**Supplementary materials**

**Evidence of sociality in the timing and location of foraging in a colonial seabird**

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**Supplementary methods**

*Data loggers and handling*

Gannets were captured on their nests by hand and weighed in a cloth bag using a suspension scale (± 25 g, Salter). Each individual was then fitted with GPS data logger (igotU GT-600, Mobile Action, Taiwan, 26.6 g) packaged in heat shrink tubing and secured to the central tail feathers using water-proof tape (Tesa 4651, Beiersdorf AG, Germany), to minimise impact on aerodynamics during plunge diving [1]. Individuals were then returned to the nest to resume normal behaviours with handling time lasting <6 min. Upon recaptures, devices were removed by peeling off the water-proof tape from the feathers, birds were again weighed and morphometric measurements were taken before release, with handling time lasting <15 min.

*Colony departures*

We first identified all tracking data in which birds undertook complete foraging trips. We defined a complete foraging trip as all trips that started and ended at the colony, contained at least one patch defined as foraging (below) and did not contain any gaps due to missing GPS fixes of > 30 minutes. We determined departure and return to the colony area using a 500 m buffer around the colony site, this radius accounts for non-foraging movements around the colony, such as when birds respond to disturbances, but do not depart the colony area. Additionally, this radius allows for the potential that departures occur from rafts and not from the colony itself, as any rafting observed at this colony occurs within close proximity of the colony (JPYA; personal observation). We also examined colony co-departures using 1.5, 5 and 10 minute time windows. Results for 1.5 and 5 minutes were qualitatively similar (supplemental figure 1). To allow for individuals’ GPS devices taking fixes up to 60 seconds apart we selected the 3-minute time window for the presented analysis, as this attempts to minimises the selected time-window while still aiming to include co-departures that might be otherwise be missed due to device resolution. As gannets have been found to have a very long visual range (10-40 km; [2]), even at the maximum of this time-window departing birds will still be in visual range of one another.

*Behavioural classification*

To identify areas in which gannets exhibit foraging behaviour during their foraging trips, we used Expectation-Maximization binary Clustering [3], a method based on maximum likelihood Gaussian mixture models [4]. EMbC is an unsupervised clustering algorithm that is easily implemented and produces biologically interpretable behavioural classification from animal tracking data. It has been previously demonstrated to produce accurate results for congeneric northern gannets [5]. The behavioural output is derived from two input variables; turning angle and speed, calculated between successive GPS relocations. EMbC produces four behavioural classification categories, obtained from the four combinations of high and low values for the two variables. As both low speed categories were categorised by speeds below 1.5 m/s we considered these together as ‘resting’ behaviour, based on previous work on gannet behavioural movements [6]. We considered high speed and low turning, indicating fast straight flight, to be ‘commuting behaviour’, while high speed and high turning was taken to represent ‘foraging behaviours’ (supplemental table 1). EMbC analysis was conducted on all complete trips simultaneously using the R package EMbC v2.0.0 [3], and a built in smoother function was applied to take into account temporal association in behavioural states.

Supplemental table 1: Minimum and maximum speed and turning angle for each behavioural state classification using EMbC. Two states with speeds below 3 km/h where merged into a single state termed ‘resting’.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Behaviour | Min speed (km/h) | Max speed (km/h) | Min turn (rad) | Max turn (rad) |
| Resting | 0 | 3 | 0 | 3.14 |
| Commuting | 3 | 120 | 0 | 0.61 |
| Foraging | 1.7 | 120 | 0.61 | 3.14 |

*Null models*

To determine if the observed patterns of co-departing behaviour could be generated simply due to random departures of individuals, we compared our observed data to null models as follows. For each colony departure we generated 10,000 permutations of each departure time, by swapping each time of departure with randomly drawn departures times from the complete dataset. This allowed each individual to maintain the same number of departures on each day across the study period, but redistributed these events to different times of the day. This method also constrained all permutated departures to observed departure times, thus controlling for the diurnal activity pattern exhibited by gannets [7]. For each set of permutations we then identified the trips in which the permutated departure times were found to be ‘co-occurring’ following the same procedure used on the observed data. We determined significance (p-values) by calculating the proportion of times the observed proportion of co-departing trips was found to be more extreme than the results obtained from the permutated datasets.

Similarly, to determine if the overlap in first foraging patches was driven purely by chance, we compared our results to null models constructed by following a similar procedure. The timing of each foraging patch was permutated 1,000 times by swapping the observed foraging time with a randomly drawn foraging patch time from within the dataset as described above. We then recalculated the temporal and spatial overlap for each permutated foraging patch following the procedure used on the observed data. Significance was again calculated as the proportion of times the observed overlap was found to be more extreme than the results obtained from the permutated datasets.

*Effect of untagged individuals*

To determine the impact of untagged individuals in the colony on our estimates of co-departure and first patch overlap, we resampled our data set at varying scales (10 – 80 individuals) and re-calculated overlap in colony departures and patch overlap as described previously. For each subsample, we drew the specified number of individuals from the whole data-set, and we repeated each sample 10 times (supplemental figure 2).

**Figures**

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**Supplemental Figure 1.** Distribution obtained from 10 0000 permutations of the proportion of trips in which at least one pair of individuals co-departed within A) 1.5 minute B) 5 minute and C) 10 minute time windows compared with the observed proportion (indicated by the dashed line) of co-departures for each time-window respectively.

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**Supplemental Figure 2.** Mean ± SE of proportion of A) trips that co-depart from the colony and B) co-occurring first patches that overlap in space for each subsample of the data (10, 20, 30, 40, 50, 60, 70 and 80 individuals). Final point indicates observed value for the full data set (n = 85).

**References**

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