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Environmental Research & Monitoring Programme

Auk Tagging and Monitoring

MacArthur Green

Interim Report 2019

VATTENFALL

MacArthur Green

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UNIVERSITY OF LIVERPOOL

Auk tagging project: 2nd year report, January 2019

CONTENTS

1 INTRODUCTION

This study aims to provide detailed data on the non-breeding season movements of adult guillemots and razorbills, with particular reference to UK populations likely to interact at some stage of the year with offshore wind farms in the North Sea. The work is funded by Vattenfall, Seatrack and Hywind. The Vattenfall component of this collaboration is part of the Environmental Research and Monitoring Programme of the European Offshore Wind Deployment Centre.

Guillemots and razorbills are among the seabirds considered most vulnerable to displacement by offshore wind farms. Assessing impacts of displacement requires knowledge of the seasonal movements of different populations. Seabird movements during the nonbreeding season are generally much less well understood than those during the breeding season due to the challenges of tracking seabirds over long periods of time. This project aims to collect movement data for common guillemots and razorbills over durations of up to several years using small geolocator tags. The new information will allow more accurate attribution of any assessed impacts to appropriate populations. This will reduce uncertainty in impact assessment, especially where this uncertainty requires more precautionary approaches to impact assessment to be followed.

Geolocator tags offer a simple and cost-effective method for long term tracking of individuals. The tags are small enough to be fitted to a leg ring but have a battery life of up to five years. Geolocator tags record light intensity (and normally also sea surface temperature) on a time base memory chip, allowing daylength and time of sunrise and sunset to be estimated. These data allow the location of the bird to be determined twice per day. The basic method of estimation provides locations that are rather imprecise. However, data processing methods as well as sea surface temperature (SST) data (since SST varies considerably among locations) can be used to further refine position estimates.

Guillemots breed in colonies on cliff ledges and under boulders at the foot of cliffs, particularly on islands that are predator-free. Razorbills breed mostly in the same kinds of boulderfields, but also breed on cliff ledges at some colonies. Adults of both species are long-lived, and come back to the same nest site year after year. A number of ringing groups regularly visit certain accessible colonies to ring guillemots and razorbills, and this study makes use of the considerable expert knowledge of bird ringers. For other colonies where no ringing was planned, professional ornithologists undertook the work. Together, we have attached tags to rings that are put onto the birds' legs when they are caught at their colonies, with the aim to catch the same individuals again one or two years later to recover the tag and download data on their daily locations between breeding seasons. From the data, a PhD student funded by this EOWDC project, Lila Buckingham, based at the Centre for Ecology and Hydrology (CEH) Edinburgh and registered at the University of Liverpool will analyse the migration routes and wintering areas used by birds from different breeding areas.

The original aim of the EOWDC project was to deploy 350 geolocator loggers on breeding guillemots and razorbills at a range of colonies from north-east England to north Scotland in summer 2017 and smaller numbers in summer 2018. Because two other projects (Hywind and Seatrack) were planning to deploy geolocators on auks at colonies in east Scotland in 2017 (East Caithness, Whinnyfold and Isle of May), we agreed a revision to this aim to include some colonies in the west of Scotland and to carry out the work as a collaboration with deployments and data from the Hywind and Seatrack projects combined with the EOWDC deployments and data. We also agreed with Marine Scotland to include data from tags deployed by Marine Scotland at Orkney and Canna in 2014-16 in this study.

At the start of the project we hoped to recover about 50% of the tags. The hope was that we could recover some after about one year on the bird, and some after two or possibly three years. It would be particularly useful to have data for two or three winters rather than for a single winter in order to assess how consistent individual birds are in their movement patterns in successive years. However, there is a balance to be struck since the chances of recovering tags are likely to decrease the more years after deployment.

2 FIELDWORK

In 2017, 436 geolocator tags were deployed, 269 on guillemots and 167 on razorbills, at eight different sites. We used two types of geolocator tag: Biotrack MK3006 tags and Migrate Technology Intigeo tags. The Migrate Technology tags were deployed on razorbills at Canna, Foula, Fair Isle, Orkney, and Farnes. MK3006 tags were deployed on guillemots at all colonies and on razorbills at East Caithness, Whinnyfold and Isle of May. Tags were deployed on colour rings, attached by a cable tie through two holes drilled through each colour ring. The colour ring design is a tried and tested one developed by CEH at the Isle of May, and has been found to be successful for both auk species. Tag deployment was licensed by the British Trust for Ornithology (BTO) and tagging was further licensed by Scottish Natural Heritage (SNH) where deployment was at colonies designated as Special Protection Areas (SPA) for these species and so requiring an Appropriate Assessment to ensure that there would be no adverse effect of the fieldwork on the integrity of these protected features.

A geolocator attached to a leg ring on a razorbill.

The aim in 2018 was to recover a sample of these tags, and to deploy another sample of tags including at some colonies not included in the project in 2017. As in 2017, there were no Health & Safety incidents at any of the colonies where fieldwork was carried out in 2018, and the fieldwork was highly successful in achieving our aims. Tags were recovered in 2018 from 118 guillemots and 47 razorbills tagged in 2017 (Table 1). This represents a recovery rate of 44% of the tags deployed on guillemots in 2017 and 28% of the tags deployed on razorbills in 2017, though with some variation among colonies (Table 1). We deployed a further 194 tags on guillemots and 172 on razorbills in June 2018 (Table 2). We aim to deploy a further 140 tags in June 2019. We therefore anticipate recovering similar numbers of tags in each of June 2019 and June 2020 as we did in June 2018, and with some of those providing data on movements of individuals over two years rather than just one.

Table 1. Recovery in June 2018 of geolocator tags deployed on breeding adult auks in June 2017 (sites listed from northwestmost to southeastmost) [a]includes one bird recovered dead in 2018

Colony	Tags from guillemots	% recovered	Tags from razorbills	% recovered	Ringing team
Canna, west Scotland	36[a] from 90	40%	4 from 20	20%	Highland Ringing Group
Foula, Shetland	13 from 40	33%	1 from 10	10%	Bob Furness
Fair Isle, Shetland	10 from 25	40%	9 from 21	43%	Bob Furness and Fair Isle Bird Observatory
Orkney			4 from 30	13%	Orkney Ringing Group
East Caithness, NE Scotland	20 from 40	50%	13 from 30	43%	Bob Swann/Mick Canham/CEH (Hywind funded)
Whinnyfold, E Scotland	24[a] from 40	60%	2[a] from 20	10%	Ewan Weston/CEH (Hywind funded)
Isle of May, E Scotland	14 from 30	47%	11[a] from 30	37%	CEH (Hywind/Seatrack funded)
Farne Islands, NE England	1 from 4	25%	3 from 6	50%	University of Newcastle and National Trust
TOTALS	118 from 269	44%	47 from 167	28%	

Table 2. New deployments in June 2018 of geolocator tags on breeding adult auks (sites listed from southwestmost to southeastmost)

Colony	Tags on guillemots	Tags on razorbills	Ringing team
Colonsay	30	9	David Jardine (EOWDC tags)
Treshnish Isles	20	20	Treshnish Isles Auk Ringing Group (EOWDC tags)
Canna	40	22	Highland Ringing Group (EOWDC tags)
Shiant Isles	0	20	Jim Lennon (EOWDC tags)
Orkney	0	22	Orkney Ringing Group (EOWDC tags)
East Caithness	40	30	Bob Swann/Mick Canham/CEH (Hywind tags)
Whinnyfold	40	19	Ewan Weston/CEH (Hywind tags)
Isle of May	34	30	CEH (Hywind, Seatrack and EOWDC tags)
TOTALS	194	172	

3 BIRD WELFARE CONSIDERATIONS

Welfare of the birds is extremely important, so all tagged birds that were caught in June and July 2018 were carefully examined for any leg injury caused by tags or colour rings they had been carrying since June 2017. No birds were injured. Most tags and colour rings remained in good condition.

A small number, especially at Fair Isle, had tags and colour rings that had been abraded by rubbing on rocks as birds moved up over the boulders from the sea to the colony, but none appeared to be sufficiently worn that there would be a risk of tag or ring loss before the 2019 breeding season for any of the birds tagged in 2017 but not recaught in 2018. However, one razorbill that was recaught at Fair Isle had abraded its tag to the extent that one of the gold pins was almost completely abraded away, as was much of the external casing at one corner of the tag, so there may be some risk of tag failure occurring by summer 2019 in a few cases. One guillemot, tagged in Canna in 2017, was found dead on the shore at Tiree in April 2018. There was no evidence to suggest that the bird's survival had been influenced by presence of a tag, and there was no damage to the bird's leg or colour ring or tag. One guillemot tagged at Whinnyfold in 2017 was found dead on the breeding ledge in 2018. It became apparent that the cause was that the metal ring (i.e. the standard BTO ring, not the colour ring carrying the tag) had got caught in a crack in the rock. It is not possible to know when this occurred (i.e. whether it happened soon after deployment, during a visit by the bird during the non-breeding season, or early in the 2018 breeding season). This is an extremely rare, if not unique, occurrence that has certainly never previously been witnessed by project staff. Two razorbills tagged in 2017, one on the Isle of May and one at Whinnyfold, were found dead on the shoreline in spring 2018, but no information was available on leg condition. No other tagged bird was found dead, so we consider that the ring-trapped bird was an extremely unusual incident, and that the remaining three individuals were most likely to be cases of normal overwinter mortality.

However, it is important to evaluate whether recovery of three dead birds on the shore represents a 'normal' occurrence or evidence of increased mortality of tagged birds, and we can do this very simply as follows: Typically slightly under 10% of adult guillemots and razorbills will die each year, mostly during winter (BTO Birdfacts). We tagged 436 birds so could expect about 40 of those to die during the year after tagging. The reporting rate of ringed guillemots and razorbills that die is around 10% (BTO Annual Ringing Reports). Birds with a colour ring in addition to a BTO metal ring probably have a higher reporting rate than birds with only a BTO ring, as the colour ring will make the fact that the bird is ringed more obvious. However, if we take a precautionary approach and assume that the reporting rate was the same as that for birds carrying only a BTO ring, we would expect about four of the 40 birds that die to be reported. Since three birds were reported dead, that seems to be close to what might be predicted if there was no influence of the tag on survival rate. This suggests that the presence of the colour ring and tag had a negligible impact on survival.

4 FIELDWORK IN DIFFERENT COLONIES IN 2018

Differences in tag recovery rates among colonies were in part due to differences in environmental conditions; higher tag recovery rates are possible where birds are experiencing good food availability, and in consequence breeding success, nest attendance, and motivation of birds to remain at the nest are high. Conversely, in areas where some adults are not breeding and where breeding birds may have failed early in the season, tag recovery is much more difficult. Part of the variation is also due to differences in the way that fieldwork is carried out at different sites. At some sites (e.g. Isle of May) ringers are present continuously through the breeding season and can recatch birds over a period of weeks. At other sites (e.g. Canna and Orkney) ringers spend only a few hours on one or two days at the colony each year, so can only sample birds that happen to be present at the time. It is clear, however, that tag recovery has generally been higher from guillemots than from razorbills. This may have been because razorbills had a less successful season than guillemots on average, with a higher rate of non-breeding and breeding failure at some colonies. It may also relate to differences in behaviour of these two species and to the fact that many razorbills tend to be in hidden sites so tagged individuals can be difficult to relocate, whereas most guillemots are in sites where they are much more easily seen. Razorbills are also, on average, more difficult to catch than guillemots.

Preparing to tag razorbills at Foula.

4.1 Colonsay

Colonsay (Argyll) was added to the project in 2018, but guillemots and razorbills there have been ringed by David Jardine for many years and he has a long-term Ringing Adults for Survival estimation (RAS) project onto which tagging has been added in 2018. The colony was also previously included in auk GPS tracking work by RSPB. Both species had a good breeding season in 2018, and tags were deployed on 30 guillemots and 9 razorbills.

4.2 Treshnish Isles

Treshnish Isles Auk Ringing Group (TIARG) has been ringing auks on the Treshnish Isles each summer since 1971, with permission from the Hebridean Trust; annual reports of the bird ringing and survey work are available at http://tiarg.org. This colony was added to the tagging programme this year and TIARG tagged 20 guillemots and 20 razorbills in June 2018. The guillemots were caught at the five accessible ledges/platforms of the Harp Rock colony at Lunga. Razorbills were caught from the boulder colonies on Lunga at Harp Rock (west coast), at 'shag alley' (east coast), and at the Boulder Beach (facing north-east). Guillemots and razorbills appeared to be having an 'average' breeding season at Treshnish in 2018, and timing of breeding was also average.

4.3 Canna

Highland Ringing Group has been ringing auks on Canna every year since 1971. Guillemots and razorbills had a very good breeding season at Canna in 2018, with large numbers of birds at colonies, high breeding success, and typical hatching dates. A large and experienced team of Highland Ringing Group members were able to deploy all of the geolocator tags made available to them in 2018: 40 guillemot tags and 22 razorbill tags. Recovery of tags that had been deployed in 2017 comprised 36

recovered from guillemots and 4 from razorbills. In addition, several Marine Scotland tags were recovered in 2018 to add to the sample of Marine Scotland tags recovered in 2015-17. These data from earlier years will be useful in comparing patterns of movement in different years. For that reason, Marine Scotland and Highland Ringing Group have agreed to make the data from the Marine Scotland tags available for use in this project.

4.4 Shiant Isles

Auks have been ringed at the Shiant Isles for many years (http://shiantsaukringinggroup.blogspot.com), and the colony was also included in GPS tracking work by RSPB. This site was added into the project in 2018, and 20 tags were deployed on razorbills (it is considered that guillemots are not safely accessible at this site).

4.5 Foula

The 2018 breeding season was yet another poor one for seabirds in Shetland, evidently due to a shortage of suitable small fish, though not quite as bad as in 2017. Guillemot and razorbill breeding numbers attending colony sites within the island were lower than anticipated, and the timing of breeding was unusually late (as it had been in 2017), which is also often a sign of chronic shortage of food. Adult attendance of chicks was also unusually low, with many small chicks left unattended while adults were apparently making exceptionally long foraging trips trying to find food for their chicks. However, breeding success of guillemots and razorbills, although low, was slightly better than in 2017. Birds had been tagged at two colonies within Foula in 2017, one at Heddlicliff which is a scree cliff and boulderfield on the east coast of the island, and one in boulders below the Sneck on the west coast of Foula.

Approaching the guillemot colony at Foula below the Sneck. Birds at this colony breed on top of the large slab (three can be seen in the photo but there are dozens on top of this rock aggregated at the rear of the slab where they are sheltered by the adjacent cliff face).

Access down the Sneck was more difficult in 2018 than it had been previously due to partial collapse of the Sneck roof structure during the winter and the collapse of some large rocks into the lower part of the Sneck. Heddlicliff also has experienced some rock slides that have made access more difficult. In 2018, 13 tags were recovered from guillemots (33% of those tagged in 2017) and 1 from a razorbill (10%). Because of the deteriorating cliff conditions at both sites in Foula no new tag deployments were made as access to the colonies may become impractical in future if these changes to cliff topography continue. Particular thanks are due to Foula Ranger, Sheila Gear, for very helpful advance advice on the seabird breeding season at Foula and for up to date information on colony access conditions.

4.6 Fair Isle

In 2017, guillemot breeding numbers on monitoring plots in Fair Isle were 26% lower than in 2016 while razorbill numbers decreased 25%; productivity in 2017 was also poor – guillemot productivity was 0.17 chicks per pair and razorbill productivity 0.5 chicks per pair in 2017 (Fair Isle Bird Observatory Report for 2017). Fair Isle, like other parts of Shetland, again experienced a poor breeding season for seabirds in 2018. Breeding of auks was unusually late. We had tagged 25 guillemots and 21 razorbills at two of the most accessible sites where Fair Isle Bird Observatory (FIBO) routinely monitor auk numbers, timing of breeding and breeding success. One of these

(Easter Lowther) is accessible by footpath equipped with a Via Ferrata allowing safe access on foot, while the other is accessible by small boat into a sheltered geo (South Ramnigeo) where landing is relatively easy under typical summer weather conditions. Despite sunny weather, there was too much swell to allow a boat trip to South Ramnigeo for six days, and so we were only able to visit that site once. There appeared to be a high incidence of non-breeding of auks at Fair Isle in 2018, with large numbers on the sea near to colonies but relatively low numbers present in colonies (especially for guillemot). In addition, the attendance at nest sites was noticeably low, and birds would leave nest sites and stand on cliffs or skerries overlooking the colony when disturbed. This made it impossible to recapture some tagged birds that were seen but could not be approached. Overall, 10 tags were recovered from guillemots (40% of those tagged in 2017) and 9 from razorbills (43%), with the recovery rate much higher from Easter Lowther than from South Ramnigeo because of constraint on boat use due to the weather. While guillemots at Easter Lowther and South Ramnigeo appeared to have a poor season, razorbills at Easter Lowther were bringing sandeels to chicks and chick survival seemed to be fairly good, suggesting possibly some improvement in sandeel availability for razorbills during the chick-rearing part of the breeding season compared with earlier in the season.

4.7 Orkney

Orkney Ringing Group have access to razorbill colonies at Muckle Skerry, Halcro Head, South Ronaldsay, and Swona. At those colonies, they deployed 30 razorbill tags in June 2017. The razorbill breeding season in Orkney was poor in 2018, with birds breeding late and evidence of nonbreeding or early season breeding failure by many birds. Orkney Ringing Group noted that several tagged birds were present in the general vicinity of colonies, but not attending nest sites. Only four of the birds tagged in 2017 were recaught (13%), but all those tags provided data sets. Orkney Ringing Group have previously deployed Biotrack tags on razorbills in Orkney, the tags being provided by Marine Scotland. They have recovered 15 of the Marine Scotland tags, 1 in 2015, 9 in 2016 and 5 in 2017. Data from those deployments have been made available for use in this project, which will give further evidence of the consistency of use of areas in different years. A further 22 tags were deployed on razorbills in 2018.

4.8 East Caithness

The breeding season at East Caithness was 1-2 weeks later than usual (including 2017), as also recorded at other east coast colonies. The ‘Beast from the East’ (a strong easterly storm that took place in March 2018) was blamed for this delay. Birds that had begun attending colonies at this time departed for some weeks, only returning in late April. Furthermore, experienced observers of the colony (Robin Sellers, Bob Swann) considered that bird densities on breeding ledges were markedly lower than in 2017, suggesting that breeding numbers were down, especially for guillemots. There was also some evidence of predation, possibly by foxes, resulting in certain sub-colonies having few or no birds present. Despite this, those birds that did breed and who avoided predation appeared to have had a successful season, since retrieval and deployments rates were close to the benchmark of 50% that such projects anticipate, with 20 guillemots (50%) and 13 razorbills (43%) retrieved, and all planned 2018 deployments achieved (40 guillemots and 30 razorbills).

4.9 Whinnyfold

Breeding was also delayed by 2-3 weeks at Whinnyfold, presumably also as a result of the effects of the ‘Beast from the East’ storm. However, in contrast to East Caithness, it seemed that razorbills

were harder hit than guillemots, with numbers lower than in 2017 in the former species. Furthermore, razorbills had a poor breeding season, with widespread breeding failure of those that made a breeding attempt. Accordingly, retrieval rates were above the benchmark of 50% for guillemots (23/40 retrieved off actively breeding birds, and one recovered dead i.e. 60% in total) but considerably lower for razorbills (1/20 retrieved off an actively breeding bird, and one recovered dead in spring 2018). Planned deployments were largely achieved (40/40 guillemots; 19/20 razorbills). However, to achieve the deployments on razorbills, it was necessary to target a large suite of areas, because of the high failure rate at the areas used in 2017.

4.10 Isle of May

As with East Caithness and Whinnyfold, breeding was delayed by 2-3 weeks. Both species had moderate breeding seasons, and retrieval rates approached the 50% benchmark (guillemots: 14/30 i.e. 46%; razorbills: 10/30 plus one recovered dead in spring 2018 i.e. 37%). Planned 2018 deployments were also achieved (34 guillemots; 30 razorbills).

4.11 Farne Islands

Fieldwork at the Farnes was coordinated by Newcastle University. Of the birds tagged in 2017, one guillemot and three razorbills were recaught in 2018.

4.12 Deployments of used tags on gannets

Tags that were manufactured in April 2017 and had been deployed on auks from June 2017 until recovery in June 2018 were retained until we were certain that data had been correctly downloaded from each tag without any faults occurring. This was not possible to determine until late July 2018, by which time it was too late to re-deploy these tags onto auks (because by that date, auks have dispersed from Scottish colonies). Keeping the tags until June 2019 and re-deploying them in June 2019 for recovery in 2020 or 2021 would risk battery drain before the tag was recovered, so we were reluctant to re-deploy these used tags onto auks in 2019. It was agreed with Vattenfall's Environmental Expert that rather than discarding used tags that had been recovered from auks in July 2018, if there was adequate battery life for these tags to be deployed for a further 12 months from August 2018 to summer 2019 that it would be good to use these tags on breeding adult gannets. As a result, we made 30 of the tags recovered from razorbills or guillemots in June 2018 available to the University of Leeds research group working on gannets on the Bass Rock, and these were deployed on breeding adult gannets in August 2018, by PhD student Chris Pollock (who is NERC funded with a studentship that has Vattenfall and MacArthur Green as CASE partners), with the intention to recover the tags in summer 2019. This represents an efficient use of tags that would otherwise have been left unused at least until 2019 and may then have been too low in battery power to be fit to re-use on auks.

5 ANALYSIS OF DATA FROM RECOVERED TAGS

Two Migrate Technology tags (one from Farne Islands, one from Fair Isle) were unable to be downloaded, and these were returned to the manufacturer, who was able to recover the data. However, all the other Migrate Technology tags downloaded full data sets. Six Biotrack tags failed to download data (3 from East Caithness, 2 from Whinnyfold, 1 from Isle of May). Partial or complete data were recovered from all but two of these tags by the manufacturer. All the downloaded data

have been put through the appropriate analysis to prepare maps of seasonal movements and these are being analysed to identify key areas used throughout the nonbreeding period. We will present preliminary results from this ongoing analysis on 19 February. It is showing that most guillemots from Canna remained in waters to the west of Scotland through the nonbreeding period, whereas most guillemots from Shetland remained in the North Sea, so the wintering areas of birds from these colonies show little overlap (compare Figures 1 and 2). Shetland guillemots tended to remain further north in the North Sea than guillemots from Whinnyfold, Isle of May or Farne Islands. However, some very interesting individual movements have occurred, with a few birds migrating to the Barents Sea in late summer, apparently to moult there. Results from analysis of 2017-18 tracks will help to inform fieldwork plans for 2019, and we expect to add data from tags recovered in 2019 and 2020 to strengthen our conclusions about the nonbreeding movements of these birds.

There are various ways to present the data. Figure 1 shows the 50% and 90% kernel density distributions of guillemots from Foula, Shetland, for the whole non-breeding period. Figure 2 shows the 50% and 90% kernel density distributions of guillemots from Canna for the whole non-breeding period. Figures 3 and 4 show kernel density plots for razorbills from Whinnyfold in August and December respectively. Figures 5 and 6 show kernel density plots for razorbills from East Caithness in August and January respectively. These are simply provided as examples, as the number of figures that could be created from so many colonies and months is enormous.

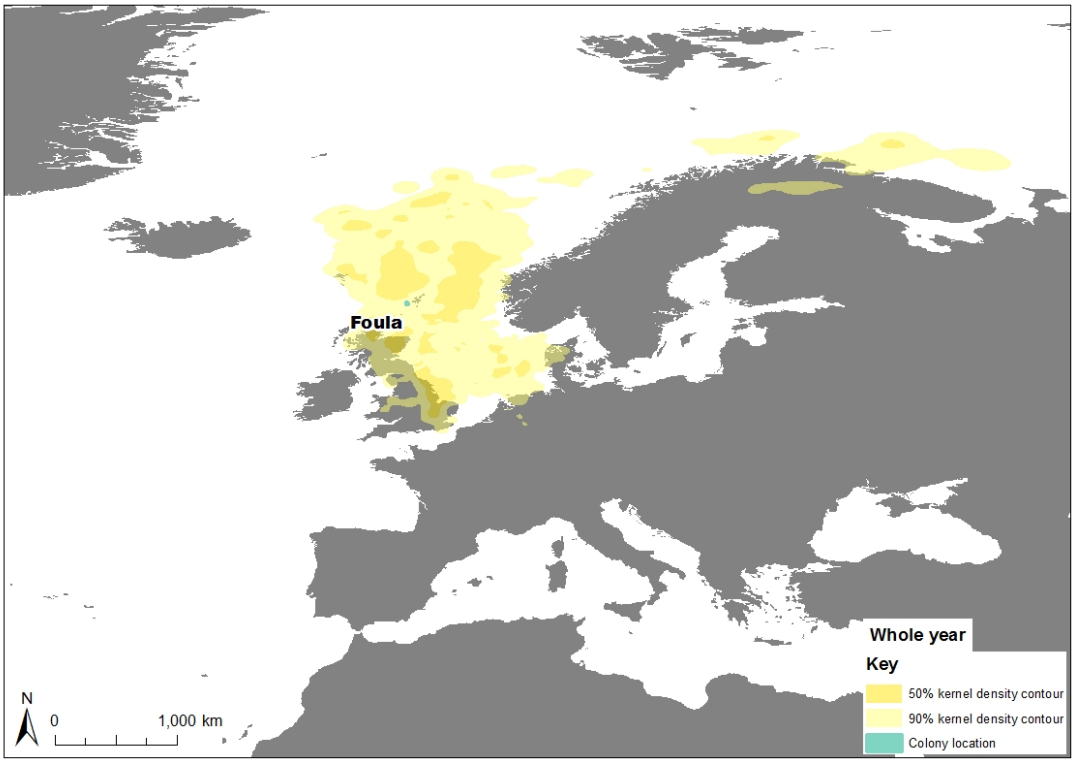

Figure 1. Distribution of guillemots from Foula (throughout non-breeding period).

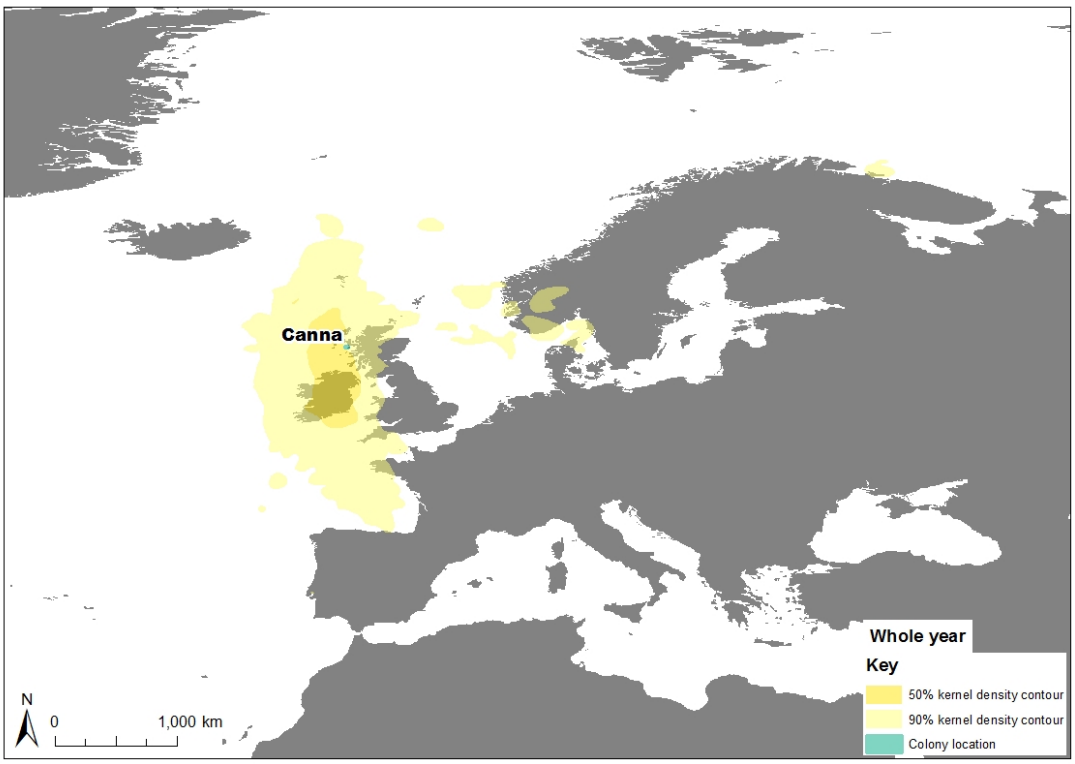

Figure 2. Distribution of guillemots from Canna (throughout non-breeding period).

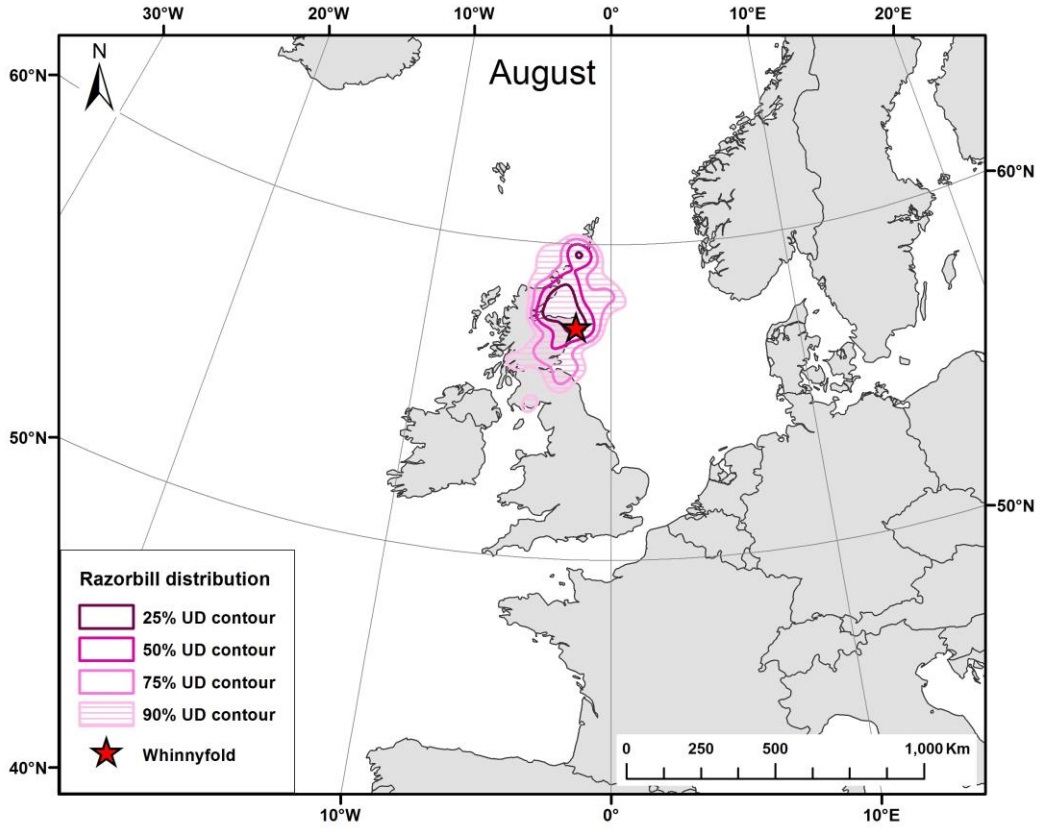

Figure 3. Distribution of razorbills from Whinnyfold in August.

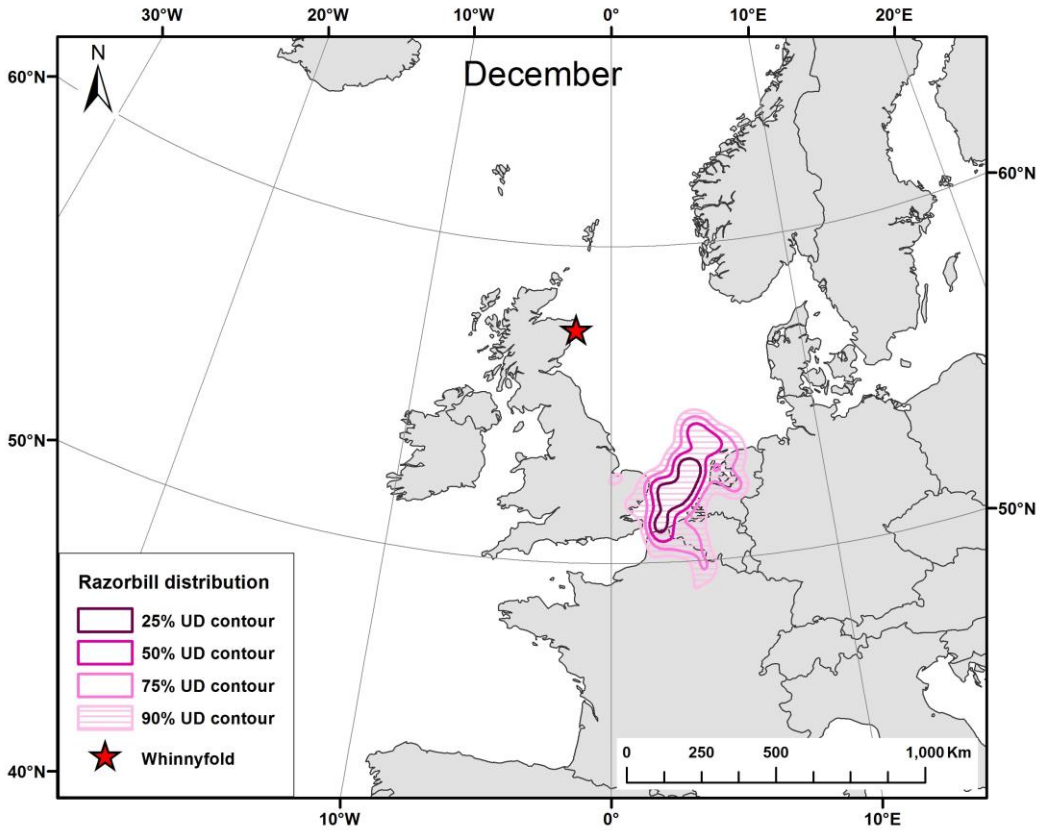

Figure 4. Distribution of razorbills from Whinnyfold in December

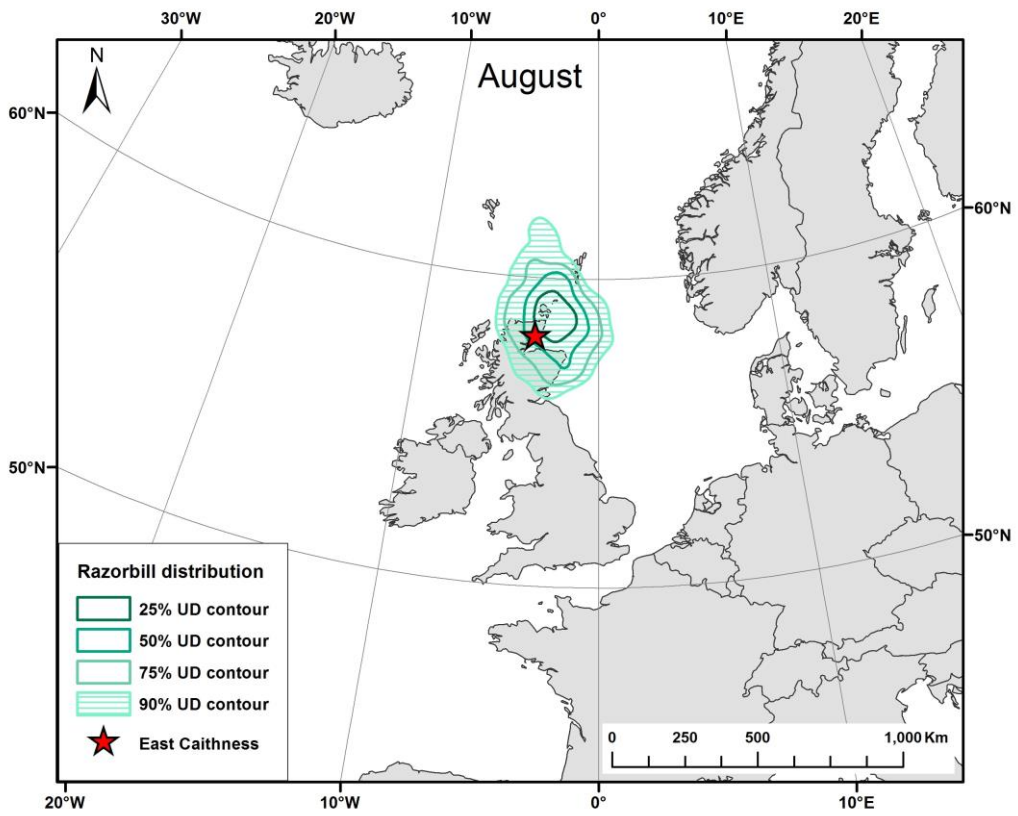

Figure 5. Distribution of razorbills from East Caithness in August.

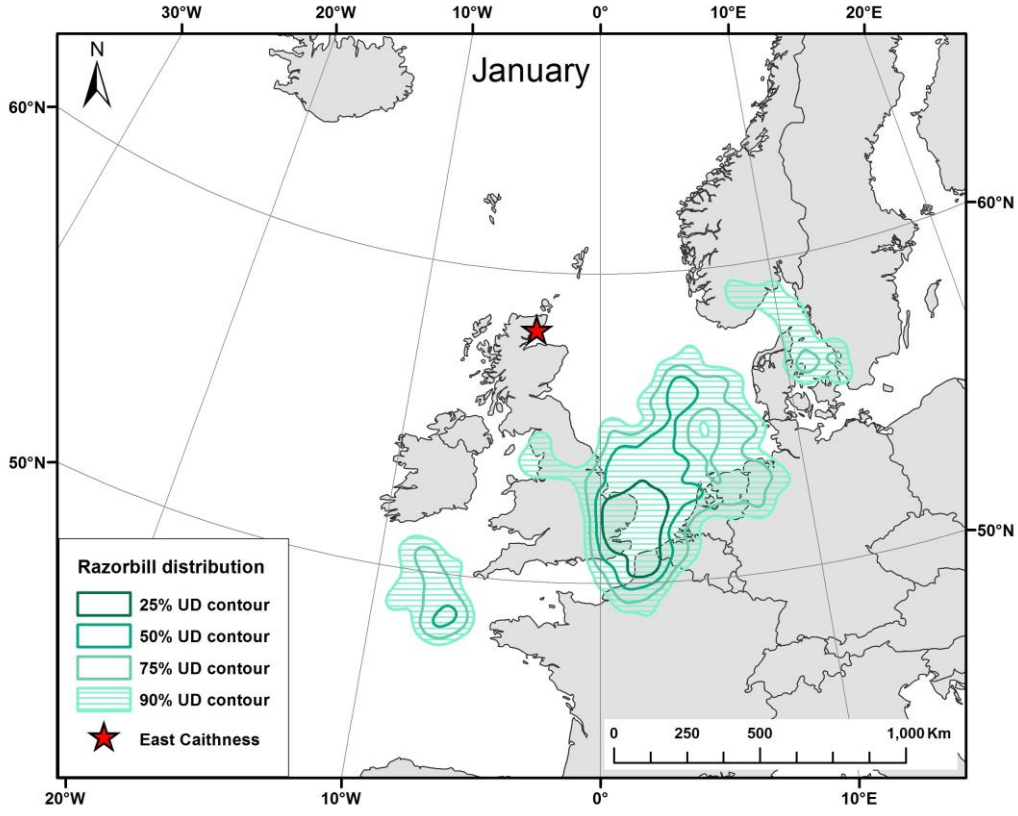

Figure 6. Distribution of razorbills from East Caithness in January.

6 PLANS FOR 2019 FIELDWORK

We have 140 tags available to deploy on guillemots in June 2019. We have discussed with RSPB a plan to deploy 10 of these on guillemots at Bempton, and we have discussed with Vogelwarte Helgoland a plan to deploy 10 tags on guillemots at Helgoland. Those are sites we have not deployed tags at in 2017 or 2018 but would extend the geographical range of sites in a very useful way, so these are top priority for 2019 deployments. We expect to deploy up to 30 tags on guillemots at the Isle of May and will most likely deploy the remaining tags at Shiants, Treshnish and Colonsay. For other sites we intend to focus on recovery of tags currently on birds rather than on further deployments. It is proving more difficult to recover tags from razorbills than from guillemots, and the battery life of razorbill tags is only about half that of guillemot tags (tags put onto razorbills are smaller which was considered appropriate to minimize any welfare risks since razorbills are considerably smaller than guillemots not only in body size but in leg size too). Therefore, we will aim to increase efforts to recover tags from razorbills, but not aim to deploy more tags on that species. There are apparently no accessible razorbills at Bempton or Helgoland, so there would be no prospect of extending the study to those sites for razorbill anyway.

The original project proposal did not include any plan to deploy time-depth-recorders (TDRs) on the birds being equipped with geolocators. Deploying TDRs and GLS loggers on the same individual would greatly improve our understanding of the winter ecology of these species, including identifying periods of the year when they are particularly energetically constrained. TDRs manufactured by Lotek have been deployed and retrieved successfully on guillemots on the Isle of May in a past study. However, dual deployments of TDR and GLS loggers have not been attempted in these species. With the importance of minimising potential negative effects of device deployments on birds, we noted that CEFAS manufacture a TDR logger that is markedly smaller than the Lotek logger used previously. It is approximately the same size and weight as the geolocators we are deploying on guillemots (https://www.cefastechnology.co.uk/media/1105/g5-product-leaflet-september-2017.pdf). Because our experience from geolocators alone has been that these have no evident impacts on bird welfare, and because the combined weight of the two loggers would comprise <1% of body mass, we are now aiming to add into this project a deployment of up to 60 TDR loggers onto birds that are also being equipped with geolocators (i.e. one tag on each leg). These TDR tags are being funded 50% by Vattenfall and 50% by Marine Scotland, as an add-on to the existing project. The aim will be to learn about foraging effort of guillemots throughout the nonbreeding period in relation to their overwinter location. We will, therefore, aim to deploy TDRs on a sample of guillemots at the Isle of May, and a sample at a colony in the west of Scotland (probably Treshnish Isles), and may also include a third colony (such as Colonsay) subject to further discussions about field logistics. This represents an exciting opportunity to add value to the project, without significant extra fieldwork costs.

7 PLANS FOR FURTHER ANALYSES TO COMPLEMENT THE TRACKING DATA

There are potential opportunities to add further analyses to obtain the most we can from the geolocation data. Where we have licences to do so, we have collected feather samples from birds from which tags have been recovered. A body feather sample permits molecular sexing of birds, so that movement patterns can be compared between the sexes. Feather samples can also be used for analysis of stable isotopes of carbon and nitrogen. In marine environments the spatial distribution of these isotopes can provide an indication of the location where birds moulted, and this method has

already been used to assist in identifying moulting areas used by guillemots and razorbills within the North Sea. There is a possibility that C and N isotopes may discriminate between birds that moult in west of Scotland waters rather than in North Sea waters. That possibility has not yet been tested, but we will have samples from birds we know have moulted in those two areas that could be used to determine whether or not isotopes are discriminatory in that regard. There may also be elemental composition differences characteristic of these different water masses. Although the project does not have a budget for stable isotope analysis or for elemental composition analysis, we are discussing the possibility for student project work to build on our geolocation data by investigating isotopic and elemental data to provide added value. We have therefore applied to the BTO for a licence to extend feather sampling to all of the study colonies from which we may recover tags in 2019.

We are also considering a new analysis of the BTO ring recovery data for guillemot and razorbill alongside our tracking data, as that would allow bias in ring recovery data to be quantified, whilst also enabling us to test long-term change in wintering distribution of guillemots and razorbills since ringing of these species has been undertaken for many decades.

8 PRESENTATION OF THIS PROJECT TO CONFERENCES AND WORKSHOPS

29 August 2018. University College Cork. Invited presentation by Francis Daunt 'Demographic consequences of individual variation in foraging and migration.' The Auk tracking project formed a significant part of the presentation.

3-6 September 2018. Liverpool. The Seabird Group. *14th International Seabird Group Conference*. Poster by Lila Buckingham. 'Putting auks on the map: a multi-colony tracking study of winter distribution'.

10 September 2018. SNH, Battleby. Floating Offshore Wind and Ornithological Impact Assessment. Oral presentation by Francis Daunt 'Tracking seabird movements'. The Auk tracking project formed a significant part of the presentation

2 October 2018. Victoria Quay, Edinburgh. Marine Scotland Science. *First Scottish Marine Energy Research (ScotMER) Symposium: Marine Renewables and Seabirds*. Oral presentation by Bob Furness and Lila Buckingham 'A teamwork approach to track auk movements in the nonbreeding period'. The talk was attended by the Minister (Paul Wheelhouse) who commented that our project represented an outstanding example of what can be achieved when the renewables industry and Marine Scotland work together with local Scottish bird experts.

11 October 2018. Peterborough. British Ornithologists' Union. Conference *Seabirds: Towards* sustainable futures for renewable energy. Oral presentations by Bob Furness 'Addressing key challenges in seabird-renewables interactions' and by Francis Daunt 'Seabirds and marine renewables: population and meta-population level issues'. The Auk tracking project formed a significant part of the broader presentations.

30 October 2018. Glasgow. hosted by Scottish Power. *Third Strategic Ornithology Monitoring and Research Workshop*. Oral presentation by Mark Trinder. 'Strategic research to reduce consenting risk'. The Auk tracking project formed a significant part of the broader presentation.

17 November 2018. Carrbridge. Scottish Ringers Conference. 50 years of seabird ringing at Canna. Oral presentation by Bob Swann. The talk included an overview of the auk tracking project, and presentation of maps showing distributions of guillemots and razorbills from Canna based on the 2018 tag recoveries and preliminary analysis of the location data. This was well received by Scottish Ringers and gave other ringing groups an opportunity to see the excellent results coming from the project; others present at the talk included Bob Furness (Foula, Fair Isle), Colin Corse (Orkney), Simon Foster (Canna), Ewan Weston (Whinnyfold), David Jardine (Colonsay) and Lila Buckingham (Treshnish Isles) so this meeting also provided an opportunity for those taking part in auk fieldwork to discuss that.

7-11 January 2019. Canterbury, Kent. NERC Postgraduate Workshop on Statistics in Ecology. Poster by Lila Buckingham. 'Putting auks on the map: a multi-colony tracking study of winter distribution'. This poster was awarded the prize for the best poster presentation at the workshop.

16 March 2019. Oban. Scottish Ornithologists Club/Argyll Bird Club/BTO Conference. Oral presentation by Lila Buckingham. 'Putting auks on the map: a multi-colony tracking study of winter ranges'.

26-28 March 2019. Warwick. BOU Conference. Poster by Lila Buckingham. 'Individual variation in migration of guillemots and razorbills: insights from a multi-colony tracking study'.

28 May 2019. Inverness. WREN workshop (Working to Resolve Environmental Effects of Wind Energy, which is under the remit of the International Energy Authority and US Department of Energy). Oral presentation by Bob Furness 'A teamwork approach to track auk movements in the nonbreeding period'.