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Red-Throated Diver Energetics Project
Final Report

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Summary

Offshore wind development around Europe is increasing to meet the demands for renewable energy production to help meet climate change targets. It is known that marine birds such as red-throated divers (RTD) are highly sensitive to disturbance caused by the construction and operation of offshore wind farms and are subsequently displaced from areas used in the non-breeding season. However, the physiological, energetic and demographic consequences of such effective habitat loss is currently unknown. If divers are already energetically constrained in the non-breeding season, they may struggle to meet the additional energetic demands following displacement. However, at the start of this project, very little was known about the behaviour of RTDs during the non-breeding season. The aim of the Red-throated Diver Energetics Project (https://jncc.gov.uk/our-work/rtde-project/) was to obtain empirical data on the proportion of time divers spend foraging during the non-breeding season, from which their ability to accommodate additional energetic costs of displacement may be inferred.

During 2018 to 2019, a total of 89 (Finland n = 32; Scotland n = 38; Iceland n = 19) individual red-throated divers were fitted with leg-mounted time depth recorder (TDR) tags (Cefas G5 Standard Time Depth Recorder) and global location sensor (GLS) tags (Biotrack/Lotek MK4083 Geolocator), with 18 individuals being caught and tagged in both 2018 and 2019 to obtain information on inter-annual variation. This report presents tag results from the 2018 to 2021 period.

GLS data were analysed, providing two locations a day during the early winter period (22 October – 31 December) and mid-winter period (1 January – 20 February), excluding periods where there is still a noticeable impact on locations from the equinox periods. RTD migration strategy, and thus wintering location, differed for each country; birds from Finland moved to the Southern North Sea after breeding, whereas birds breeding in Scotland remained largely around the Scottish coast, travelling further south during the early winter period, and Icelandic birds remained around the north coast of Iceland. Birds from Scotland and Finland are therefore likely to spend some or all of the winter period in areas overlapping with both existing and proposed offshore wind developments around the UK.

TDR data were analysed, grouping dives into bouts of two or more dives within 66 seconds of one another. To encapsulate only the non-breeding period, only data from the 20 September until the tag failed was included. This period likely included the start of the moulting period through to mid-December for most birds, but for some that departed later from the breeding ground, a short amount of the breeding period may be included. RTDs mostly foraged at shallow depths of around 8 m, with the maximal foraging depth recorded at 41 m. RTDs spent an average of 3 to 5 hours per day foraging in dive bouts consisting of multiple short dives, almost exclusively during daylight hours. There was some variation noted between RTDs from different countries; birds from Scotland spent less time foraging and the average dive was shorter than the other two countries, whereas birds from Iceland spent over an hour more each day foraging in more and longer dives than birds from both Scotland and Finland. Time spent foraging varied over the course of the early winter, particularly for Finnish birds which foraged less in October (during migration when birds spent more time swimming) and more during December to January. Icelandic birds showed a slight increase in foraging during November to December, whereas Scottish birds foraged relatively consistently throughout the early winter. On average, during the early winter, RTDs spent just under 17% of their day foraging, the actual proportion of which varied throughout the early winter period dependent on location, moult, migration and other factors. This temporal and spatial variation suggests that divers, as a species, may have the capacity to adapt their foraging behaviour to reflect changing conditions, and hence potentially accommodate the additional energetic cost of displacement. However, this ability is likely to

be constrained by environmental factors such as daylight hours and food availability, and hence vary between populations and locations. The availability of alternative suitable habitat is particularly crucial to accommodate and fulfil the foraging needs of any displaced birds.

Using GLS and TDR tags, this project provided initial empirical data on the over-wintering locations and foraging behaviour of RTDs from three distinct populations, allowing for the first insight into RTD energetic budgets to help inform whether divers might have the capacity to accommodate the additional energetic costs of displacement and barrier effects caused by offshore wind farm developments.

Contents

1 Introduction

In recent years, the UK Government set an ambitious target of 40GW of electricity generation from offshore wind in UK waters by 2030, increasing this aim to 50GW in 2022 (GOV.UK 2022, 2020). With other European countries also relying on substantial increases in offshore wind power development, offshore wind production in the North Sea is likely to reach 70GW by 2030 (WindEurope, 2017). Whilst renewable energy is a vital contributor in mitigating the effects of climate change by reducing global carbon emissions, the impacts of large-scale deployment of offshore wind on marine wildlife remain unclear (Masden *et al*. 2015).

Red-throated divers are known to be sensitive to disturbance caused by offshore wind farms, which leads to displacement from their foraging areas (Dierschke *et al*. 2016; Furness *et al*. 2013; Halley & Hopshaug 2007; Heinänen *et al*. 2020; Irwin *et al*. 2019; Mendel *et al*. 2019; Percival 2014; Petersen *et al*. 2006; Welcker & Nehls 2016), with evidence of displacement effects up to 8 to 20 km from the edge of an offshore wind farm (Heinänen *et al*. 2020; Mendel *et al*. 2019; SNCBs 2022; Vilela *et al*. 2020; Webb *et al*. 2016). Red-throated divers favour marine areas with shallow seas and sandy substrate (e.g. Irwin *et al.* 2019), areas which are also preferred for fixed offshore wind development as the most technically and commercially viable. In the UK, red-throated diver overwintering distribution overlaps with areas ideal for offshore wind development (Bradbury *et al.* 2014; Gove *et al.* 2016; O'Brien *et al.* 2008), with wind farms planned or constructed in areas of high red-throated diver density (The Crown Estate 2019). Consequently, red-throated divers pose a consent risk for offshore wind development; current uncertainty about the environmental impacts of offshore wind development on red-throated divers has led to delays in the planning process and cancellation of offshore wind projects (e.g. London Array Phase 2). Uncertainty around likely consent decisions for future offshore wind projects in areas of high densities of red-throated divers causes higher development and production costs and failure of governments to meet renewable energy targets.

Despite extensive evidence for displacement of red-throated divers from offshore wind farms, the consequences of displacement on individual birds, and the wider population as a whole, are unknown. Displacement and barrier effects can increase energy expenditure and/or decrease energy intake through being displaced from preferred foraging grounds (Drewitt & Langston 2006), resulting in a decrease in body condition. Individuals in poorer condition may not migrate, may have reduced breeding success or may even die. These demographic changes may then lead to reductions in annual survival and productivity of individuals and consequent decreased population growth rate and size (Dierschke *et al*. 2017).

Whilst it is challenging to obtain early warning signs of population size decrease, it is possible to assess whether red-throated divers are already challenged to meet their energetic requirements and to maintain body condition during the non-breeding season. If individuals forage for only short periods each day, they may be able to find sufficient prey to meet their energetic requirements, even if they are foraging in less preferable habitats. From this, it could be inferred that they may also have capacity to increase time spent foraging to meet any additional energetic demands caused by displacement and barrier effects (assuming that other processes, such as intra-specific density dependence, do not outweigh the benefits of spending longer foraging). Conversely, if divers are already spending long periods foraging each day during the winter, they are unlikely to be able to markedly increase their time spent foraging following displacement and may not cope well with displacement.

Red-throated diver activity and energy budgets had never previously been investigated before this project started. During an expert workshop on red-throated diver displacement, a research project was conceived specifically to investigate this (Dierschke *et al*. 2017) and was subsequently carried out between 2018 and 2021. This novel tagging project, for the first time, obtained empirical data on time budgets, dive depth and frequency, and other key behavioural information, leading to an understanding of red-throated diver energetics. By attaching time depth recorder (TDR) and geolocator (GLS) tags to divers on their breeding grounds, and then retrieving the tags in the following years, information on dive frequency, duration and depth, as well as approximate location, was obtained for the non-breeding season. From this, it can be inferred whether divers have the capacity to accommodate the additional energetic costs of displacement and barrier effects caused by offshore wind farm developments.

This report summarises the overall results from the Red-throated Diver Energetics Project, presenting novel data on wintering location and foraging behaviour from red-throated divers tagged in southern Finland, north Scotland (Orkney and Shetland) and north-east Iceland, along with discussion and interpretation of the results in the context of offshore wind development, further recommendations and a list of additional project outputs.

2 Methods

2.1 Data collection

During 2018-2019, a total of 89 (Finland n = 32; Scotland n = 38; Iceland n = 19) individual red-throated divers were fitted with leg-mounted time depth recorder (TDR) tags (Cefas G5 Standard Time Depth Recorder) and global location sensor (GLS) tags (Biotrack/Lotek MK4083 Geolocator), with 18 individuals being caught and tagged in both 2018 and 2019 to obtain information on inter-annual variation. The nine-month battery life of TDRs meant that birds had to be trapped and tags replaced each summer in order to collect data over multiple winters. Once tagged birds were caught, tags were quickly removed and morphometrics taken in line with current ringing standards to assess body condition and to determine the sex of the birds (Baker 2016). Measurements taken included culmen length, tarsus length, wing length and body mass (see O'Brien *et al*. 2018 for more information). No tags were deployed in 2020 or 2021 but efforts were made to retrieve tags from divers.

For information on selection of study areas and details of tag deployment methods during the 2018 and 2019 breeding seasons, see O'Brien *et al.* (2018) and O'Brien *et al*. (2020). For details on tag retrieval in 2019 - 2021, see O'Brien *et al*. (2020), Thompson *et al*. (2020) and Thompson *et al*. (2022).

2.2 Data analysis

2.2.1 GLS analysis

GLS data were analysed using the methodology detailed in Duckworth *et al*. (2020). Two locations per day were generated from the GLS data. Population level estimates of core location were estimated from the 50% kernel densities contour, representing core distributions used (Buckingham *et al*. 2022). All available locations from all individuals within the stated timeframes were used to generate estimates. RTDs from the study populations completed their breeding attempts in mid-late August (Duckworth *et al*. 2021); however locations shown are from the early winter period (22 October – 31 December) and mid-winter period (1 January – 20 February) to exclude periods where there is still a noticeable impact from the equinox periods on estimated locations. To further remove any clearly anomalous data points, any points above 75° North were excluded, as often heavily shaded data points are pushed to the northernmost degrees of latitude. To ensure population kernel distributions were not biased towards individuals with more years of data, an average location for each calendar date was taken for those individuals across the study period. This meant that each individual had equal weighting in the final population kernel. This averaging is justified by the high repeatability of movements of individuals between years that was observed in preliminary analyses.

2.2.2 TDR analysis

TDR data were analysed using the same methodology as in Duckworth *et al*. (2021). Briefly, TDR data were downloaded from the TDR tags and baselines were corrected to account for baseline drift, before sequential pressure readings of greater than one meter were classified as diving events. Dives were then grouped into diving bouts based on being related to each other, with less than 66 seconds of surface time between dives signifying related events. Finally, only diving bouts with greater than two dives were considered foraging bouts, while those with two or fewer dives were considered as either miscellaneous or exploratory dives. To encapsulate only the early winter period, data is presented from the TDR tags from 20 September until the tag failed. This period likely included the start of the moulting period through to mid-December for most birds, but for some that departed later from the breeding ground, a short amount of the breeding period may be included. Mean maximum depth and dive duration were assessed by looking at all diving events, while dives per day and foraging time were assessed by only looking at dives within foraging bouts. The time spent foraging represents the time spent in a foraging bout and therefore shows both the time spent diving and the inter-dive period (resting between dives). Including inter-dive periods gives a more meaningful representation of foraging than just diving, as it represents the true time an individual must commit to foraging. Mean values and standard errors across sites were generated using mixed effects models with site as a fixed effect and individual ID as a random effect. All data processing and analysis was carried out in R version 4.0.3.

2.2.3 Behavioural analysis

We summarised the data streams of each RTD every 10 minutes, giving recordings of temperature and depth from the TDR tag, and time of day and water immersion from the GLS tag. We then generated a decision tree to classify each 10-minute interval into one of five behaviours: active on water, foraging, swimming, resting and flying. Criteria for each of the behaviour classifications can be seen in Duckworth *et al*. (in prep). Briefly, behaviours were classified based on using tag-derived data to first determine whether an individual was: diving, on water, or fully out of the water (in flight). Following this, we further classified birds that were on water. We did this using temperature and immersion data to determine whether the bird was resting (associated with the leg being tucked into the plumage), swimming or active (preening, leg waggling or other miscellaneous behaviours). Across each day, the time an individual bird spent in each of the five behaviours was summarised to give their behaviour budget. Budgets are only presented for a given date for a given population where there were at least three individuals recorded on that date. The time populations spent in each of the behaviour on each day of the early winter was predicted using Generalised Additive Mixed Effects models, where the best fitting models were selected using Akaike Information Criteria for small sample size (AIC_C). The output times spent in each of the behaviours, across the three populations, were then scaled to 24 hours, to account for the sum of the predicted behaviour budgets not always equalling 24 hours.

3 Results

3.1 Wintering location

RTD migration strategy and thus wintering location differed for each country; birds from Finland moved to the Southern North Sea after breeding (Figure 1), whereas Scottish birds remained largely around the Scottish coast, travelling further south during the early winter period (Figure 2), and Icelandic birds remained around the north coast of Iceland (Figure 3). For more details on wintering locations and links with stable isotopes, see Duckworth *et al*. (2022).

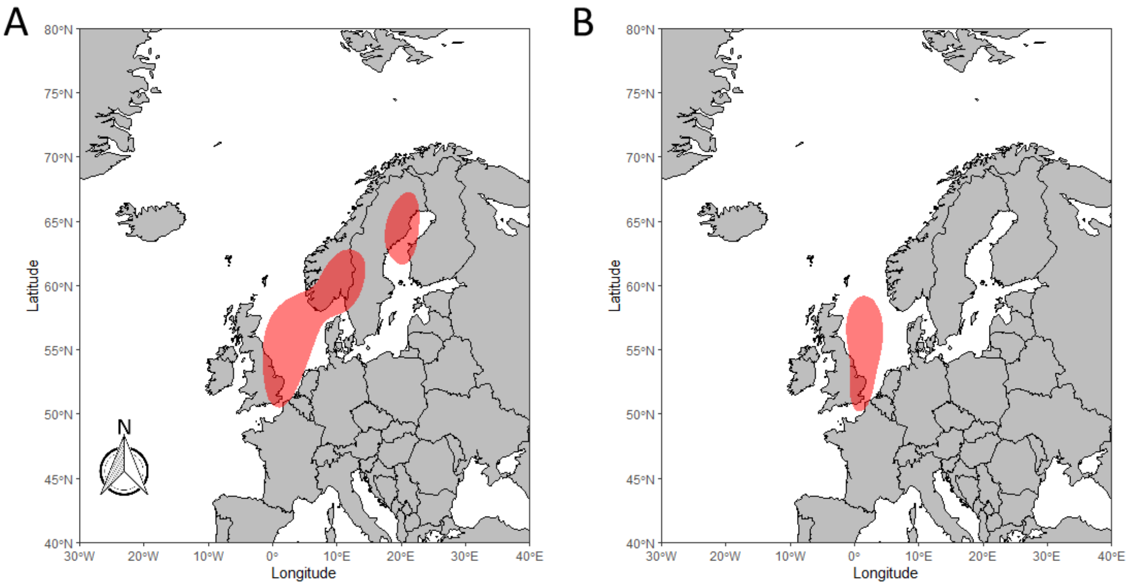

Figure 1. 50% kernel density distribution of the locations of red-throated divers *Gavia stellata* sampled in Finland during the early (A) and mid- (B) winter period. Both panels show the 2018–2021 study period (Duckworth *et al*. 2022).

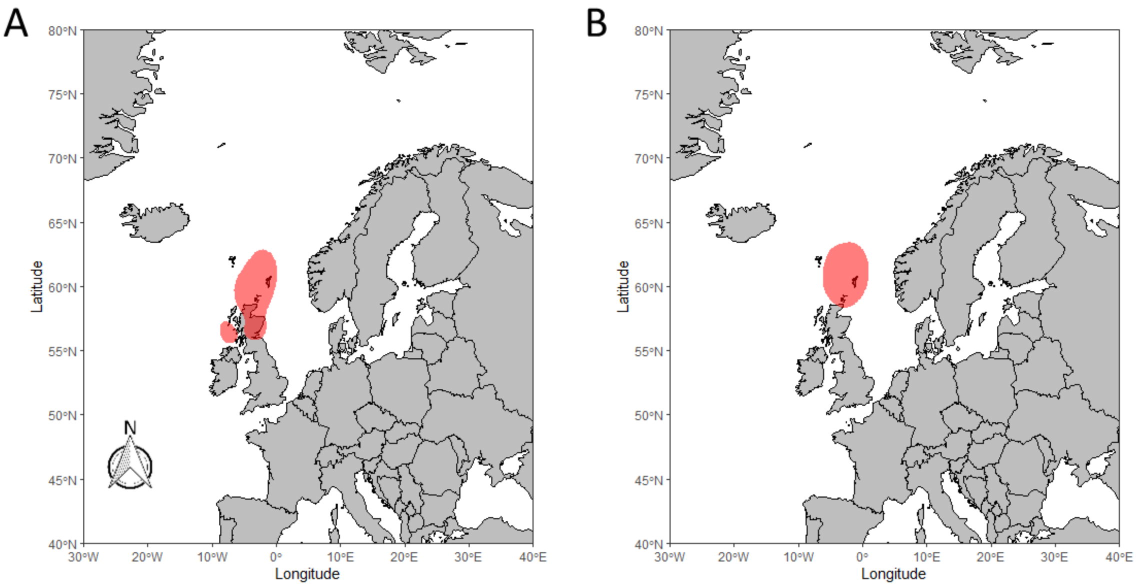

Figure 2. 50% kernel density distribution of the locations of red-throated divers *Gavia stellata* sampled in Scotland during the early (A) and mid- (B) winter period. Both panels show the 2018–2021 study period (Duckworth *et al.* 2022).

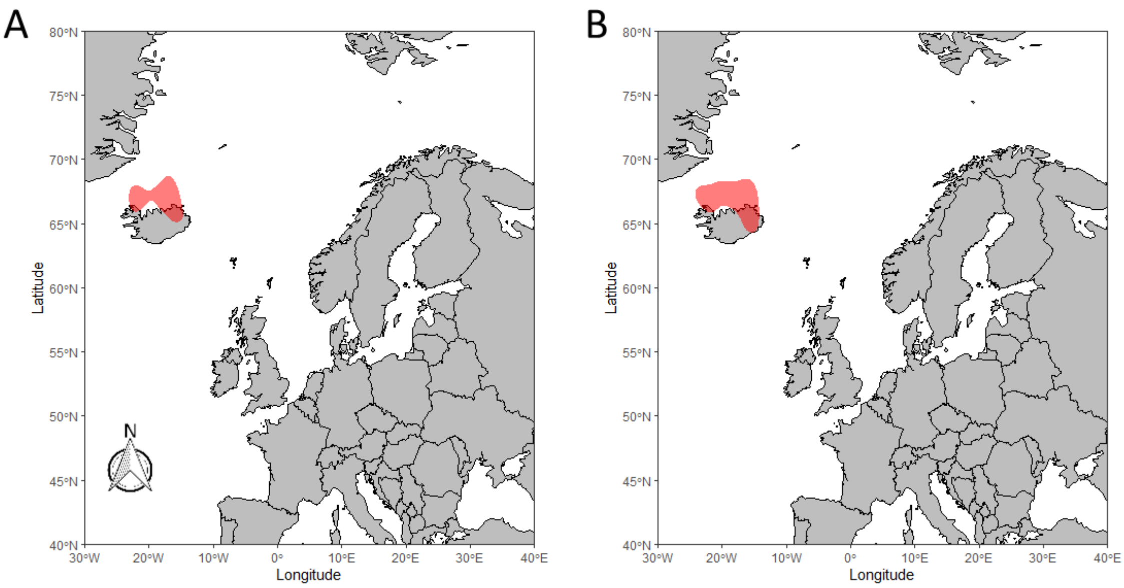

Figure 3. 50% kernel density distribution of the locations of red-throated divers *Gavia stellata* sampled in Iceland during the early (A) and mid- (B) winter period. Both panels show the 2018–2021 study period (Duckworth *et al.* 2022).

3.2 Foraging metrics

RTDs foraged at a maximum depth of 41 m, with most dives at a shallower depth of less than 8 m (Table 1). RTDs spent an average of 3 to 5 hours per day foraging in dive bouts consisting of multiple short dives (Duckworth *et al.* 2021). There was some variation between divers from different countries; birds from Scotland spent the least amount of time foraging and the average dive was shorter than the other two countries, whereas Icelandic birds spent over an hour more each day foraging in more and longer dives than birds from both Scotland and Finland (Table 1). Time spent foraging varied over the course of the early winter, particularly for Finnish birds which foraged less during October (during migration when birds spent more time swimming) and more during December to January. Icelandic birds showed a slight increase in foraging during November to December, whereas Scottish birds foraged relatively consistently throughout the early winter (Figure 4).

Table 1. Foraging metrics for tagged red-throated divers *Gavia stellata* during the non-breeding season between 2018 and 2021. Unless otherwise stated, values shown are means (SE).

	Max depth (metres)	Mean max depth across dives within a foraging bout (metres)	Time foraging/day (hours)	Dive duration (seconds)	No. foraging dives per day
Finland	41.1	7.3 (0.7)	3.6 (0.3)	33 (2)	226 (23)
Iceland	29.3	5.8 (0.8)	4.9 (0.4)	30 (2)	351 (27)
Scotland	39.0	6.0 (0.8)	3.4 (0.4)	23 (2)	249 (27)

3.3 Behaviour budgets

In Scotland and Iceland, time spent engaging in different behaviours was relatively consistent over the early winter period, although more time was spent active on water during September to October, likely when the birds were in moult and needing to spend a greater proportion of their time preening (Figure 4). The increase in this activity corresponded with less time spent resting, but from October onwards the amount of time spent resting increased as time active on water decreased. Birds from Finland showed more behavioural variation during the early winter, with a notable increase in time spent foraging and resting during the later months, and more time swimming and active on water during September-October, coinciding with the moulting and migration periods. During the periods of higher activity on water, time spent foraging decreased.

For all birds, "resting" occurred predominantly at night and "foraging" almost exclusively during the day (<1% of dives were during the night). "Active on water" and "swimming" occurred during both day and night, whilst "flying" only occurred during the day.

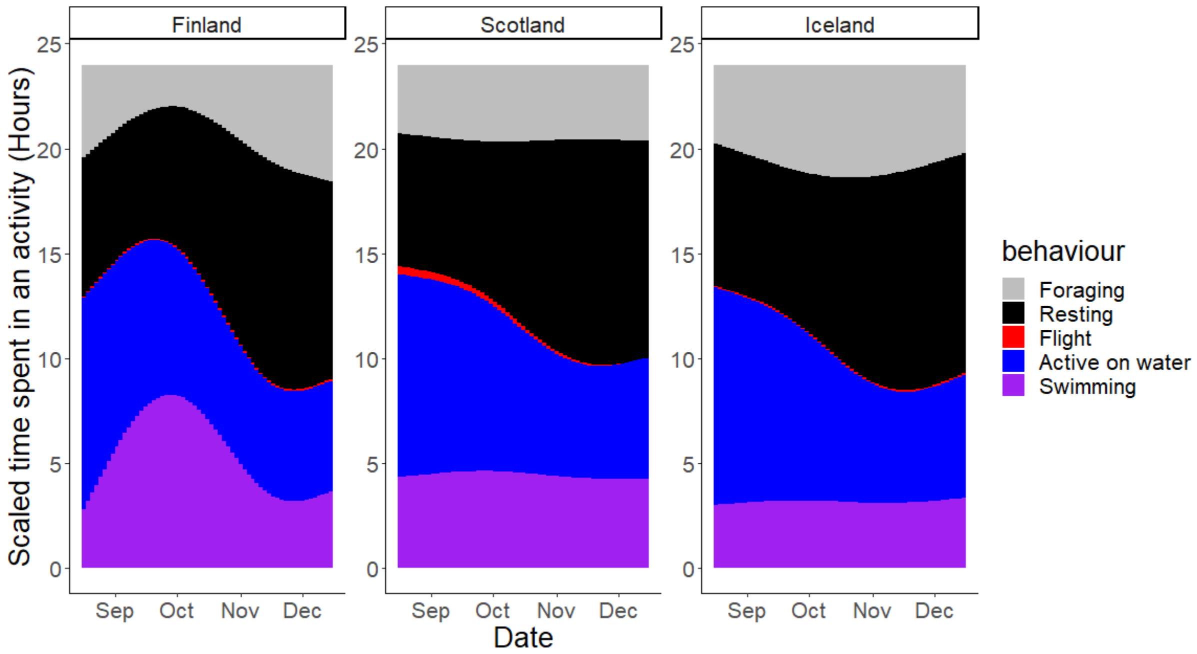

Figure 4. Average time tagged individual red-throated divers (RTD) *Gavia stellata* from three populations spent engaged in different behaviours during the early winter period. 'Active on water' incorporates the time when RTDs are awake but not foraging or actively swimming, participating in activities such as preening.

See Section 5 below for further results and discussion.

4 Discussion and conclusion

This project identified that each population of RTDs occupies different wintering grounds, with birds breeding in Orkney, Shetland and Finland likely to occupy areas overlapping with offshore windfarms around the UK. Tagged birds showed a preference for foraging in shallow seas, areas which are also preferred for fixed offshore wind development, reaffirming the potential for displacement of RTDs from these areas if developed upon. Time spent foraging varied between populations and throughout the early winter, with an average 3 to 5 hours per day spent foraging during daylight hours only. The variation in migratory strategies and behavioural budgets between the populations suggests that RTDs as a species have the ability to adapt and adjust their behaviour to reflect environmental conditions during the winter period, but the limits of this are likely constrained by daylight hours and food availability.

Each population of RTDs showed a different strategy in their wintering behaviour. Birds from Finland were migratory, wintering in the southern North Sea, an area of existing and potential wind farm development from the recent Offshore Wind Leasing Round 4 in England and Wales, whereas birds from Scotland wintered mainly off the north coast of Scotland, encompassing some areas of existing and potential wind farm development from the Scottish Offshore Wind Leasing Round ScotWind (see also Bradbury *et al*. 2014; Gove *et al*. 2016; O'Brien *et al.* 2008 for additional information on RTD wintering distributions in the UK). Icelandic birds remained around the northern coast of Iceland, and as such are unlikely to interact with any offshore wind developments around the UK or in the North Sea. O'Brien *et al*. (2008) found that the highest number of RTDs wintering around the UK occurred in the Southern North Sea, which suggests that the divers at greatest risk of displacement from offshore wind farms in these areas are likely be migratory, such as those from Finland.

Foraging was comprised of bouts of many dives of short duration (average 30 secs per dive), mostly to depths less than 8m, although dives occasionally reached 40 m. This suggests that RTDs favoured marine areas with shallow seas and sandy substrate (e.g. Irwin *et al.* 2019), areas which are also preferred for fixed offshore wind development as the most technically and commercially viable. Dives were a mix of benthic and pelagic, with Scottish birds spending more time feeding pelagically than the other two populations (Duckworth *et al*. 2021), demonstrating the influence of the local environment on RTD foraging behaviour (Duckworth *et al*. 2021).

Foraging bouts from Scottish birds were shorter and were composed of fewer dives than those from Finnish and Icelandic birds. This difference could be related to foraging success and food availability, as fewer dives and a shorter time in each foraging bout may indicate that the time required to meet the energy demand of each foraging bout is lower. This is also partly demonstrated in other aquatic birds, such as kittiwakes (Chivers *et al*. 2012) and guillemots (Davoren & Montevecchi 2003), with birds increasing the duration of foraging bouts in years where food availability was lower. This therefore suggests that foraging success could have been higher for Scottish birds than the other two populations, which is also supported by the lower daily time spent foraging (Table 1).

Icelandic birds spent the most time per day foraging. Research suggests that light levels are important to allow pursuit-foragers to efficiently track and capture prey (Wilson *et al*. 1993). Icelandic birds increased time spent foraging per day in the run up to the winter solstice, after which time spent foraging then began to decrease. Although RTDs predominantly foraged during daylight hours, light levels are exceptionally low in Iceland in mid-winter, therefore RTDs likely had to forage during twilight to meet their energy requirements. Foraging in low light levels may have resulted in less successful foraging attempts and therefore more time needed to be spent foraging to meet their needs. It is also equally possible that foraging conditions deteriorate during winter in Iceland, although not to an extent that requires divers to migrate given the costs and risks of migration.

RTDs seemingly spend a significant proportion of their time resting. However, as this behaviour occurred mostly during the night, the proportion of time spent resting may simply reflect the long hours of darkness seen during the winter – on the shortest day, daylight levels range from 1:45mins in NE Iceland to 5:31mins in W Shetland and 7:44mins in SE England. Time spent resting increased towards late December, corresponding with the winter solstice, which indicates that RTDs can adapt their behavioural budget in line with light levels. However, as foraging occurred almost exclusively during the day and twilight, birds seemed to be limited in their capacity to adjust the proportion of their time spent foraging based on the number of light hours available, which in some locations is very restrictive. For migratory or partially migratory populations in particular, the ability to increase time spent foraging will also depend on food availability, which presumably varies depending on location.

Each population spent more time active on water immediately after the breeding season, which corresponds to the post-breeding moult. Differences seen in the behavioural budgets from each population, such as time spent swimming and active on water, are likely due to the different migratory strategies, wintering locations and food availability seen from each population. Although it is unclear how adaptable each distinct population is (two years of data with overall low sample sizes), the variation in strategies and behavioural budgets suggests that RTDs as a species have the ability to adapt and adjust their behaviour to reflect environmental conditions during the winter period. This does however need to be considered alongside evidence that suggests displacement effects can be detected up to 8 to 20 km from the edge of an offshore wind farm (Heinänen *et al.* 2020; Mendel *et al.* 2019; SNCBs 2022; Vilela *et al.* 2020; Webb *et al.* 2016), reiterating the requirement for alternative suitable habitat to be available to accommodate and fulfil the foraging needs of any displaced birds.

Although the sample size in this study was relatively small, it provides a significant initial insight into RTD wintering location and behaviours of three distinct populations, including confirming differing migratory strategies between populations and for those birds tagged over multiple years, they demonstrated a high level of repeatability in between-year wintering locations (Duckworth *et al*. 2021).

Recapture rates of around 50% appear to leave room for improvement, but these rates are similar to those seen in other tagging studies (e.g. Buckingham *et al*. 2022; Pollock *et al*. 2021). Given the difficulty of recapturing tagged birds due to the sensitivity of RTDs to human presence, inaccessible sites, and the restrictions of Covid-19 on fieldwork during the study period, these rates reflect a remarkable effort made by the field teams.

There were some limitations to the use of GLS data for estimating location, particularly during the period surrounding the equinox, and when the birds performed behaviours that resulted in the shading of the tags. Duckworth *et al*. (2021) therefore suggest the avoidance of GLS tags on RTDs for future studies aiming to identify detailed locations, but for the purposes of this project, the data retrieved provided novel insights into RTD locations during the early and mid-wintering periods, in particular population-level differences in migratory strategy and overwintering locations at the regional scale. In this project, pooling locations across populations allowed to obtain location estimates for the core areas used by RTD populations, but determining the specific locations used by individuals on a daily basis was not possible. This still allowed us to address our project specific aims of identifying broad areas of overwintering importance.

The Red-Throated Diver Energetics project has identified that wintering RTDs from Scotland and Finland are likely to spend some or all of the winter period in areas overlapping offshore wind developments, both existing and proposed, around the UK. On average, the divers spent just under 17% of their day foraging during the early winter, the actual proportion of which varied throughout the early winter period dependent on location, moult, migration and other factors. This temporal and spatial variation suggests that divers may have the capacity to adapt their foraging behaviour to reflect changing conditions, and hence potentially accommodate the additional energetic cost of displacement. However, it is important to note that this ability is likely to be constrained by environmental factors such as daylight hours and food availability. Improving understanding of the distribution and availability of suitable foraging resources (habitat and prey) to overwintering RTDs is therefore crucial to fully appreciate the potential energetic and demographic consequences of displacement by offshore windfarm developments.

5 Further outputs

Further details, results and discussion can be found in the following additional project outputs:

- JNCC Report 605. Possible Behavioural, Energetic and Demographic Effects of Displacement of Red-throated Divers.
- JNCC Report 627: Red-Throated Diver Energetics Project: 2018 Field Season report.
- JNCC Report 637: Red-Throated Diver Energetics Project: 2019 Field Season Report.
- JNCC Report 638: Red-Throated Diver Energetics Project: Preliminary Results from 2018/2019.
- JNCC Report 673: Red-Throated Diver Energetics Project: 2020 Field Season Report
- JNCC Report 697: Red-Throated Diver Energetics Project: 2021 Field Season Report.
- Duckworth, J., O'Brien, S., Väisänen, R., Lehikoinen, P., Petersen, I.B., Daunt, F. & Green, J.A. 2020. First biologging record of a foraging Red-Throated Loon *Gavia stellata* shows shallow and efficient diving in freshwater environments. *Marine Ornithology*, 48: 17-22.
- Duckworth, J., O'Brien, S., Petersen, I.K., Petersen, A., Benediktsson, G., Johnson, L., Lehikoinen, P., Okill, D., Väisänen, R., Williams, J., Williams, S., Daunt, F. & Green, J.A. 2021. Spatial and temporal variation in foraging of breeding red-throated divers. *Journal of Avian Biology*, 52: e02702.
- Duckworth J., O'Brien S., Petersen I.K., Petersen A., Benediktsson G., Johnson L., Lehikoinen P., Okill D., Väisänen R., Williams J., Williams S., Daunt F. & Green J.A. 2022. Winter locations of red-throated divers from geolocation and feather isotope signatures. *Ecology and Evolution*, 12: e9209.

The following outputs are in preparation for submission to peer-review:

- Duckworth J., O'Brien S., Petersen I.K., Petersen A., Benediktsson G., Johnson L., Lehikoinen P., Okill D., Väisänen R., Williams J., Williams S., Daunt F. & Green J.A. Variation in non-breeding strategy drives differences in behaviour and energy expenditure of red-throated divers. Pending submission.
- Duckworth J., O'Brien S., Petersen I.K., Petersen A., Benediktsson G., Johnson L., Lehikoinen P., Okill D., Väisänen R., Williams J., Williams S., Daunt F. & Green J.A. Linking foraging behaviour to isotope signatures in a diving bird. Submitted to Proceedings of the Royal Society B.
- Thompson D.L., O'Brien S., Ruffino L., Lehikoinen P., Johnson L., Okill D., Petersen A., Petersen I.K., Väisänen R., Williams J., Williams S. Capture and biologger deployment is not detrimental to breeding success and body condition of red-throated divers *Gavia stellata*.

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