Tracking the at-sea behaviours of Manx shearwaters (*Puffinus puffinus*) from western Ireland



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Summary

Seabirds are one of the most threatened bird groups worldwide and protecting habitats that are critical to their survival is a key strategy for mitigating population declines. Because seabirds spend most of their lives at sea, recent technological advances have been essential for uncovering movement patterns and space use in otherwise elusive species. Until recently, however, tracking data were primarily used to identify high-use areas without considering the specific behaviours individuals were performing potentially overlooking risks encountered in lower aggregation areas or when displaying specific behaviours. While foraging is vital for food acquisition, many seabirds also rest/raft at sea, forming large aggregations that are thought to play an important role in maintenance and social behaviours. Despite their likely ecological importance, these areas have received relatively little conservation attention. Ireland hosts internationally significant populations of breeding Manx shearwaters (*Puffinus puffinus*), a species known to form large nocturnal rafts. Using an extensive GPS-tracking dataset collected from four major Irish colonies, this report maps the spatial distribution of foraging and resting behaviours in both offshore and coastal waters. Our results indicate that foraging and resting behaviours share similar spatial distributions. During short trips, most individuals foraged and rafted relatively close to their colonies. Although each colony has an associated marine SPA extension, these aggregations are only marginally covered by the current SPA network. Extending by 10km the SPAs associated with each colony will protect up to 45.7% of core resting areas. During longer trips, birds frequently visited the west coast between the Dingle Peninsula and the Aran Islands, travelled long distances to feed within North Atlantic mesopelagic systems such as the Rockall Basin, and even moved beyond Irish waters into the Hebrides region of Scotland. Core used areas in the immediate vicinity of Cruagh and High Island dramatically overlapped while intersections between Great Blasket and Inishvickillane were more limited. In contrast, the region between Dingle and the Aran Islands appears to attract birds from Great Blasket, the largest colony in Ireland, as well as individuals from the three other colonies during longer foraging trips. These findings align with aerial survey data showing high abundances of Manx shearwaters in the region and underscores the importance of these waters as shared, multi-colony hotspots for both foraging and resting.

Introduction

Seabirds are among the most threatened bird groups worldwide (Dias *et al.*, 2019) and are particularly vulnerable to numerous pressures, including predation by invasive species, bycatch, competition with fisheries for food, and the impacts of climate change. Protecting habitats that are critical to their survival is therefore a key strategy to mitigating these threats. Identifying such areas is essential for designing effective conservation measures that align with conservation objectives while remaining compatible with other marine activities, maximising conservation outcomes, enforcement, and compliance, and minimising economic loss and conflict.

Because seabirds spend most of their lives at sea, recent advances in biologging technologies have provided invaluable tools for investigating the movements and space use of otherwise elusive species, offering crucial insights for conservation strategies (e.g. Davies *et al.*, 2021). Until recently, (Wood *et al.*, 2025), tracking data were mostly used to identify areas of high use without considering the specific behaviours individuals were performing. This may have led to an underestimation of risks present in lower-density areas or during particular behaviours. For instance, individuals may face elevated bycatch risk when foraging (e.g. Cleasby *et al.*,2022), or be more vulnerable to collisions with anthropogenic structures during transiting flights (Desholm *et al.*, 2005). When rafting or resting on the water, birds may be more susceptible to disturbance or pollution, while these behaviours have been shown to be important for maintenance and social interactions in many seabird species (McSorley et al., 2003; Weimerskirch et al., 2010). Species such as shearwaters and petrels typically form large rafting aggregations at dawn and dusk near their colonies (Richards *et al.*, 2019; Rubolini *et al.*, 2015), making biologging especially valuable for capturing these nocturnal and elusive behaviours. In Europe, numerous Special Protection Areas (SPAs) have been designated to safeguard seabird breeding colonies and, increasingly, adjacent marine areas. Yet rafting hotspots remain comparatively overlooked (but see Arneil *et al.*, 2020; Colhoun *et al.*, 2023; Wilson et al., 2008).

Ireland and Britain host substantial proportions of the global populations of several seabird species (Burnell *et al.*, 2023), including Manx shearwaters (*Puffinus puffinus*), around 90% of which are believed to breed in these regions (Mitchell et al., 2004). In Ireland, the largest colonies occur off Co. Kerry and Co. Galway (Mitchell et al., 2004; Arneill, 2018; Burnell et al., 2023). Thanks to previous tracking studies carried out in Ireland (Arneill *et al.*, 2020, Colhoun *et al.*, 2023; Darby *et al.*, 2022, Wischnewski *et al.*,2019) and the UK (e.g. Dean *et al.*, 2015; Guilford *et al.*,2008; Richards et al., 2019), the at-sea behaviour and ecology of the species—including foraging and rafting—are now better understood, providing a solid foundation for evidence-based conservation.

The identification and classification of SPAs under the European Union Conservation of Wild Birds Directive (2009/147/EC) in Irish waters form part of the national commitment to protect 30% of marine areas by 2030.

To support the extension of existing SPAs and guide the designation of new ones, we capitalised on extensive tracking data from Irish Manx shearwaters to:

- Identify foraging and rafting hotspots both near colonies and across the wider West Coast
- Characterise the at-sea behaviour of individuals
- Locate multi-colony aggregation areas and quantify overlap among core used areas.

Methods

Study sites

This study was conducted on four islands located on the West coast of Ireland (Figure 1): Cruagh (Co. Galway, (53.525°N; -10.217°E)), High Island (Co. Galway, (53.54643°N; -10.2565°E)), Great Blasket (Co. Kerry, (52.10315N°, -10.5223E°)) and Inishvickillane (Co. Kerry, (52.0429N°, -10.6070E°)) islands. A survey conducted between 2019 and 2021 estimated 109,390 pairs across Great Blasket and Inishvickillane islands, with Great Blasket accounting for 82% of the national population (Burnell et al., 2023). Based on the size and national importance of those colonies for the species, both islands are grouped in a designated Special Protected Area (SPA) (Blasket Islands SPA [Site code: 004008]) for which Manx shearwaters are listed as qualifying interest. With around 33,000 (95% CI: 28,441 – 37,231) Apparently Occupied Sites (AOS), the Cruagh colony is the second largest colony in the country (Colhoun *et al.*, 2023). The island is part of a SPA [Site code: 004170] for which the species is listed as qualifying interest underpinning the SPA designation. Finally, High Island has an estimated breeding population of 818 (95% C.I., 660-976; Arneill, 2018) AOS, and is part of an SPA [Site code: 004144] alongside Inishshark and Davillaun islands but for which Manx shearwaters are not listed as a qualifying interest. Currently those SPAs extend to a distance of 500m (200m in the case of High Island) from each island to accommodate rafting areas for Manx Shearwaters and other nesting seabirds.

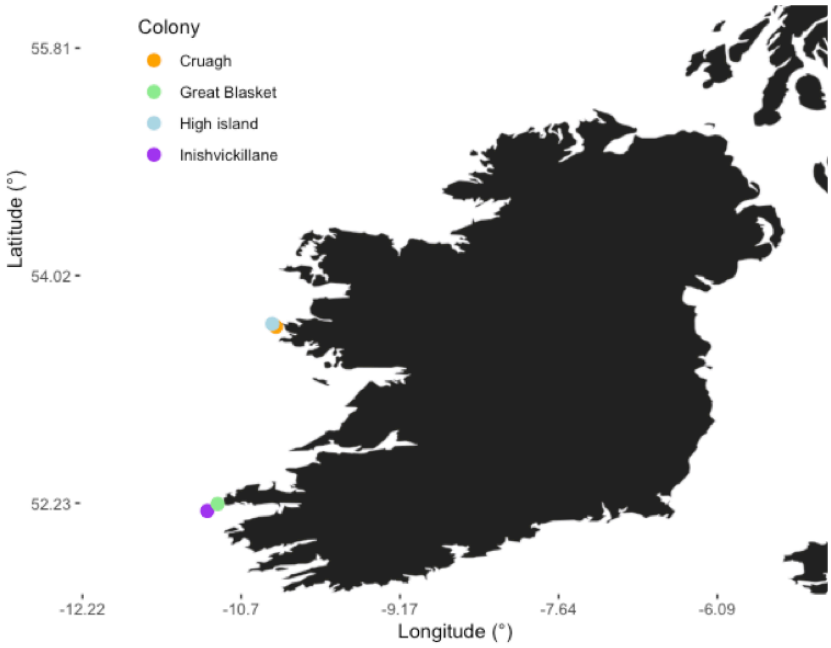


Figure 1: Location of the four Manx shearwater colonies of interest.

GPS Telemetry

A total of 83 breeding adults was equipped with GPS devices during the breeding season (Table 1). Some individuals were tracked multiple times over the season and/or the years. Birds were caught at night using purse nets placed over burrow entrances, or via access tunnels that were set up to monitor adults and chicks (Wischnewski *et al.,* 2019). GPS tags (see Table 1 for tag details) were attached to the back of the birds using Tesa tape (4651, tesa GmbH, Hamburg, Germany) on body feathers. On Cruagh and Inishvickillane, GPS tags were programmed to record positions every ten minutes continuously. On Great Blasket and High Island, the tags were set to record at either four or eight-minute intervals (during chick-rearing) and twelve-minute (during incubation) intervals. Handling time was kept to a minimum and all tracking activities were undertaken under licences from National Parks and Wildlife Service and the British Trust of Ornithology and were approved by University College Cork animal ethics committee (for work conducted on Great Blasket and High Island).

Table 1: GPS deployment details.

Colonies	Dates	Number of individuals tracked	GPS type and weight	GPS resolution(s)
Cruagh	21/07-06/08/2023	14	Pathtrack nano-fix GEO + RF 5-6g (42x15x9.5mm + antennae)	10 mins
High Island	26/07-04/08/2014	5	i-gotU GT-120, *Mobile Action Technology* 13-17g	4 or 8 mins
High Island	30/05-22/08/2015	36	i-gotU GT-120, *Mobile Action Technology* 13-17g	12 mins (incubation) 4 or 8 mins (chick-rearing)
High Island	25/07-02/08/2016	9	i-gotU GT-120, *Mobile Action Technology* 13-17g	4 or 8 mins
Great Blasket	17/07-10/08/2014	8	i-gotU GT-120, *Mobile Action Technology* 13-17g	4 or 8 mins
Great Blasket	03/07-09/08/2015	11	i-gotU GT-120, *Mobile Action Technology* 13-17g	4 or 8 mins
Inishvickillane	20/07-05/08/2023	4	Pathtrack nano-fix GEO + RF 5-6g (42 x15x9.5mm+ antennae)	10 mins

Data Processing

Before conducting analysis, GPS datasets were cleaned to remove any erroneous locations. All analyses were conducted using R software (version 3.6.3). Tracks were linearly interpolated to 4, 8, 10 or 12 mins intervals (based on each GPS resolution, see Table 1) using the package '*PathInterpolateR*' (github.com/jedalong/PathInterpolatR). To avoid interpolating locations over long periods with no fixes (due to scheduled GPS failing to acquire fixes, e.g. due to a bird diving), tracks were split into sections when gaps of greater than 40 mins were present. Foraging trips were defined as when an individual spent at least 1h further than 2 km from the colony, with locations at the colony (0.5 km radius) excluded from further analysis to exclude time spent on land. Departure and return times from/to the colony were noted for each foraging trip and the trip duration calculated. For each foraging trip, the distance between successive locations was calculated using the package '*raster*' before being summed to obtain the total distance travelled. The distance between the colony and the furthest point of each foraging trip (hereafter 'maximum range') was also calculated using the same package. Manx shearwaters typically display a bimodal foraging strategy (Wischnewski *et al.,* 2019), alternating numereous short trips to maximize food delivery to the chick, and longer trips dedicated to self-maintenance. After plotting the distribution of trips maximum range (Figure 2), short trips were defined as trips with a maximum range ≤ 200km while long trips, less frequent, were the ones with the maximum range exciding that threshold.

Statistical analyses

Using the package '*momentuHMM*' (McClintock and Michelot, 2018), we performed Hidden Markov Models (HMM) and inferred three behavioural states (rest, area-restricted search (ARS), and transit) from step lengths and turning angles between successive points (Kane *et al*., 2020). Step lengths and turning angles were modelled with a gamma distribution and a von Mises distribution respectively, adapting starting parameters from Kane et al., 2020 to each tag resolution. Travelling is usually characterised by wide turning angle and long distances between GPS locations reflecting directed flight. ARS is assumed to represent active foraging behaviour (Bennison *et al.*, 2018), usually with steep turning angles and intermediate distances between points while rafting is associated with steep turning angles but short step lengths made passively resting on the sea surface. The time spent in each behavioural state per foraging trip was then calculated. To examine the spatial distribution of rafting and foraging behaviours, kernel utilization distributions (UDs) were calculated with the package '*adehabitatHR'* (Calenge, 2006) and a 3km resolution, for each foraging trip based on GPS locations identified respectively as resting and ARS by the HMM. UDs were then standardized before being averaged per individual and colony (and year for Great Blasket and High Island) for each trip type ('short' *vs*. 'long', see above). Overlaps between colonies were mapped and the UDs were plotted against density obtained from the aerial survey ObSERVE II (Giralt Paradell *et al.*, 2024) to discuss the representativeness of our results.

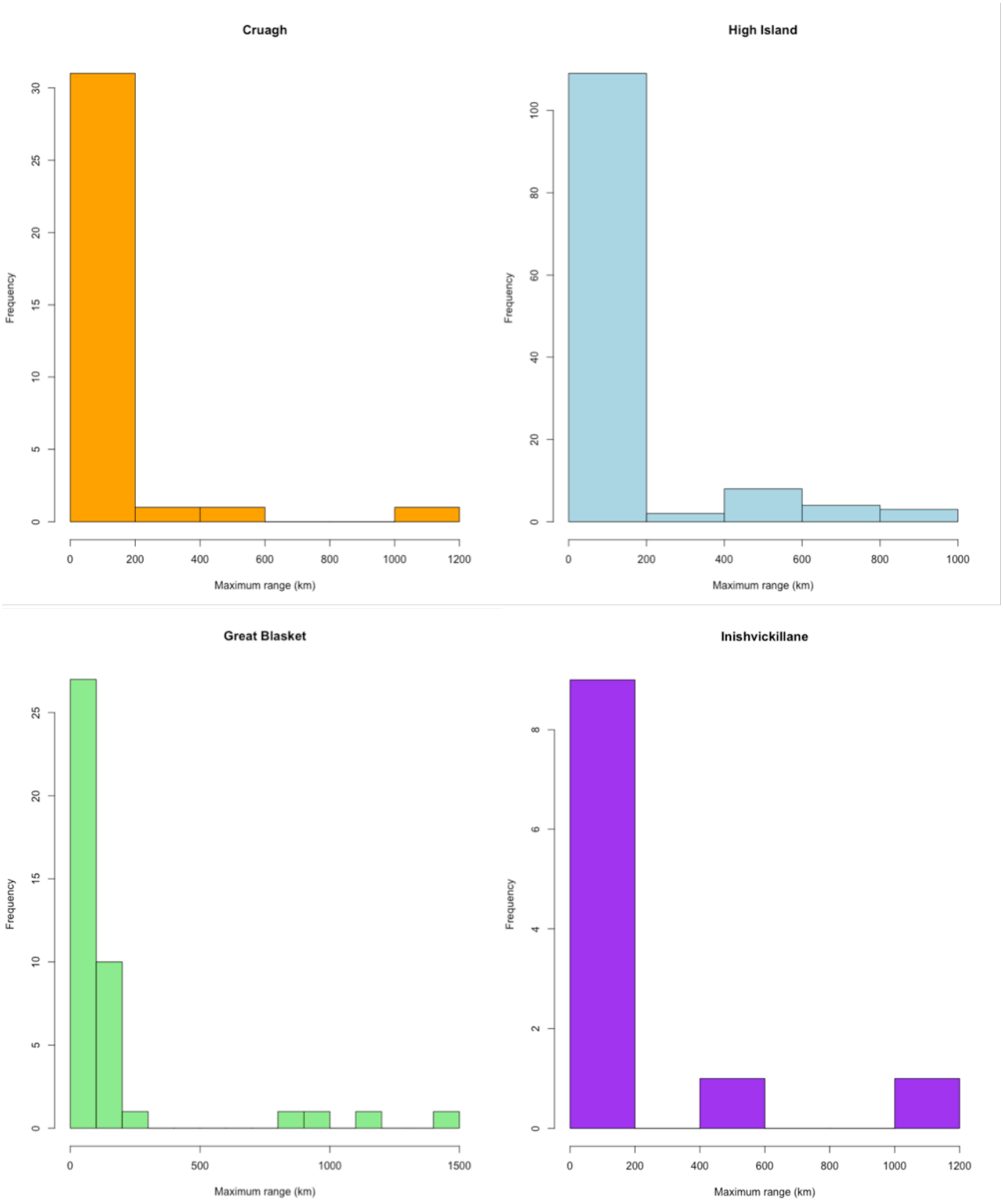


Figure 2: Distribution of the trip maximum ranges for the four colonies. Short trips were defined with a maximum range ≤200km while long trip maximum ranges excided that threshold.

Results

Description of foraging trips

Overall, the 83 individuals tracked performed 213 foraging trips, for which 193 were complete (Table 2). Most of the incomplete trips were classified as such as the battery died before the bird went back to the colony. All trips were kept to perform UD calculations but only complete ones were retained when describing trip metrics (see Table 3 & 4).

Table 2: Details of foraging trip numbers for each colony.

Colony	Year	Number of individuals	Number of complete foraging trips	Number of incomplete foraging trips
Cruagh	2023	14	34	-
High Island	2014	5	9	-
High Island	2015	36	95	12
High Island	2016	9	9	1
Great Blasket	2014	8	18	4
Great Blasket	2015	11	17	3
Inishvickillane	2016	4	11	-

During short trips, individuals from Cruagh remained relatively close to the colony, staying offshore of Clifden (Figures 3 & 7, Appendix 2). In contrast, birds from High Island ranged more widely, using coastal waters from Clew Bay to Aran Islands (Figures 4 & 8, Appendix 2). Manx shearwaters from Great Blasket regularly travelled northward along the coast, frequenting areas between the Dingle Peninsula and offshore Mullaghroe (Figures 5 & 9, Appendix 2). Although some birds travelled north, resting in waters close to Cruagh, individuals from Inishvickillane generally headed south during short trips reaching waters as far as Mizen Head and Cape Clear Island (Figures 6 & 10, Appendix 2). When undertaking long trips, birds from all colonies ventured far offshore, visiting major oceanographic features such as the Rockall Basin. Additionally, individuals from Cruagh, High Island and Inishvickillane also travelled northwards to Sligo and Donegal Bays and, in some cases, reached as far as the Hebrides in Scotland (Figures 3–10).

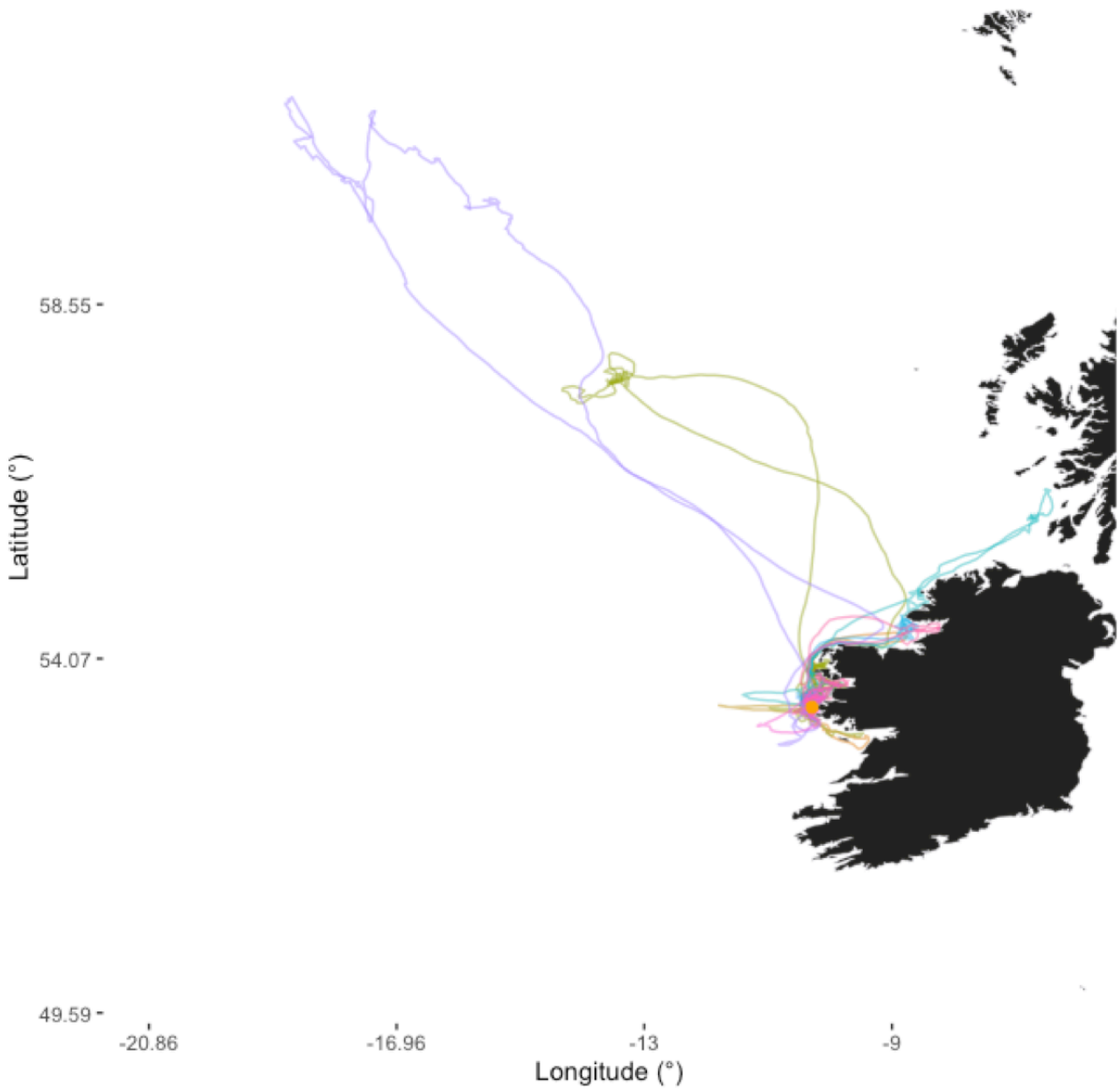


Figure 3: Foraging trips performed by Manx shearwaters from Cruagh Island (orange dot) during the breeding season in 2023. Each colour corresponds to an individual.

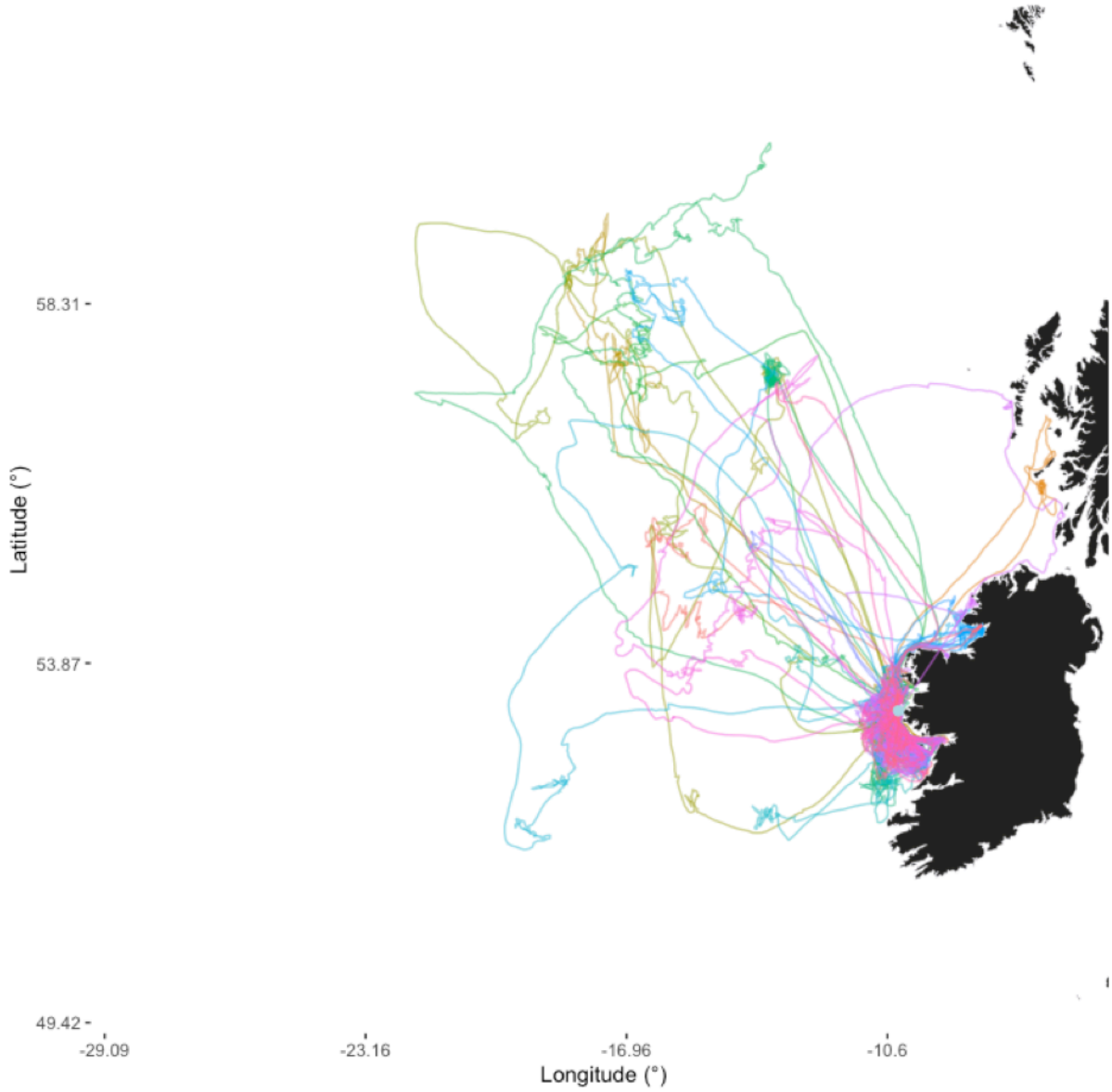


Figure 4: Foraging trips performed by Manx shearwaters from High Island (blue dot) during the breeding season in 2023. Each colour corresponds to an individual.

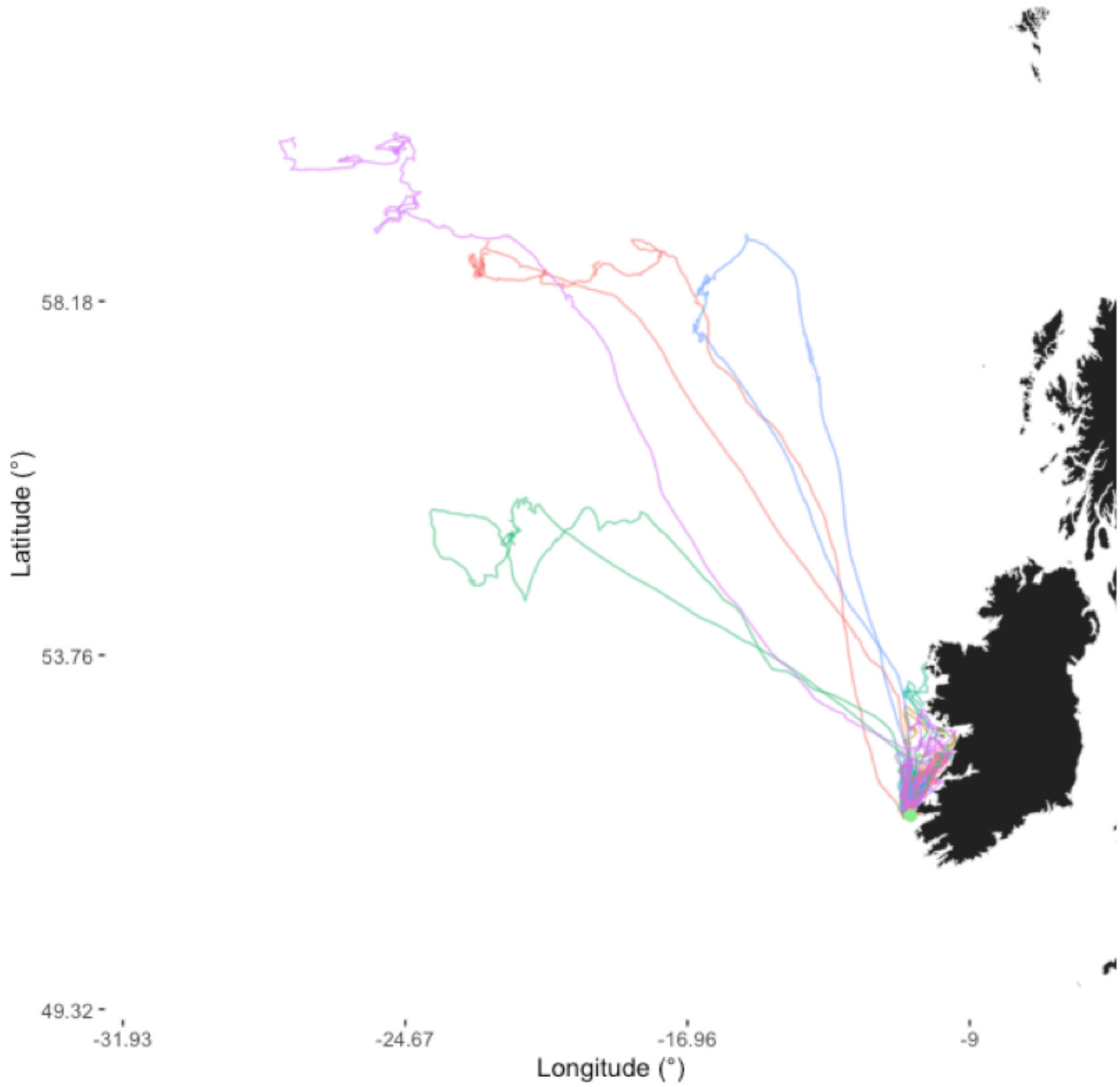


Figure 5: Foraging trips performed by Manx shearwaters from Great Blasket Island (green dot) during the breeding season in 2023. Each colour corresponds to an individual.

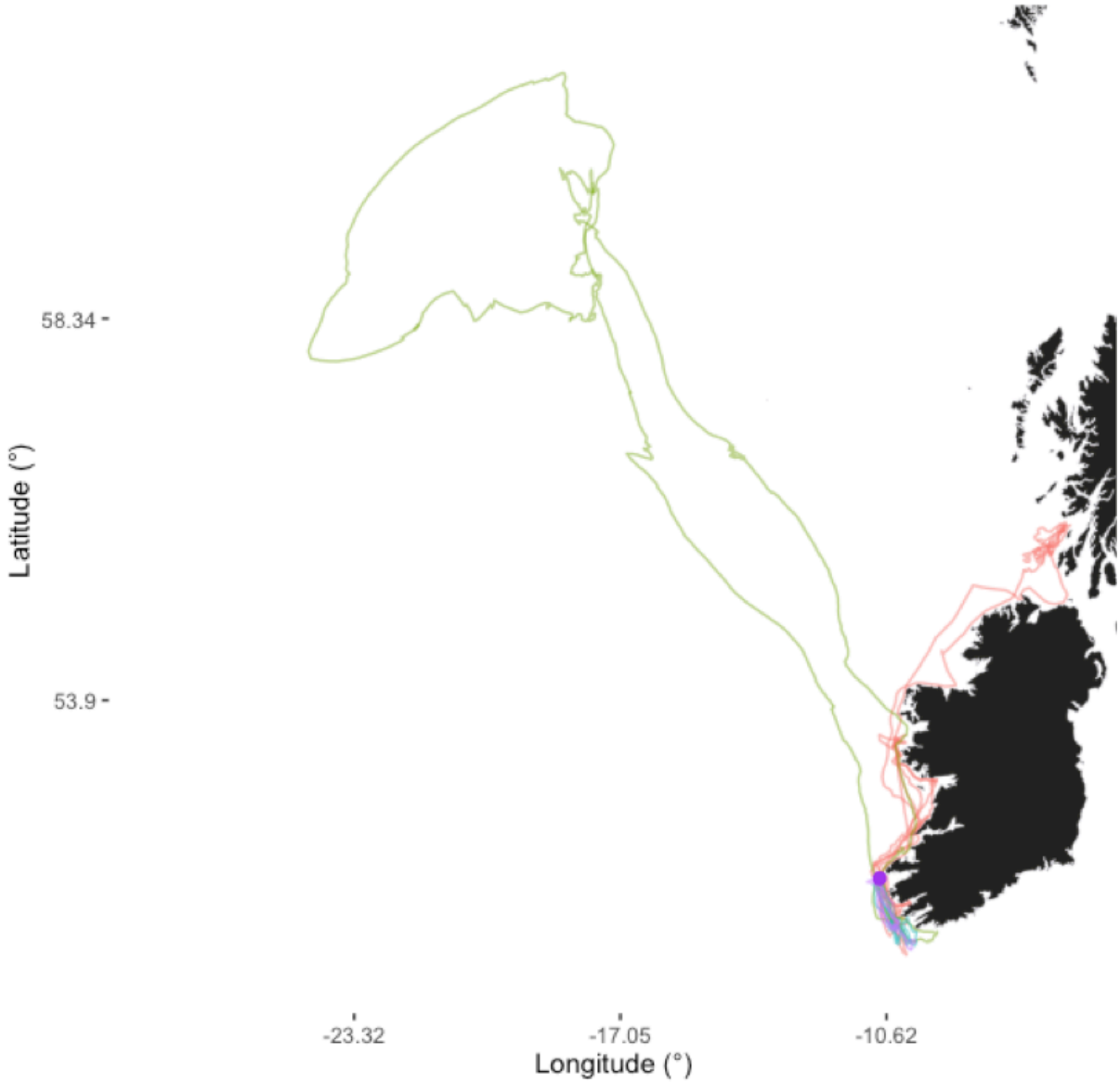


Figure 6: Foraging trips performed by Manx shearwaters from Inishvickillane (purple dot) during the breeding season in 2023. Each colour corresponds to an individual.

There were a lot of variability in foraging trip ranges, duration and total distance travelled (Table 3&4) and further analysis will be required to confirm if there are significant differences between colonies. Although values varied between trips and colonies, during short trips individuals spend around a third of their time resting and around half of it foraging. Individuals were spending more time transiting during long trips than short ones.

Table 3: Short foraging trip characteristic means and standard deviations per year and colony. Only complete foraging trips were considered here.

Colony	Year	n	Max range (km)	Duration (h)	Total distance (km)	% Resting	% Foraging	% Transiting
Cruagh	2023	31	48.4±42.9	37.3±25.1	259.5±218.9	30±13	53.9±11.4	13.2±11.2
High Island	2014	8	83.9±39.5	27.7±16.5	292±175.1	30.4±11.6	47.5±5.7	22.4±8.7
High Island	2015	84	64.6±32.4	38.8±43.4	365±369.4	29.5±12.4	49.9±12	19.7±8.4
High Island	2016	8	78.9±46.7	33.2±12.9	334.3±159.8	26±8.7	53.6±7.4	20.6±5.8
Great Blasket	2014	17	84.4±34.1	27.9±16.4	275±142.5	29.3±10.2	49.8±5.7	21.0±11.6
Great Blasket	2015	13	65.9±43	22.9±11	244.2±183.8	22.8±14.7	55±11.8	21.9±11.8
Inishvickillane	2023	9	110.9±45	42.2±33	406.6±270.4	20.3±12.6	57.5±8.9	19.3±8.1

Table 4: Long foraging trip characteristic means and standard deviations per year and colony. Only complete foraging trips were considered here.

Colony	Year	n	Max range (km)	Duration (h)	Total distance (km)	% Resting	% Foraging	% Transiting
Cruagh	2023	3	645.2±322.5	134.7±50.9	2199.3±1046	24.6±2.6	39.8±1.1	34.9±3.6
High Island	2014	1	468.5	116.7	1540.5	31.7	36.4	29.2
High Island	2015	11	583±142	210.7±81.6	2733.6±705.3	26.8±5.7	41.5±9.6	30.2±11.6
High Island	2016	1	335.6	48.1	811.4	25.5	33	41.7
Great Blasket	2014	1	1108.6	188.9	3266.8	26.9	37.9	35.3
Great Blasket	2015	3	679.1±400.8	133.4±50.5	1951±924	34.1±9.2	32.3±6.7	30.4±10.3
Inishvickillane	2023	2	863.4±452.2	212.5±68.6	3748±1729.7	22.1±7.4	47.6±2.2	29.9±9.7

Distribution of at-sea behaviour

During short trips, individuals (except those from Inishvickillane) usually concentrated in areas in the direct vicinity of their colony to rest (Figure 7 to 10): For example, during those trips, birds from Cruagh spent 46.2% of their resting time at 10km or less from the colony (23.6%, 51.2%, 8.3% for birds from High Island, Great Blasket and Inishvickillane respectively). During longer trips birds still rafted relatively close to their island of origin while also resting along the way of their journey (Figure 7 to 10). Foraging behaviour followed similar distribution than rafting (Appendix 2).

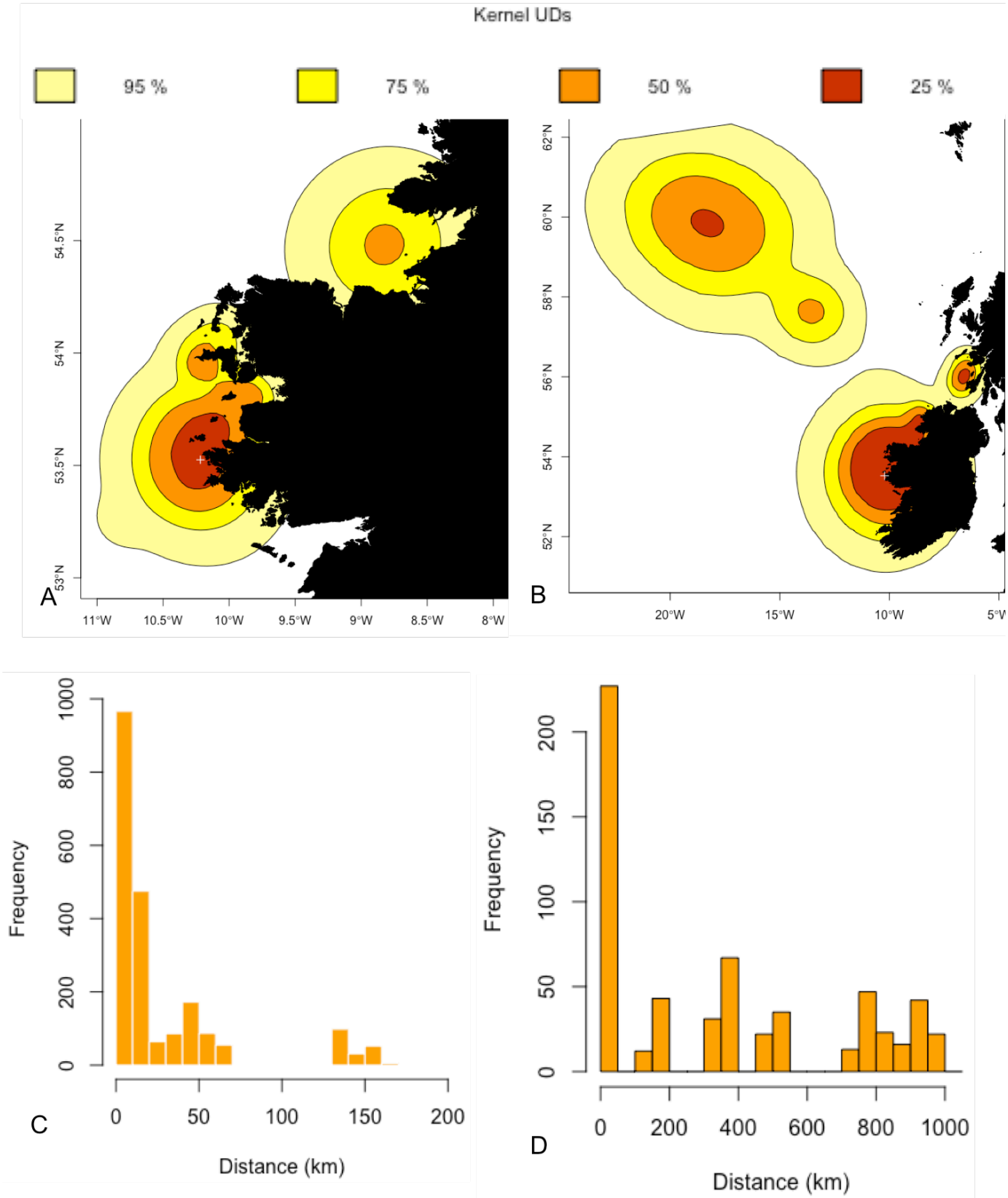


Figure 7: Utilisation Distributions (UDs) of resting behaviour during short (A) and long (B) trips for individuals from Cruagh (white cross). Distribution of the resting behaviour during short (C) and long (D) trips with increasing distance to the colony.

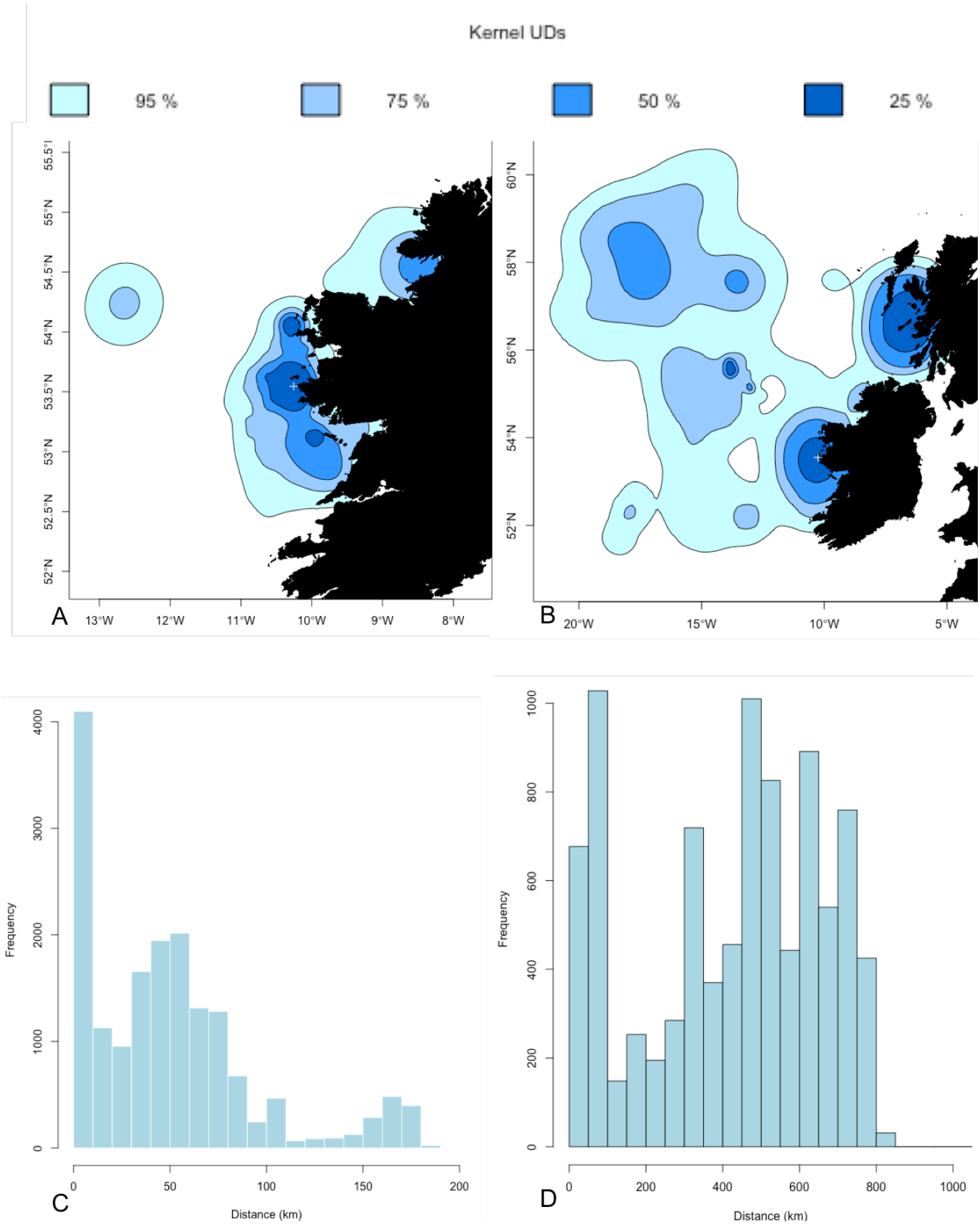


Figure 8: Utilisation Distributions (UDs) of resting behaviour during short (A) and long (B) trips for individuals from High Island (white cross). Distribution of the resting behaviour during short (C) and long (D) trips with increasing distance to the colony.

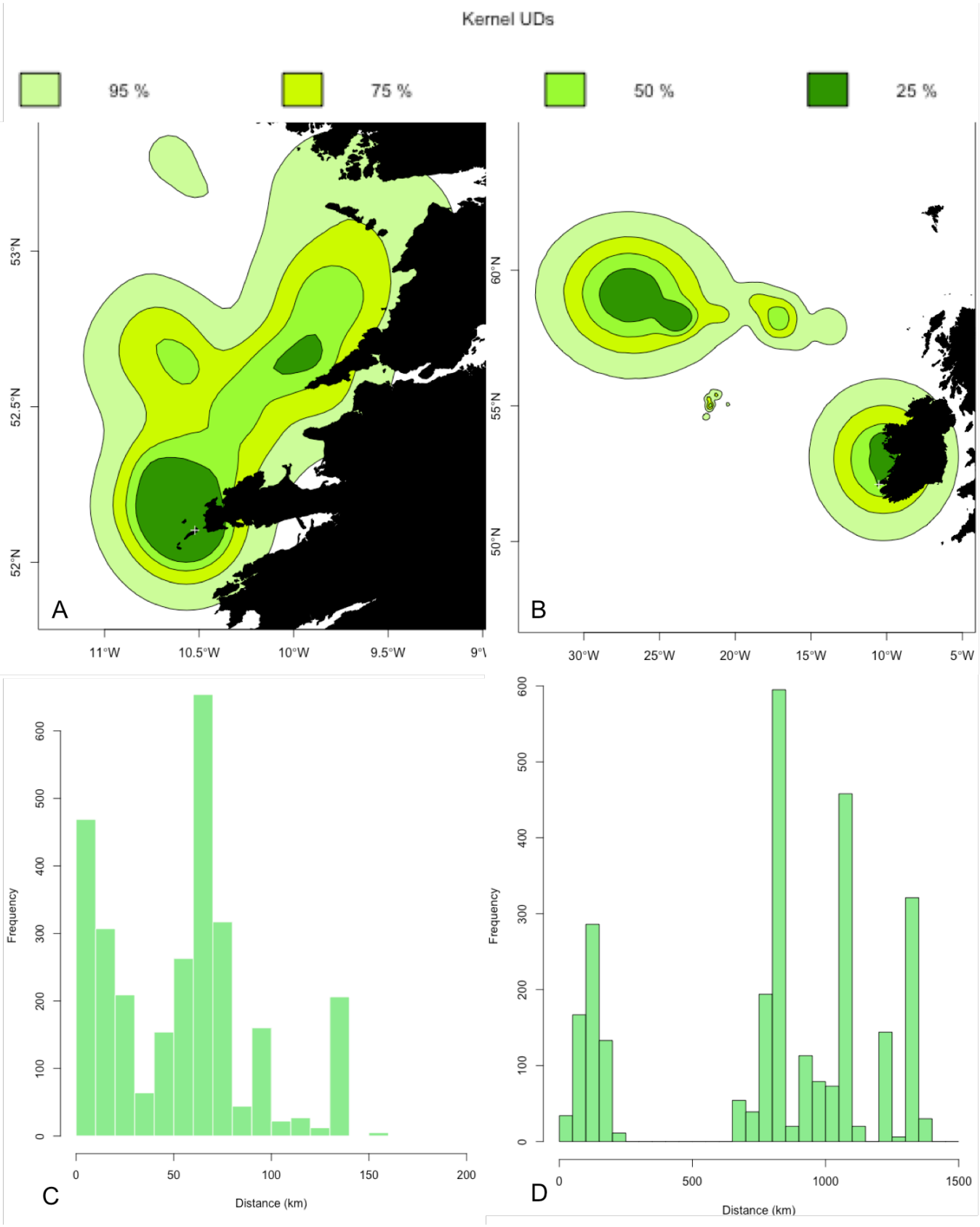


Figure 9: Utilisation Distributions (UDs) of resting behaviour during short (A) and long (B) trips for individuals from Great Blasket (white cross). Distribution of the resting behaviour during short (C) and long (D) trips with increasing distance to the colony.

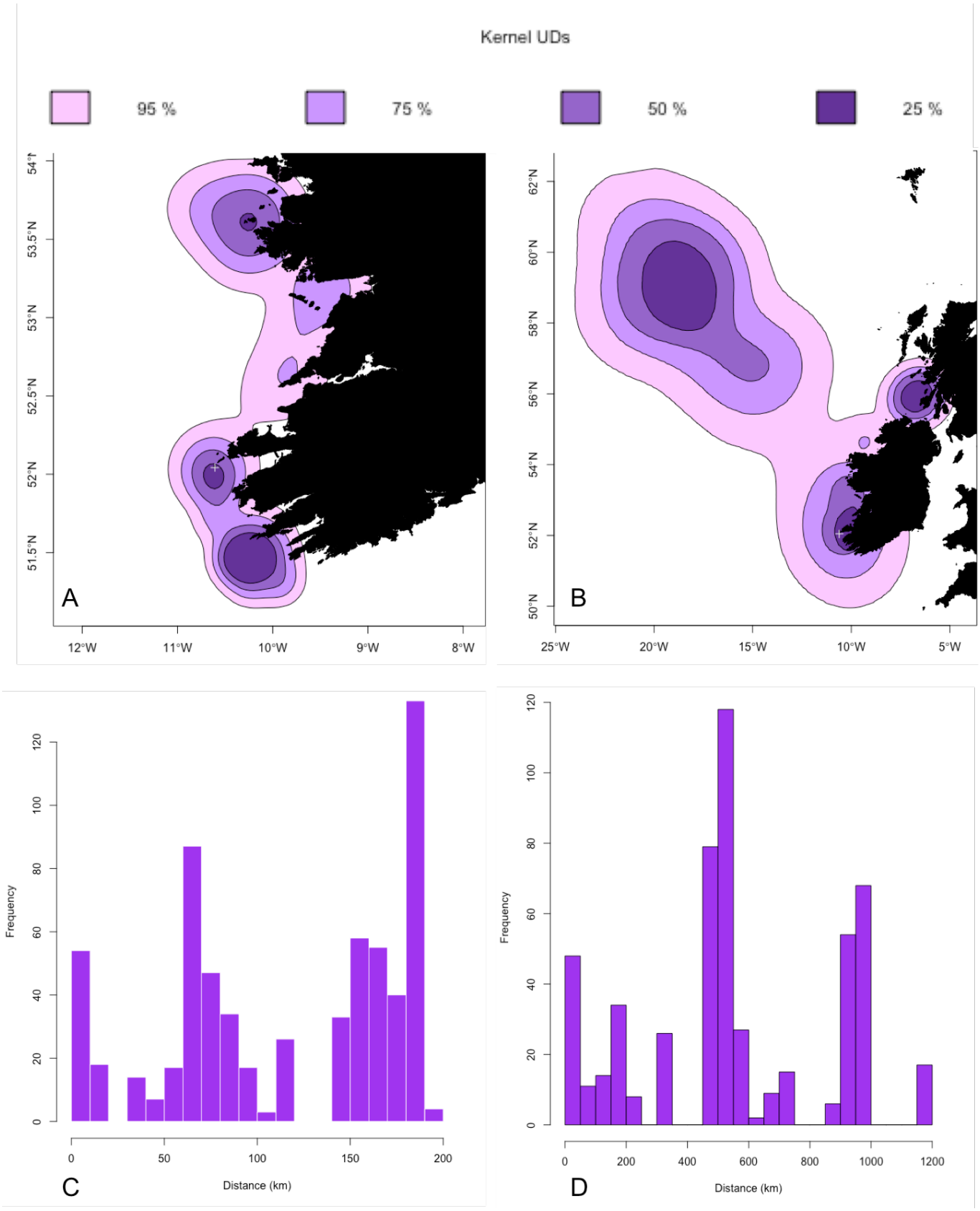


Figure 10: Utilisation Distributions (UDs) of resting behaviour during short (A) and long (B) trips for individuals from Inishvickillane (white cross). Distribution of the resting behaviour during short (C) and long (D) trips with increasing distance to the colony.

Although birds concentrated around their colony of origin to raft, the 25% kernel UDs for rest (hereafter 'core resting area') defined from short trips have important sizes (Table 5) and are barely covered by the current SPAs that only extend to a maximum of 500m offshore from the colonies (see Figure11). All type of trips considered, we observed an important variability in the amount of time birds spent in the core resting area (Table 5): during some trips, individual do not stay while others spent as much as 30 hours rafting there.

Table 5: Surface of the 25% kernel utilisation distribution obtained using GPS points classified as resting during short trips and time spent resting in this area all trips considered.

	Cruagh	High Island	Great Blasket	Inishvickillane
Areas (km^2)	830	1912	1125	1393
Time spent (Mean±sd in hour)	8±6.8	4.3±4.1	2.7±2.2	5.6±3.5

Except for birds from Inishvickillane for which this patterns were less marked, individuals mostly rested in the corresponding core areas (obtained from short trips) in the early morning before leaving for the rest of their trip, and in the early evening when coming back to the colony (Figure 12).

Overlaps and important areas

Individuals tended to aggregate near their colonies to rest and forage, with some core-use areas showing overlap between neighbouring colonies (Figure 11). For instance, 94% of the core resting area identified for Cruagh (based on short trips) falls within that of High Island. Surprisingly, some individuals from Inishvickillane also rested in this zone, whereas only 4.8% of their own core resting area overlapped with that of Great Blasket, despite the two colonies being geographically close.

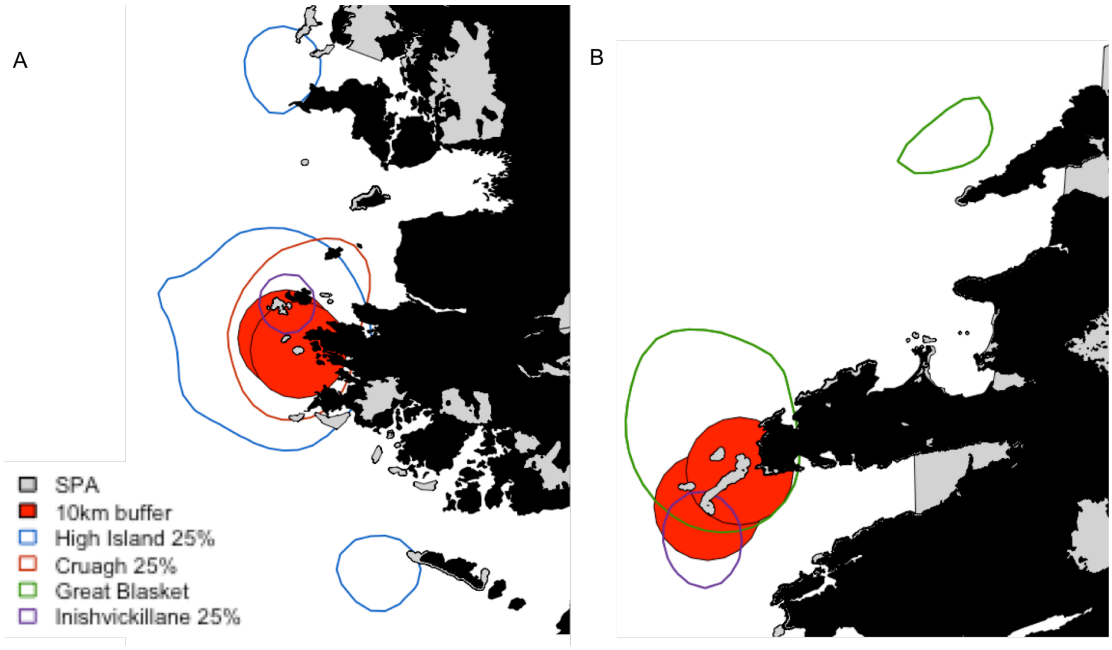


Figure 11 : Overlaps of the core resting areas between High Island/Cruagh (A), and Great Blasket/Inishvickillane (B), SPAs and 10km extensions.

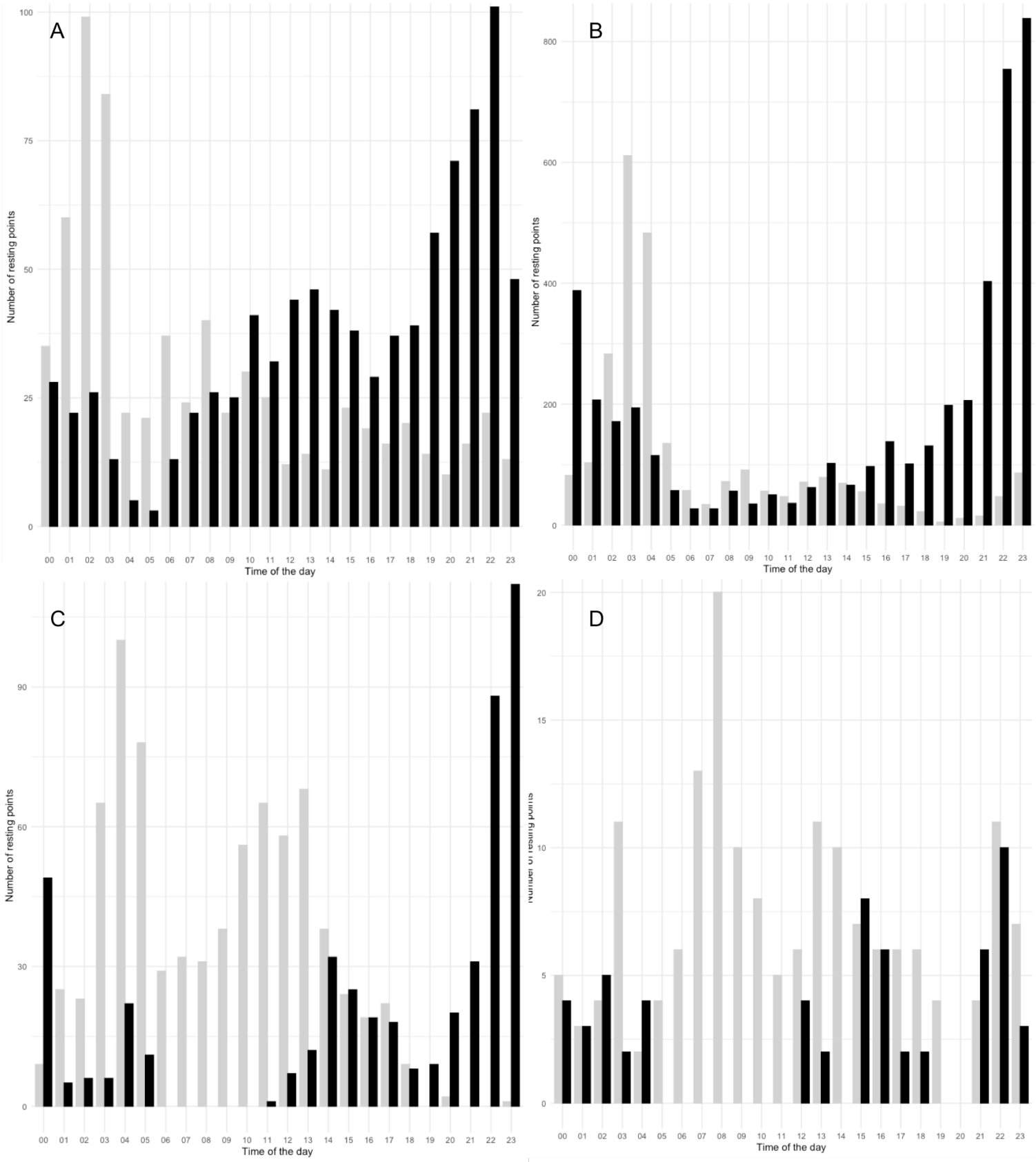


Figure 12: Number of resting points per hour of the day in the 25% kernel UD obtained using GPS points classified as resting during short trips, while leaving (light grey) or returning (back) the area for Cruagh (A), High Island (B), Great Blasket (C) and Inishvickillane (D).

Extending the current SPAs by a 10 km buffer around each island would substantially increase protection of these key areas, covering up to 45.7% of Cruagh's core resting area (and 19.3%, 34.7% and 19.8% for High Island, Great Blasket and Inishvickillane, respectively) (Figure 11). Finally, during both short and long trips, individuals from all colonies heavily used the coastal corridor between the Dingle Peninsula and the Aran Islands. This pattern is consistent with results from the ObSERVE II aerial surveys conducted in 2021–2022 (Figure 12).

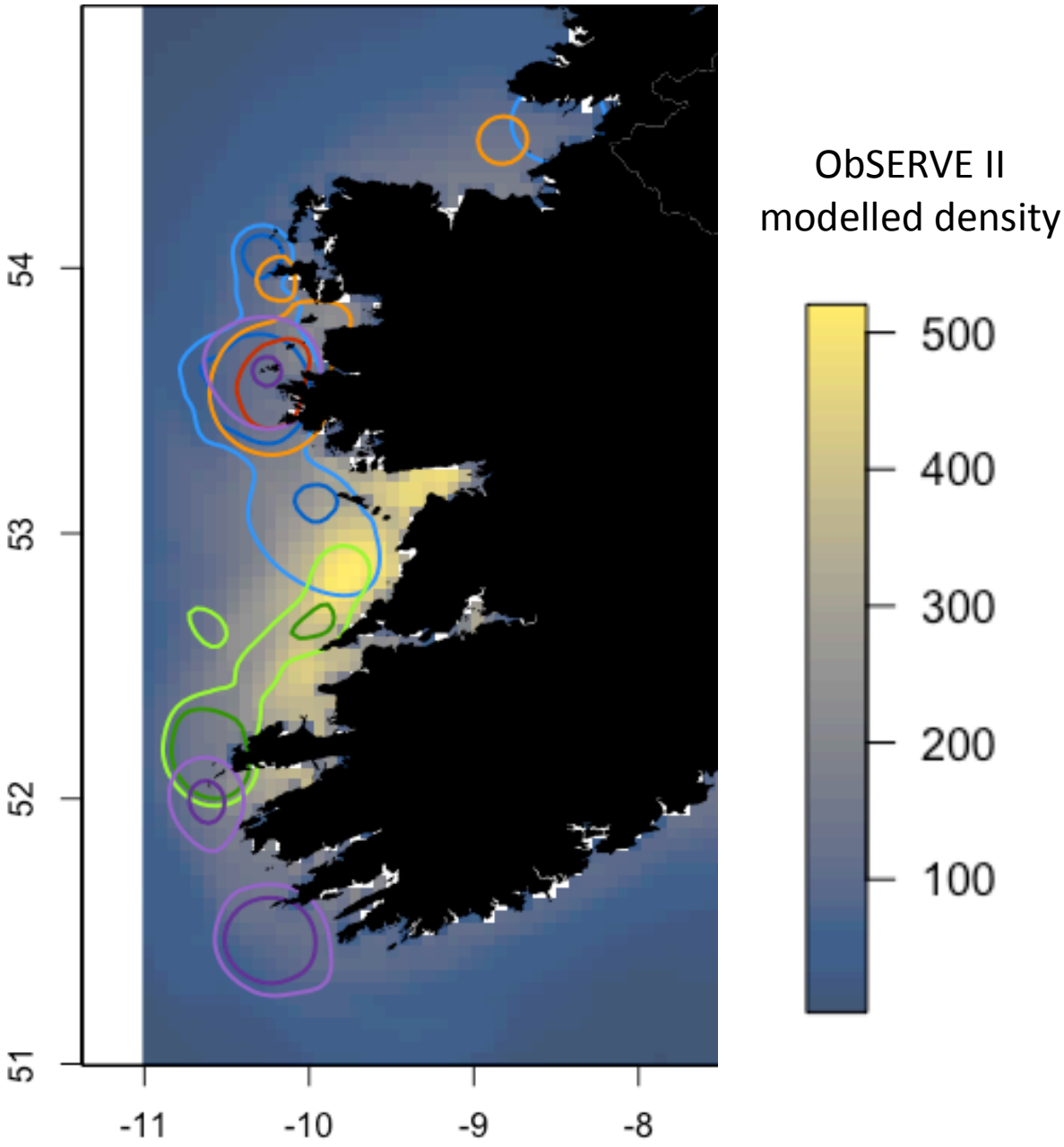


Figure 12: Overlap between ObSERVE II modelled density and 25% (dark) and 50% (light) rest UDs for Cruagh (orange), High Island (blue), Great Blasket (green) and Inishvickillane (purple).

Discussion

Based on the foraging trips and Utilisation Distributions, we identified several key areas used by the Manx shearwater population breeding along the west coast of Ireland. Birds aggregated to rest and forage in the immediate vicinity of the colonies, but also in more distant locations such as between the Dingle Peninsula and the Aran Islands, the Rockall Basin, Donegal Bay, and the Hebrides. This results are in adequation with patterns obtained from the ObSERVE II surveys even if birds spotted from the plane were mostly detected while flying, suggesting that those areas were also heavily used by birds commuting to foraging grounds. When focussing on High Island and Great Blasket, Arneill *et al.* (2020), showned that all rafting within 10km of the colony happened at a mean distance of 4.89km ± 2.37km and 4.11km ± 2.11km respectively. In this study we demonstrated that extending the current SPAs coverage by 10km around each colony would not only cover those hotspots but also protect the core used areas by up to 45% for Cruagh and 35% for Great Blasket, improving the protection of these two biggest Irish colonies.

Although the drivers of Manx shearwater foraging distributions have received some attention (Darby *et al.*, 2022), the environmental factors influencing rafting distributions remain poorly understood (but see Richards, 2019) and require further investigation. These may relate to colony location, tides, moon phase (Rubolini *et al.,* 2015), predator abundance (e.g. gulls), or the number of conspecifics present. The temporal patterns of arrival and departure in the core resting areas are consistent with previous findings and observations suggesting an anti-predator strategy (Miles *et al.,* 2013), which appears widespread across the species' distribution. As rafting around the colony is generally assumed to facilitate the exchange of foraging information (Weimerskirch *et al.,* 2010), different peaks in arrival and departure at core resting areas may indicate that birds have only a limited window in which information can be shared. This requires further investigations in relation with time spent in the area but may point to additional, yet unidentified roles of these aggregations.

Although our conclusions are supported by numerous foraging trips, several limitations should be considered. As in any tagging study involving a subset of a population, we assume that rafting locations identified from tagged individuals are representative of the broader colonies. This assumption is particularly important for Inishvickillane, where only four individuals were tracked. Additional tracking at this site would improve inference regarding rafting locations across the Blasket SPA. Another source of variation lies in the use of different tag types among colonies, which may have influenced observed differences, as tagging can affect Manx shearwater foraging and diving behaviour (Clairbaux *et al.*, 2025). Differences in temporal resolution across tags also complicate behavioural classification: coarser resolutions likely contributed to potential misclassification between foraging and resting. Although the species' foraging ecology inherently involves sequences of diving (foraging) followed by resting, and although HMMs performed satisfactorily in distinguishing Manx shearwaters behaviours (Darby *et al.*, 2022), time interval between locations remains a key parameter influencing HMM performance (Schoombie *et al.*, 2024). Incorporating dive data has been shown to reduce classification uncertainty (Saldanha *et al.*, 2023) and might be a powerful tool to improve classification accuracy in future analysis.

Finally, birds from High Island and Great Blasket were not tracked during the same period as birds from the other two colonies, providing only a snapshot of spatial distribution. Similarly, the ObSERVE data were collected in 2021–2022, when none of the colonies were being tracked.

Conclusion and perspectives

Despite these limitations, our study provides valuable and robust insights into the areas used by Manx shearwaters from the four main Irish colonies, offering an important baseline for identifying and protecting key at-sea habitats and emphasises the promising role of behavioural state–classification models for conservation purposes. We showed that the current SPA network provides limited coverage of the core used areas for the local populations, thereby reducing its potential conservation benefits and underscoring the need for future extensions. Finally, this study outlines a West Coast–wide conservation perspective, focusing not only on the immediate surroundings of each colony but also on broader, shared areas that should be considered in the design of a coherent protected-area network. Such an integrated protection framework has the potential to deliver greater conservation benefits, enhancing ecological connectivity, improving population resilience, and ensuring that management measures align more closely with the species' true spatial ecology.

Acknowledgments

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Appendices

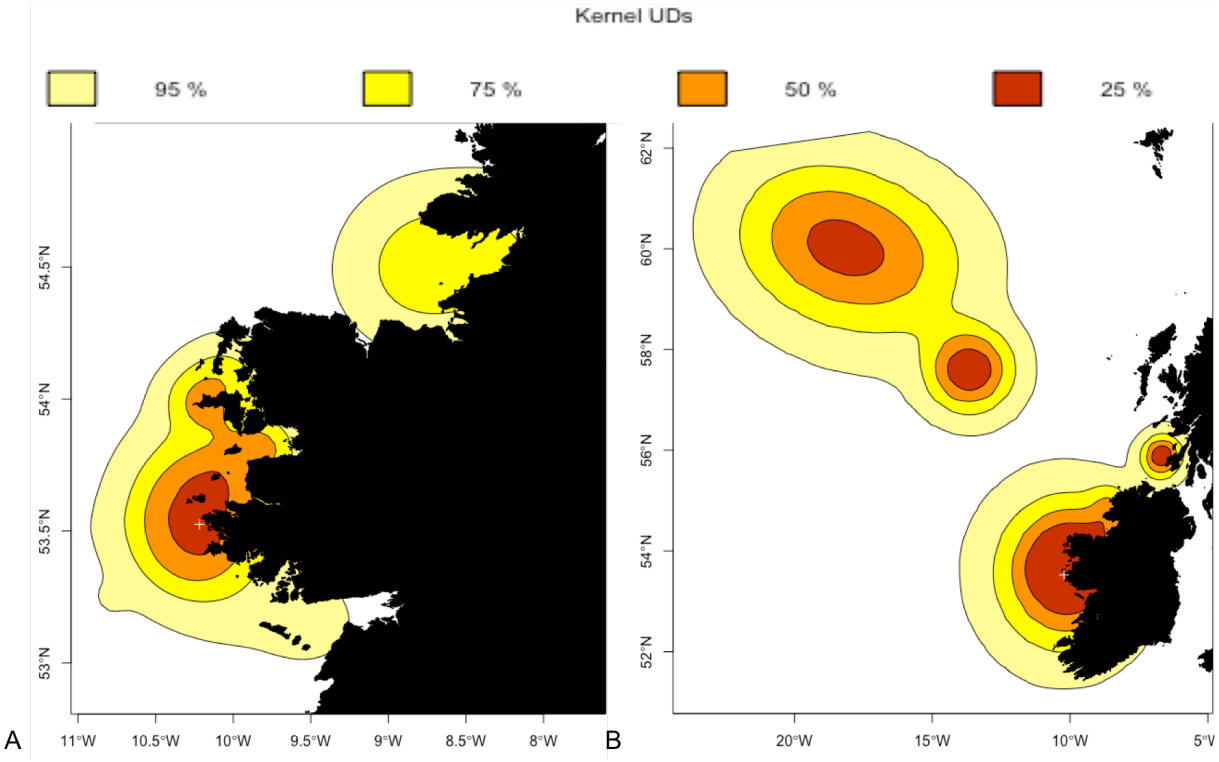
Appendix 1: List and content of the files provided alongside this report.

Except when specified otherwise, files are provided in a folder corresponding to the associated colony.

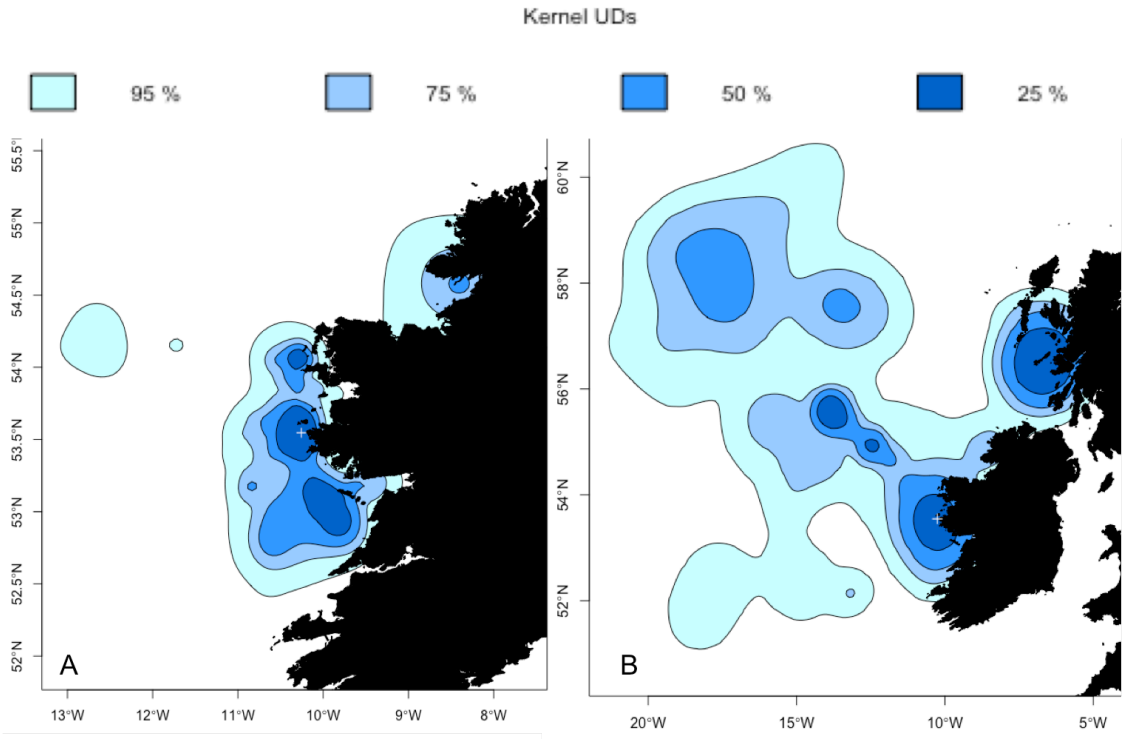
1. The cleaned data for each colony: "Tot_ind.csv" for Cruagh, "inish_2023.csv" for Inishvickillane, "gb_2014-15.csv" for Great Blasket, "hi_2014-16.csv" for High Island. This corresponds to the raw dataset provided by Arneill.G and Colhoun. K with the exception of the data file for Cruagh that required combining individuals, removing erroneous data point and converting the Date_Time column in a readable format.
2. One file per colony "[Name of the colony]_ interp_10mins.csv" containing for each point, the interpolated Date and Time, the interpolated locations, the corresponding Bird ID, the section of the trip to which the point belongs (see methods) and the distance to the colony (DistCol column).
3. For Great Blasket and High Island a file called "Res" that contained for each trip section, the associated GPS resolution (see Table 1).
4. One file per colony "Trip_meta_[Name of the colony]_.csv" containing the list of the trips with corresponding Bird ID, ID of the trip (trip_bis column), Start and End dates, the duration of the trip (Duration column), the maximum range (Maxrange column), the total distance travelled (Totdist column), the time spent in each behaviour (Time[behaviour] columns), the % of time spent in each behaviour (Perc[behaviour] columns) and the time spent in the core resting areas defined with short trips (Timeresting_Core column). For Great Blasket and High Island, the column "nbsection" indicates the number of sections (and therefore gaps of more than 40mins, see methods) presents in that trip. For those two colony, the column "Departure" and "Return" indicate if the Departure and the Return of the trip were considered as reliable (Yes, e.g. no location recorded until the bird was far away at-sea) or (No, e.g. tag battery died at-sea) and were used to determine if the trip was complete or not.
5. One file per colony "Trip_points_[Name of the colony]_..csv" containing interpolated locations that are in foraging trips associated.
6. One file per colony "[Name of the colony]_HMM.csv" containing for each interpolated location in a trip the corresponding interpolated Date and Time, the Bird, section, trip IDs (trip_bis column for trip ID), the distance to the colony, the year, the HMM behavioural state (hmm_state column, 1= Rest, 2=Foraging, 3=Transit), the distance to the previous point in the trip (EcDist column) and finally the type of trip that point is in (Trip_type, Short or Long, see methods).
7. One file per colony "Resting_CORE.csv" containing the interpolated location identified as REST that fell in the core resting areas (25% UD) defined for the corresponding colony, using short trips.

8. For each individual, a shapefile called "Trips[individual ID].shp" containing the interpolated foraging trip of that individual.
9. For each individual, a .jpeg file called "Trips[individual ID].jpeg" plotting the trips of that individual. One colour per trip. For Great Blasket and High Island, the legend corresponds to each trip number associated with the trip year (e.g. 1_2014, 2_2014, 1_2015 etc..) as some individual were tracked several years.
10. For each colony, 4 rasters containing the Utilisation Distribution values for resting and foraging behaviours during short and long trips. Name: "[Type of trip]Trips_Kernel[behaviour]_average_[colony]_.tif". For Great blasket and High Island, those rasters are also provided for each of the year tracking took place. Rasters have a 3km resolution and are projected in UTM29.
11. For each colony, 4 shapefiles corresponding to 25%, 50%, 75% and 95% UDs for resting and foraging during short and long trips. Names: "[Type of trip]Trips_kernel_[behaviour]_ [valueUD]_[colony].shp" for the lines version and "[Type of trip]Trips_kernel_[behaviour]_ [valueUD]_POLY_[colony].shp" for the polygons. Those files are projected in UTM29.
12. One raster containing the ObSERVE II (Abundance Manx shearwaterSummer Combined.tif) modelled abundance for the species.
13. One file (LocationColonies.csv) containing the location of each colonie.
14. One R code containing the annotated script to reproduce the analysis described in this report.

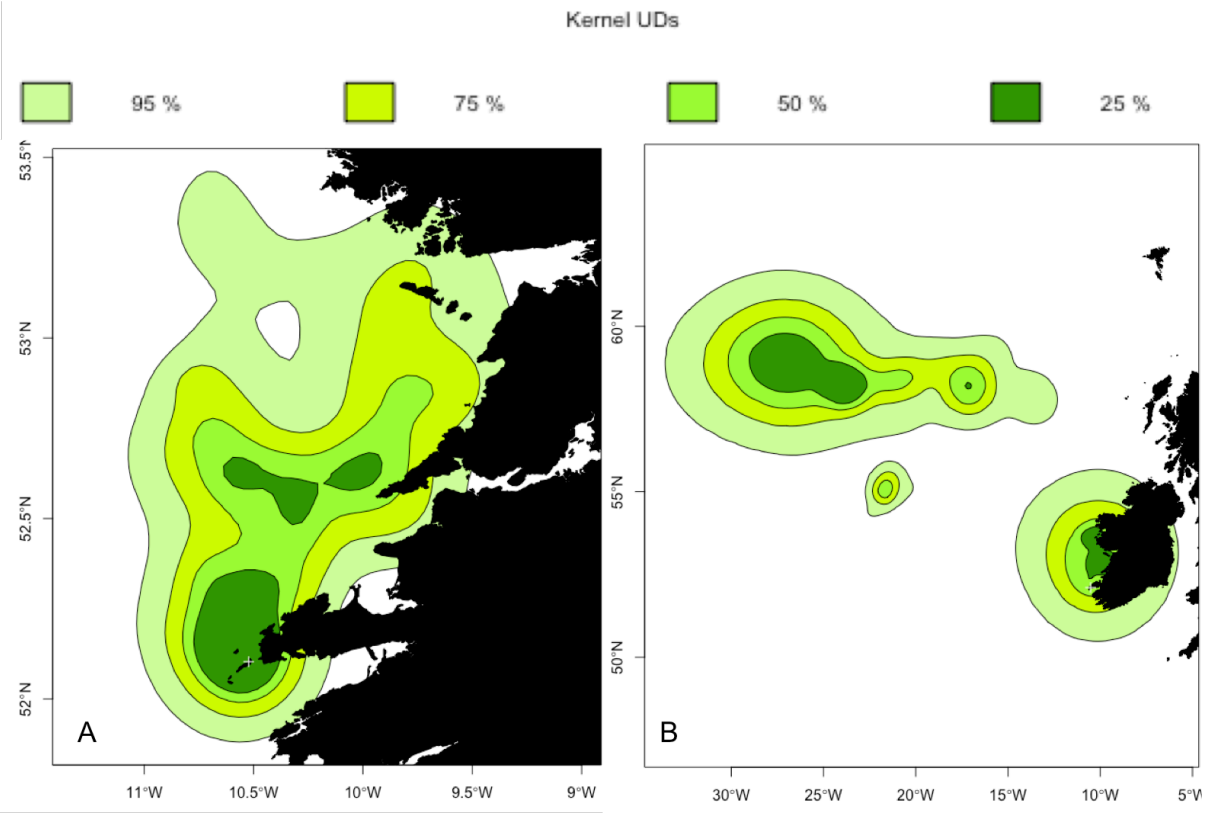
Appendix 2: Utilisation Distributions (UDs) of foraging behaviour



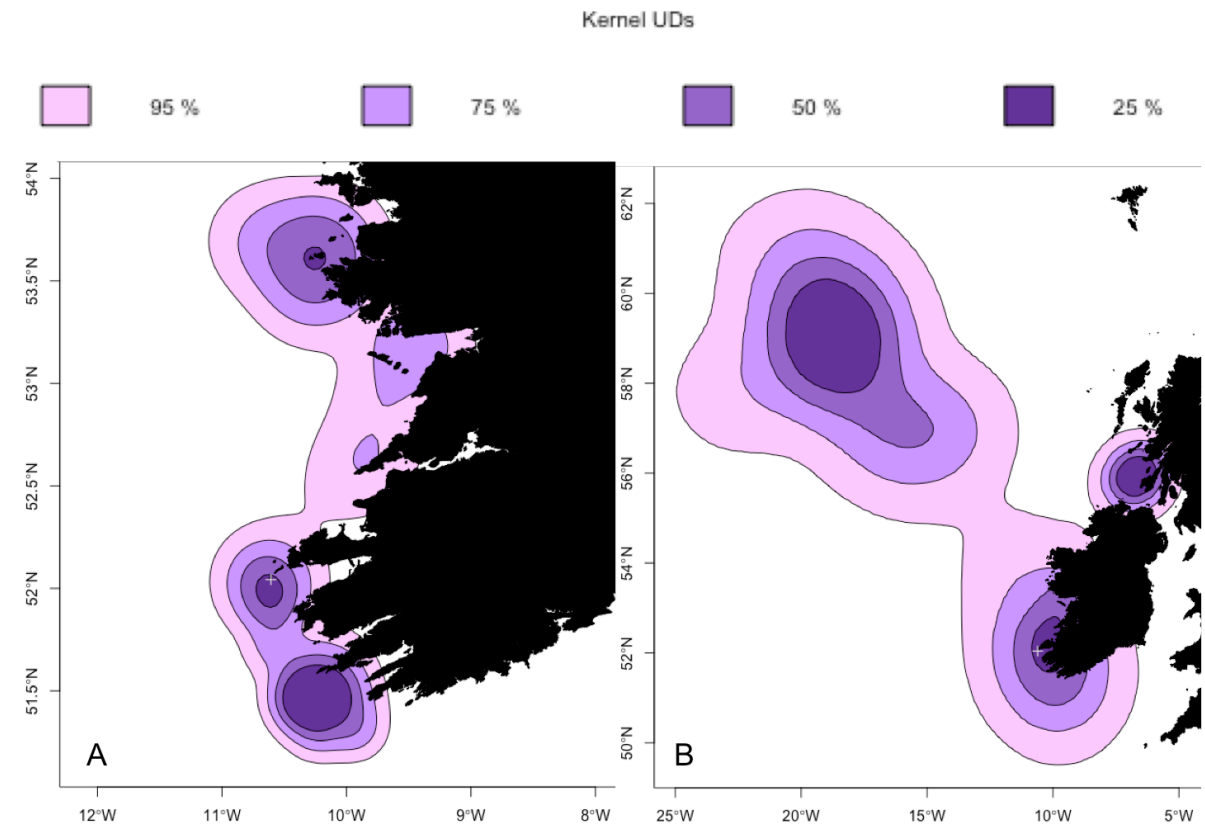
Utilisation Distributions (UDs) of foraging behaviour during short (A) and long (B) trips for individuals from Cruagh (white cross).



Utilisation Distributions (UDs) of foraging behaviour during short (A) and long (B) trips for individuals from High Island (white cross).



Utilisation Distributions (UDs) of foraging behaviour during short (A) and long (B) trips for individuals from Great Blasket (white cross).



Utilisation Distributions (UDs) of foraging behaviour during short (A) and long (B) trips for individuals from Inishvickillane (white cross).