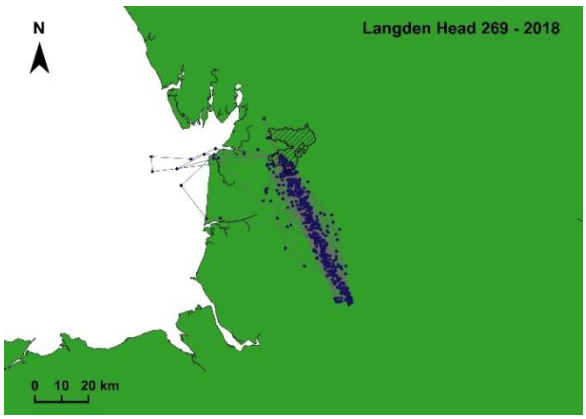


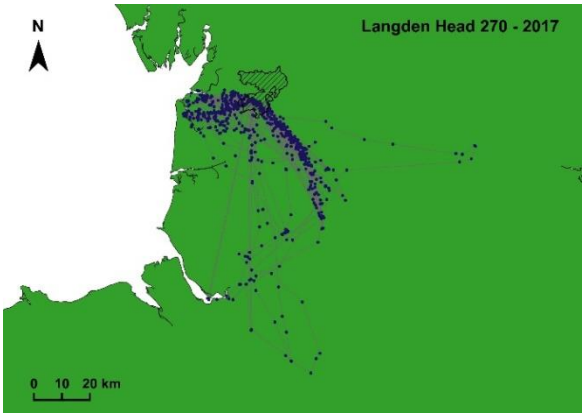


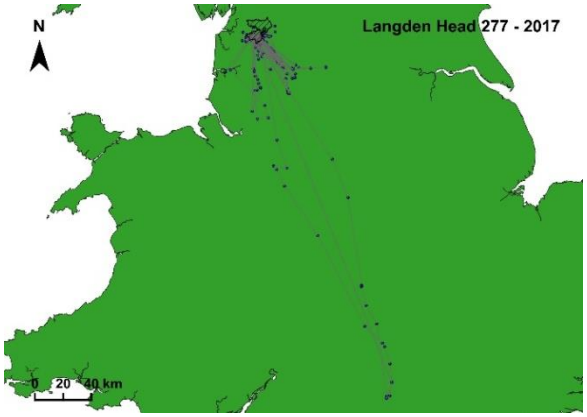








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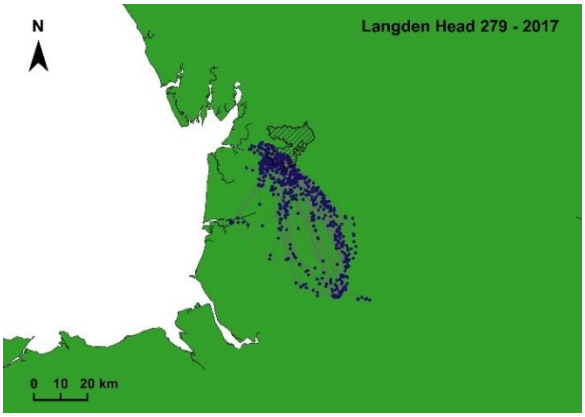
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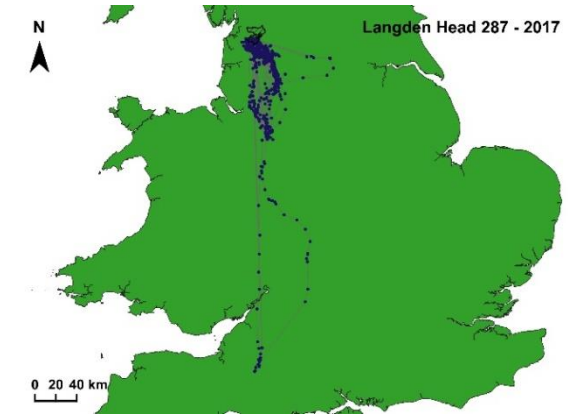
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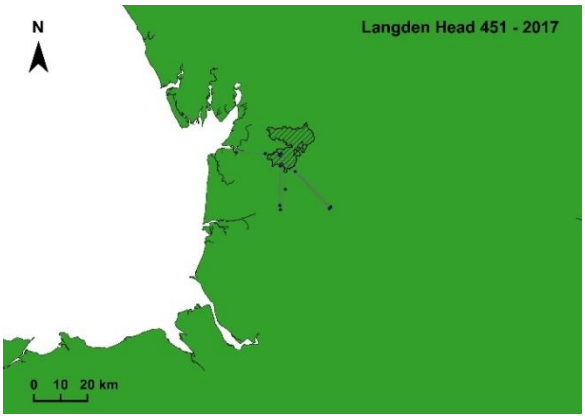
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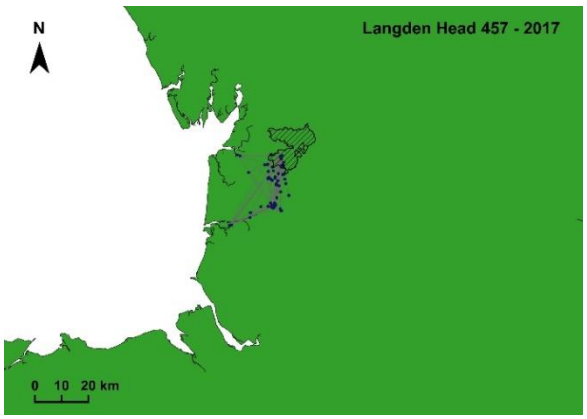
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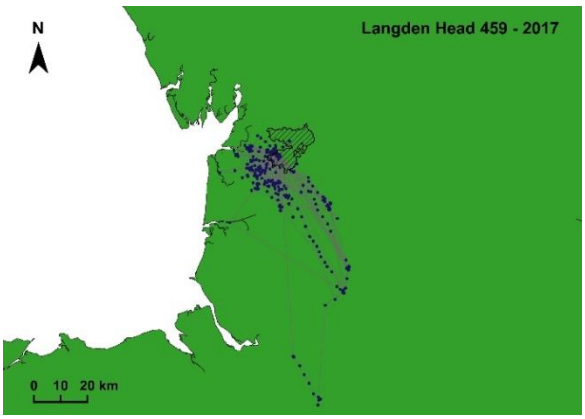
0 10 20 km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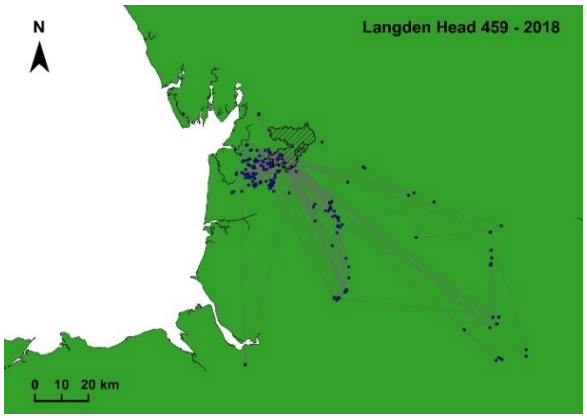
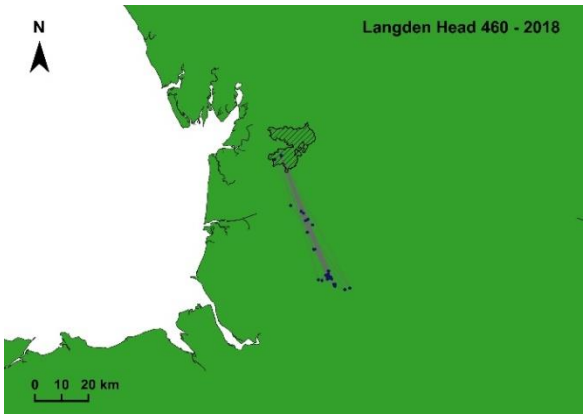
0 10 20 km


N
Langden Head 459 - 2018
0 10 20 km


N
Langden Head 460 - 2017
0 10 20 km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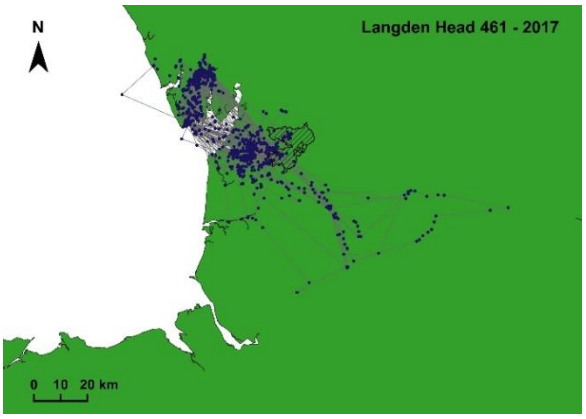
0 10 20 km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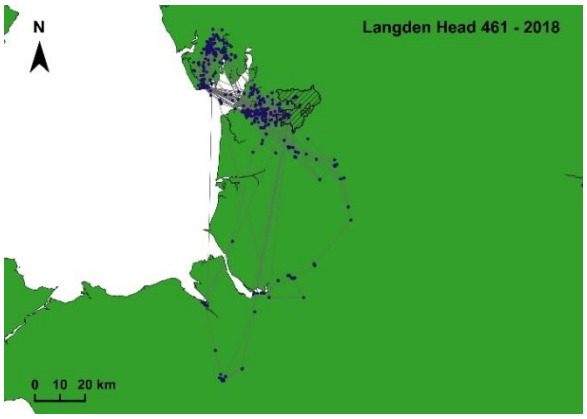
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Langden Head 461 - 2018
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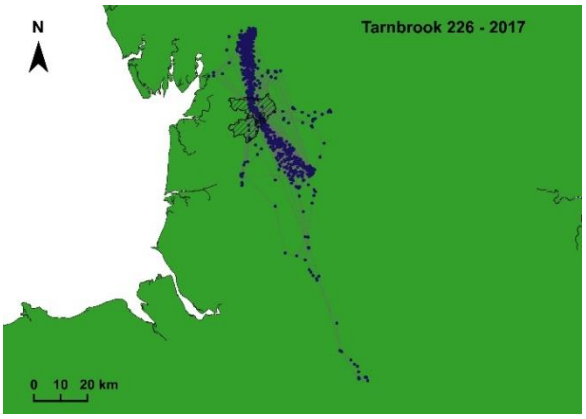
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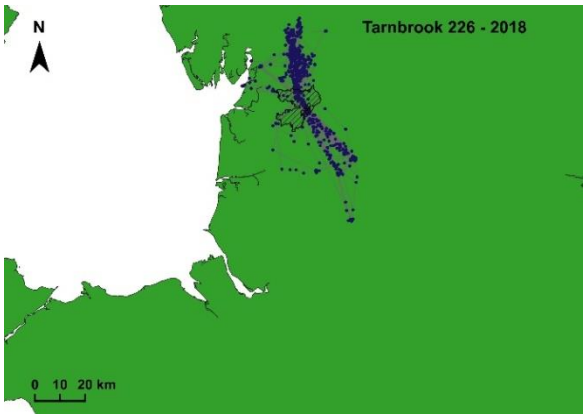
Tarnbrook 226 - 2017
0 10 20 km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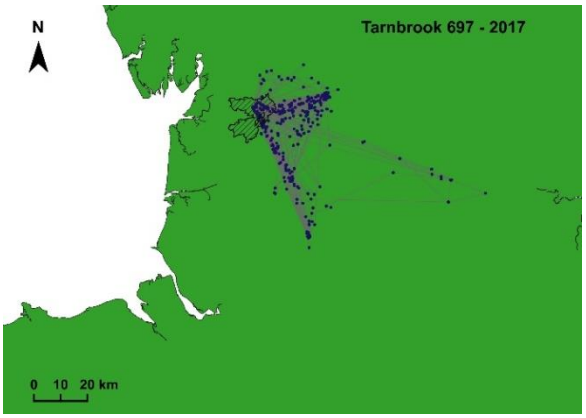
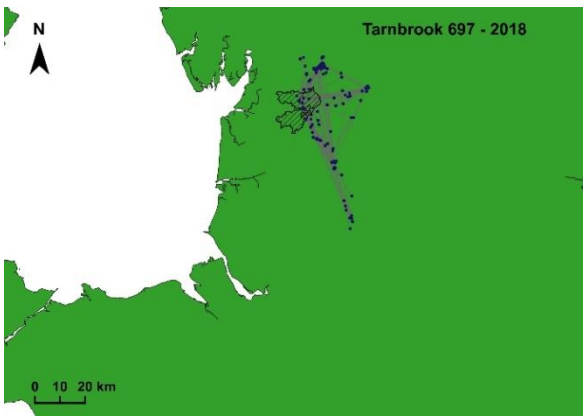
Tarnbrook 226 - 2018
0 10 20 km


N
Tarnbrook 697 - 2017
0 10 20 km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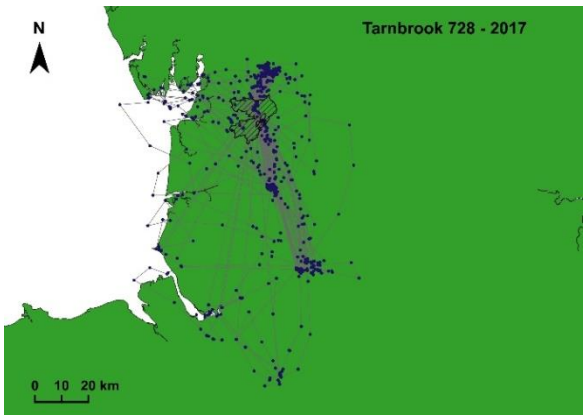
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Tarnbrook 728 - 2017
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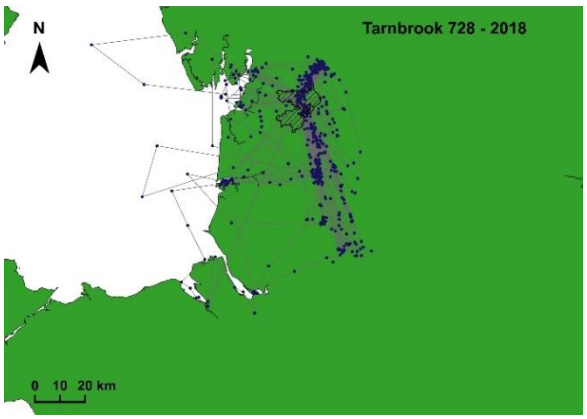
N
Tarnbrook 728 - 2018
0 10 20 km

Appendix 4 Summary of data available for analysis for individual Lesser Black-backed Gulls in 2015 and 2016 from Clewley *et al.* (2017a). As only limited data for a limited sample of individuals were collected during 2015, only results for 2016 are presented in this report for comparison with the results provided for 2017 and 2018.

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	

Appendix 5 Notes regarding tagged Lesser Black-backed Gulls known or suspected to have died since 2016.

Bird 178 – Stationary GPS data transmitted from 4 July 2017 from a farm building near Preston suggesting that the bird had died. A subsequent search on 6 August 2017 recovered the tag from a well decomposed corpse.

Bird 237 – Found dead incidentally at the Langden Head colony on 7 July 2018 on a visit to ring chicks. The bird had been long dead (several weeks or more) and was found in a mostly desiccated state. There were no apparent injuries and the position of the harness position looked good as far as could be told given the state of decay. There were a relatively large number of other dead adults in the colony (150+) in 2018, presumed to have died from botulism.

Bird 262 – We received a report on 16 May 2017 from keepers from the Abbeystead Estate in the Bowland Fells SPA that this bird had been shot by them. Both the corpse and tag were returned to us for examination, the freshness of the corpse indicating that the bird had been shot within one or two days of the day of the report.

Bird 263 – Stationary GPS data transmitted for several days adjacent to a busy main road suggests that this bird died around the evening of 28 July 2016. A search of the area (near to the Bowland Fells SPA) was made after this period on 7 August, but no bird or tag was recovered.

Bird 270 – Stationary GPS data transmitted from 14 July 2017 suggesting that the bird had died near Cowpe Reservoir in Lancashire. A corpse and the tag were found following a search on 7 August 2017, but with no obvious cause of death.

Bird 284 – Reported to us on 26 August 2016 by a member of the public as dead, possibly having collided with power lines around Chipping in Lancashire.

Bird 461 – Recovered on 16 May 2018 from Langden Head. There was no apparent cause of death and no indication that either the device or harness had caused any problems to the bird.

Bird 462 – Stationary GPS data were transmitted from 25 August 2016 from a site near the M1/M6 interchange. The bird subsequently ‘moved’ across the field, which we interpret to be a scavenger moving the body. An intensive search was made of the area on 4 October 2016 and while we did not find the corpse, we found the tag with chewed harness material suggesting that the bird was predated.

Bird 697 – Stationary GPS data were transmitted from a river meadow near Blackburn from early May 2018. No recovery of any bird or tag was made so it is uncertain whether the bird died. This is one of two individuals fitted with a weak-link harness so it is possible that the harness failed shedding the tag.

Appendix 6 Time spent by individual Lesser Black-backed Gulls in the Bowland Fells SPA in the 2017 and 2018 breeding seasons, including time in the colony.

	2017			2018		
ID	**Total time (hrs)**	**Overlap (hrs)**	**%**	**Total time (hrs)**	**Overlap (hrs)**	**%**
Langden Head 178	2243.07	876.53	39.08	-	-	-
Langden Head 237	3674.17	2096.27	57.05	2018.82	1337.32	66.24
Langden Head 245	2593.85	923.76	35.61	1667.52	1042.33	62.51
Langden Head 269	2901.72	1588.73	54.75	3117.15	1401.6	44.96
Langden Head 270	2954.47	1870.16	63.3	-	-	-
Langden Head 277	2377.27	1744.55	73.38	-	-	-
Langden Head 279	2228.97	1415.66	63.51	-	-	-
Langden Head 287	2713.82	1529.39	56.36	-	-	-
Langden Head 459	2718.3	1557.29	57.29	2704.03	1486.97	54.99
Langden Head 461	2993.25	550.38	18.39	1225	265.56	21.68
Tarnbrook 226	2857.9	1328.97	46.5	2699.55	1571.67	58.22
Tarnbrook 697	2029.25	790.63	38.96	699.52	322.14	46.05
Tarnbrook 728	2038.83	728.49	35.73	2906.98	1565.35	53.85
Mean			**49.22**			**51.06**

Front cover: Edmund Fellowes / BTO; back cover: Edmund Fellowes / BTO

Assessing the habitat use of Lesser Black-backed Gulls *Larus fuscus* from the Bowland Fells SPA in 2017 and 2018.

This report presents the results of GPS tracking of Lesser Black-backed Gulls (*Larus fuscus*) breeding at the Bowland Fells Site of Special Scientific Interest (SSSI) and Special Protection Area (SPA) in 2017 and 2018. The report builds on previous results from 2016. The aims of the study were to identify potential feeding areas and to quantify the amount of time spent by the gulls within the SPA boundary.

The tracking data from Lesser Black-backed Gulls from the Bowland Fells SPA in 2017 and 2018 were consistent with previous findings for 2016 and highlighted the importance of terrestrial habitats. There was some individual variation in the extent and pattern of birds' foraging ranges. However, for all birds, home range analyses indicated that key foraging areas were outwith the SPA. The most frequently visited habitats tended to be urban areas and landfill sites to the south and south-east of the SPA, but regular use of nearby agricultural land was also seen. As in 2016, marine environments were only sparsely used in 2017 and 2018.

The additional years of tracking data confirm the previous assessment that the SPA provides an important breeding site for Lesser Black-backed Gulls, but that their key foraging sites are outside the SPA. While many individuals were consistent in their foraging site preferences across years, there were examples of birds shifting sites. It is likely that as some favoured areas, especially landfills, become less profitable for foraging in the future, birds will shift more towards more urban or agricultural foraging, depending on individual preference and stage of breeding.

Suggested citation: Clewley, G.D., Scragg, E.S., Green, R.M., Thaxter, C.B. & Burton, N.H.K. 2019. Assessing the habitat use of Lesser Black-backed Gulls *Larus fuscus* from the Bowland Fells SPA in 2017 and 2018. *BTO Research Report* **714**, BTO, Thetford, UK.

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