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Red-Throated Diver Energetics Project 2020 Field Season Report

Danni Thompson, Sue O'Brien, Lise Ruffino, Logan Johnson, Petteri Lehikoinen, David Okill, Aevar Petersen, Ib Krag Petersen, Roni Väisänen, Jim Williams & Stuart Williams

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For further information please contact:

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough PE1 1JY
www.jncc.gov.uk

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This report is compliant with the JNCC Evidence Quality Assurance Policy https://jncc.gov.uk/about-jncc/corporate-information/evidence-quality-assurance/.

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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 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. But the physiological, energetic and demographic consequences of such effective habitat loss is currently unknown.

This report details the third field season of the Red-throated Diver Energetics Project (https://jncc.gov.uk/our-work/rtde-project/). During 2018-2020, archival geolocator (GLS) and time depth recorder (TDR) tags were deployed and retrieved from red-throated divers breeding in Scotland, Finland and Iceland to quantify foraging behaviour and approximate non-breeding season locations. This empirical data will provide insight into the time divers spend foraging, thus providing insight into whether divers potentially have capacity to accommodate displacement effects of offshore wind development.

Due to the coronavirus pandemic, no fieldwork for the Red-throated Diver Energetics Project was carried out in Scotland in 2020. However, some breeding success monitoring and ringing of chicks was carried out by local ringing groups, during which, one adult tagged bird was caught, and its tags removed. In Finland, 15 tagged birds were resighted and eight of these were trapped. In Iceland, six tagged birds were trapped. Tags were also recovered from three dead birds during winter 2019/20. No tags were deployed in 2020.

Breeding success was calculated as the total number of nests producing at least one fledged chick (¾ grown) divided by the number of nests of known fate. Breeding success during summer 2020 was variable between sites, ranging from 35% in Shetland to 59% in Finland and 66% in Orkney. The success rates in both Orkney and Finland were average compared to 2018 and 2019, however for Shetland the success rate was poor compared to the previous two years. Breeding success metrics for Iceland were unavailable at the time of writing.

If leg-mounted tags have a negative impact on divers, e.g. by increasing drag on divers' legs when diving for prey, then we would expect body condition of tagged birds to be lower in 2020, compared with when they were first tagged, after having carried tags for one or two years. Using body mass as a proxy of body condition, repeated weighing of the same individuals allows assessment of any change in body condition after carrying tags for one or two years. The mass of birds caught in 2020 was compared with the mass of when they were first caught and tagged in either 2018 or 2019. The average difference between first and second year of capture was 3.7g, suggesting negligible change over time, and this was supported by analysis which found no significant change in median body mass between captures.

Of the 18 tagged birds recovered dead or recaptured during the 2019/20 winter and 2020 summer, a total of 14 TDR and 18 GLS tags were retrieved. In some cases, birds had lost a TDR tag (n=3) or did not have a TDR tag deployed (n=1). Data for a full winter period were available from 15 GLS tags, another two GLS tags failed to record any data and one GLS tag provided data for only some of the winter period. The problems with substantial GLS tag failure due to water ingression, encountered in 2019, were absent and tag failure rate for GLS tags retrieved in 2020 was low for a study of this sort. Ten TDR tags provided data for the post-breeding and mid-winter period, with batteries dying prematurely in two TDR tags, in October and November, and the remaining eight TDR tags recording until late December/early January, consistent with the TDR tags retrieved in 2019. Additionally, four TDR tags only recorded for short periods, until July, August or September, due to the tag

casing being damaged. The cause of the damage is unknown but occurred during deployment. GLS tag data for two consecutive years are available for five birds and TDR tag data are available for three birds over two consecutive years, allowing for novel insight into interannual variation in location and foraging behaviour.

Due to an absence of breeding success data for Iceland at the time of writing, it was not possible to conduct further analyses this year on trapping effects. Although 2020 was the third and final field season for Finland and Iceland, we hope that a third year of tag retrieval fieldwork can be undertaken in Scotland next year, subject to coronavirus restrictions.

Contents

1 Introduction

Recently, the UK Prime Minister set an ambitious target of 40GW of electricity generation from offshore wind in UK waters by 2030 (GOV.UK 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 remains unclear (Masden *et al*. 2015). Red-throated divers are sensitive to disturbance caused by offshore wind farms, which leads to displacement from their foraging areas (Furness *et al*. 2013; Halley & Hopshaug 2007; Heinänen *et al*. 2020; Mendel *et al.* 2019; Percival 2014; Petersen *et al*. 2006; Welcker & Nehls 2016). However, the energetic costs and demands of this displacement on both individuals and populations are unknown. This study aims to obtain the first ever empirical evidence on red-throated divers' foraging behaviour during the non-breeding season, which will enable inference about the energetic consequences of displacement.

It is important to quantify any detrimental effects of attaching biologging devices to wild animals, particularly if the devices have not been used or their effects quantified on a species previously. As this project is the first to attach time depth recorder (TDR) devices to red-throated divers, and as the effects of attaching leg-mounted geolocator (GLS) tags to divers have not been previously quantified, we attempted to measure the effects that carrying tags may have on the divers (tag effects). Additionally, red-throated divers are highly sensitive to disturbance, so we also investigated whether there were any noticeable effects of trapping and handling the birds (trapping effects).

In 2018 and 2019, breeding red-throated divers were tagged in Scotland, Finland and Iceland with GLS and TDR tags to obtain empirical evidence on birds' locations and foraging activity during the non-breeding season. These data will allow us to infer whether red-throated divers are able to accommodate the increased energetic costs of displacement and barrier effects from offshore wind farms.

This report details the 2020 field season of the Red-throated Diver Energetics (RTDE) Project, in particular describing red-throated diver breeding success, the recapture and resighting rates of tagged divers in 2020, and it also describes tag effects by looking at changes in body mass of tagged divers over multiple years of capture. For further information and for details of previous field seasons, see *O'Brien et al. (2018) and O'Brien et al.* (2020).

2 Coronavirus

On 23 March 2020, the UK government issued measures to reduce the spread of coronavirus. Throughout summer, measures in Scotland required that to protect themselves and others, people should stay at home and only go outside for essential food, health and work reasons. JNCC made the decision not to allow fieldwork for the RTDE Project in Scotland in 2020 to ensure the safety of fieldworkers and others.

In Finland and Iceland, during the 2020 fieldwork season, government restrictions for managing the coronavirus pandemic were less stringent than in Scotland. Consequently, it was possible to undertake fieldwork in both Finland and Iceland whilst adhering to the restrictions imposed. We requested that all fieldworkers follow their government's advice and adhered to all restrictions. Field work carried out in Iceland was done so in accordance with Icelandic Government guidelines, however this work was not under contract to JNCC. In Finland, JNCC contracted ringers for fieldwork in 2020, which included a special risk assessment and mitigation statement, alongside frequent contact with the contractors to ensure that compliance with Finnish Government requirements continued to be met. This provided the option to rapidly cease fieldwork if necessary, for the health of contractors and the local communities in which they were operating.

We hope that we will be able to resume the remaining tag retrieval fieldwork in Scotland in 2021 whilst ensuring appropriate measures are in place to ensure that any coronavirus restrictions are adhered to.

3 Methods

3.1 Breeding success

Breeding success was monitored at nest sites of both tagged and untagged birds in Shetland (n=35), Orkney (n=41) and Finland (n=104), and in Iceland for tagged birds only, using methods detailed in O'Brien *et al.* (2020). The data were unavailable for Iceland at the time of writing. A breeding attempt was recorded at each of the monitored nest sites, i.e. at least a nest scrape was noted even if no eggs or chicks were seen. Breeding success was calculated as the total number of nests producing at least one fledged chick divided by the number of nests of known fate. A chick was assumed to have fledged once it was ¾ grown (approximately three weeks old), although further follow-up checks were not carried out to minimise disturbance.

Analysis of trapping effects on breeding success was not performed as there was no contracted fieldwork to recapture tagged birds in Scotland and there were no control sites in Iceland.

3.2 Tag deployment and retrieval

3.2.1 Tag deployment in 2018 and 2019

In total, 89 (Finland n=32; Scotland n=38; Iceland n=19) individual red-throated divers have been 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 TDR battery life required birds 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): culmen length, tarsus length, wing length and body mass (see O'Brien *et al.* (2018) for more information). No tags were deployed in 2020 and tags will not be deployed in 2021.

For information on tag deployment during the 2018 and 2019 breeding season and for details on retrapping methods, see O'Brien *et al*. (2018) and O'Brien *et al*. (2020). Information on the choice of study areas and details of deployment methods are also detailed within the previous reports.

3.2.2 Feather sampling

Feather samples were taken from all birds caught in 2019 and 2020 for stable isotope analysis. Feathers were clipped from the neck, a secondary covert and a secondary flight feather. A flank feather was also plucked for genetic analysis as part of a separate study. For details on feather sampling, see O'Brien *et al*. (2020). In total, 220 feather samples were obtained from divers in 2019 and 2020.

3.3 Tag effects

3.3.1 Resighting

Resighting refers to the number of divers tagged in 2018 or 2019, which were also seen in 2020. Tagged birds were first searched for at the lakes where they were previously tagged. If they were not seen at this initial breeding site, then other suitable lakes within the area were searched in a radius up to 10km from the initial site. Red-throated divers exhibit high survival rates (Hemmingsson & Eriksson 2002; Schmutz 2014) and show strong interannual nest site fidelity (Okill 1992) so we would expect the number of resightings to be high.

3.3.2 Tag effects on body mass

Leg-mounted tags are not thought to have a negative impact on the foraging performance of foot-propelled foragers over short time periods, however the impacts may differ when tags are attached for periods greater than one year (Ropert-Coudert *et al.* 2009). If leg-mounted tags have a negative impact on divers, e.g. by increasing drag on divers' legs when diving for prey, then we would expect body condition of tagged birds to be lower in 2020, compared with when they were first tagged, after having carried tags for one or two years (Elliott *et al*. 2012; Geen *et al.* 2019). Using body mass as a proxy of body condition, repeated weighing of the same individuals allows assessment of any change in body condition after carrying tags for one or two years.

Body mass in 2020 was compared with the body mass of each tagged bird's previous capture in either 2018 or 2019. The average and range residual of body mass was calculated for the sample (n=15). A non-parametric Friedman rank test was performed on the body mass data to test whether there was a significant difference between the median body mass recorded when birds were tagged (either 2018 or 2019) and when they were recaptured (2020). Data was available for Finland (n = 8), Iceland (n = 6) and Shetland (n = 1). Due to small sample sizes, it was not possible to test for differences in body mass change between study sites nor between the 2018-2020 and 2019-2020 periods.

4 Results

4.1 Breeding success

At the time of writing, breeding success data was available for Shetland, Orkney and Finland. Across these three sites, a total of 179 occupied red-throated diver nest sites were monitored during 2020 of both tagged and untagged birds. Breeding success varied across the three sites, ranging from 35% in Shetland to 59% in Finland and 66% in Orkney (Table 1).

Table 1. Breeding success (number of successful nests (producing at least one ¾ grown chick) divided by the number of nests of known fate) in Shetland, Orkney and Finland in 2020.

Sites	No. of nests monitored	No. of failed nests	No. of successful nests	No. nests of unknown fate	Breeding success (%)
Orkney	41	13	25	3	66%
Shetland	35	22	12	1	35%
Finland	103	42	61	0	59%

4.2 Recapture of tagged birds in 2020

The focus of this year's fieldwork was to retrap birds tagged in 2018 and 2019 in both Finland and Iceland and retrieve the tags. Six birds with tags deployed in 2018 were retrapped in 2020 from Finland (n=5) and Iceland (n=1). Of the 33 birds tagged in 2019, nine were trapped in 2020 from Finland (n=3), Iceland (n=5) and Scotland (n=1).

An additional three tagged birds were recovered dead during the 2019/20 winter. A Finnish-tagged bird was recovered on the northeast coast of France, near Le Crotoy, and two Shetland-tagged birds were recovered along the east coast of Britain, one near Inverness and one near Scarborough. Brief visual examination of the dead birds by the finders gave no clear indication as to the cause of death in any individual.

4.3 Tag effects

4.3.1 Resighting

At the time of writing, resighting data was only available for Finland. In Finland, 15 tagged red-throated divers were resighted and of these, eight were recaptured and had tags removed. The remaining seven birds which were not recaptured either did not begin to breed or failed early on, so no trapping attempts were possible. Since being tagged in either 2018 or 2019, ten tagged females and nine tagged males remain uncaptured. Of these, 11 birds have not been resighted, six of which are female. The fates of these birds are unknown. Two tagged birds from Finland were seen breeding in 2020 at different nesting sites to where they were originally tagged, and a similar anecdotal sighting was reported in Shetland. These observations support those made in previous years, including in Orkney and Iceland, evidencing that red-throated divers do occasionally move breeding sites, which can affect the likelihood of a resighting.

4.3.2 Tag effects on body mass

During 2020, 15 tagged birds were retrapped in Finland (n=8), Shetland (n=1) and Iceland (n=6). For these birds, the average residual of body mass in 2020 compared to their previous capture in either 2019 or 2018 was 3.7g (range 150g to 160g) (Table 2). The median body mass did not significantly differ between the year they were tagged (2000g) and the year they were recaptured (2045g) (Friedman chi-squared = 0.07; df = 1; p-value = 0.79). This supports the previous finding of no significant change in recorded body mass for birds tagged in 2018 and recaptured in 2019 (O'Brien *et al*. 2020).

Table 2 Body mass in year of first capture and in 2020. The residual of body mass is calculated as an indicator of change.

Site	Ring no.	Date of first capture	Mass (g)	Date of second capture	Mass (g)	Residual of body mass (g)
Finland	GS0439	06/06/2018	2185	14/06/2020	2120	-65
Finland	GS0812	22/05/2018	2170	01/06/2020	2240	70
Finland	GS0813	24/05/2018	2075	23/05/2020	2115	40
Finland	GS0821	01/06/2018	2065	23/06/2020	1915	-150
Finland	GS0826	03/06/2018	1620	26/05/2020	1690	70
Finland	GS0811	14/06/2019	2275	22/05/2020	2265	-10
Finland	GS0814	24/05/2019	2010	22/05/2020	2120	110
Finland	GS0829	10/06/2019	2155	29/05/2020	2045	-110
Shetland	1440081	17/06/2019	1930	05/08/2020	1938	8
Iceland	115113	26/05/2019	1495	01/07/2020	1410	-85
Iceland	115117	28/05/2018	1720	02/07/2020	1710	-10
Iceland	115119	25/06/2019	1445	29/06/2020	1460	15
Iceland	115125	24/06/2019	2000	29/06/2020	2160	160
Iceland	115128	25/06/2019	1925	30/06/2020	1860	-65
Iceland	115130	26/06/2019	1980	03/07/2020	2060	80

4.4 Tag data retrieved

Of the 18 tagged birds recovered dead or recaptured during the 2019/20 winter and 2020 summer, a total of 14 TDR and 18 GLS tags were retrieved (Table 3). In some cases, birds had lost a TDR tag (n=3) or did not have a TDR tag deployed (n=1).

Table 3 Tags retrieved during the 2019/20 winter and 2020 summer. Location, unique metal ring number, year of tagging, whether birds were tagged for consecutive years, number of days from deployment that each tag continued collecting data for each year and whether the bird was trapped alive or dead are shown. Where birds were tagged and retrapped for two consecutive years, two sets of duration data have been provided. Tags which recorded for a sufficient duration to provide information on winter location/foraging behaviour of that bird are indicated by a "*". Where no tag was deployed or tags were lost/failed to record data, these have been labelled as such.

Country	Ring No.	Year of Tagging	GLS Duration (days)	TDR Duration (days)	Trapped alive or found dead?
Finland	GS0814	2018+2019	374*+ >1yr*	lost + 224*	Alive
Finland	GS0834	2018+2019	109 + >1yr*	220* + 73	Dead
Finland	GS0812	2018	686*	226*	Alive
Finland	GS0829	2018+2019	384* + >1yr*	212* + 207*	Alive
Finland	GS0811	2018+2019	175* + >1yr*	231* + 218*	Alive
Finland	GS0826	2018	71	39	Alive
Finland	GS0813	2018	139*	219*	Alive
Finland	GS0821	2018	465*	51	Alive
Finland	GS0439	2018	fail	81	Alive
Iceland	115113	2018+2019	336* + >1yr*	221* + 217*	Alive

Iceland	115117	2018	458*	220*	Alive
Iceland	115119	2018+2019	346* + >1yr*	258* + 132	Alive
Iceland	115130	2019	841*	Not deployed	Alive
Iceland	115128	2019	>1yr*	182*	Alive
Iceland	115125	2019	>1yr*	lost	Alive
Shetland	1410844	2018+2019	fail + 191*	230*+ lost	Dead
Shetland	1440081	2019	>1yr*	lost	Alive
Shetland	1420581	2019	214*	153*	Dead

To provide an idea of tag duration, of the 18 sets of tags retrieved during the 2019/20 winter and 2020 summer, most were initially deployed in June (n=11), with some in May (n=6) and July (n=1).

Of the 18 GLS tags retrieved, 16 tags gave some information on non-breeding season location and only two tags failed to record at all. Of those tags that recorded data, 15 tags recorded for the full winter period, with only one tag failing to record beyond October. Tag performance for tags purchased and deployed in 2019 was high, and the issues with water ingression that occurred with the tags purchased in 2018 did not reoccur.

Of the 14 TDR tags retrieved, four recorded little data, failing in July, August or early September. In some cases, there was evidence of damage to the tag casing with subsequent water ingression causing tag failure. The cause of damage was not clear but appears to have occurred after the tags were deployed, possibly due to divers attempting to remove the tags. A further two tags failed in October and November whilst the remaining eight TDR tags recorded until late December or early January.

Seven birds of the total either recovered or recaptured in 2020 were tagged with two sets of tags over two consecutive winters (2018/19 and 2019/20). Of these, five had GLS tags that provided location information from both winters, and three had TDR tags that provided foraging behaviour data from both winters. Whilst a small sample size, this is novel information on inter-annual variability in red-throated diver foraging behaviour that has never been obtained previously.

5 Discussion

5.1 Breeding success

Orkney had a much higher rate of breeding success in 2020 than in 2019 and 2018; 65% compared to 48% and 32% respectively. The majority (60%) of those which failed did so at the egg stage for unknown reasons. Shetland had a poorer year of only 35% breeding success compared to 53% in 2019 and 47% in 2018. Most (91%) of the breeding failures in Shetland also occurred at the egg or young chick stage. Eggs/chicks were known to be predated at four nest sites of untagged birds – two by otter, the others undetermined – but it is not known what caused the failure of the remaining nests. Finland had an average year of 59% compared to 57% and 62% in 2019 and 2018 respectively.

5.2 Tag effects

5.2.1 Resighting

Red-throated divers are long-lived species, with an adult survival rate of at least 84% (Hemmingsson & Eriksson 2002; Schmutz 2014) It is also known that red-throated divers exhibit high inter-annual breeding site fidelity (Okill 1992). Therefore, we would expect the quantity of resightings of tagged birds to be similarly high. However, quantity of resightings does not necessarily represent survival rate as there are many reasons why a tagged bird may not be resighted in a given year, including asynchronous breeding phenology, moving nesting sites, skipping a breeding season (Giudici *et al.* 2010), and practical difficulties in resighting tagged birds due to both terrain and sensitivity of the species to disturbance (for further details see O'Brien *et al.* 2020). In other words, a low quantity of resightings does not necessarily equate to a low survival rate.

Six tagged birds have been found dead during the period June 2018 to August 2020 (Finnish ringed birds n=4; Scottish ringed birds n=2). Given that a total of 89 divers were tagged during this period, this gives a very coarse estimate of mortality of 6.7% or an adult survival rate of 93.3%, which would be as expected for a long-lived species such as red-throated divers. This survival rate is a crude measure as it does not account for the actual numbers of live birds carrying tags at the point when each individual was reported dead. It also does not account for birds that died and were not found. For example, no tagged birds have been reported dead from Iceland, but this is likely due to corpses not being found rather than an absence of mortality. We have insufficient evidence to conclude whether low numbers of resightings are due to tagged birds being alive but not being seen or to higher mortality rates of tagged birds.

5.2.2 Body mass

The average residual of body mass is close to zero, and there no was no significant difference in the median body mass between years, suggesting that there is no apparent negative effect of tags on body condition on the birds recaptured in 2020. This finding supports that found in 2019 (O'Brien *et al.* 2020), however note that the sample size for 2020 was smaller than in 2019 and that birds may not have been measured consistently at the same time or stage in the breeding season across all years.

6 Conclusions and Recommendations

Although 2020 provided some fieldwork limitations, it remained a successful year for tag retrieval with 18 tagged birds recaptured or recovered across three countries, including seven birds which had been tagged over two consecutive years. Unfortunately, due to data availability and largely an absence of data from Scotland due to the lack of fieldwork, it was not possible to perform robust statistical analyses to identify any trapping effects on the birds.

Although Finland and Iceland data from 2020 appears to support the previous finding that tags do not affect the body mass of tagged birds (O'Brien *et al*. 2020), due to the absence of data from Scotland this year, this finding should be treated with caution. Furthermore, we were unable to sufficiently analyse any tagging and trapping effects on resighting and breeding success from 2020 due to similar restrictions with the data.

We therefore recommend undertaking fieldwork in 2021 in Scotland to retrieve as many tags as possible, from an ethical standpoint, as it is currently inconclusive as to whether or not tags may have a detrimental effect on the survival and body condition of the birds.

This tagging study is the first of its kind to gather empirical evidence on foraging activity of red-throated divers. Analysis on interannual variation in both winter foraging behaviour and wintering location will be performed as part of the PhD associated with the project. In order to inform future projects, we also recommend detailed analysis into potential tag and trapping effects on red-throated divers once additional data from both the 2020 and 2021 field seasons is obtained.

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