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Greenland White-fronted Geese in Hvanneyri: studies during spring and autumn in 2017

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Executive Summary

The Greenland White-fronted Goose *Anser albifrons flavirostris* is a distinct sub-species of the circumpolar Greater White-fronted Goose *Anser albifrons*. The global population trend has been characterised by a significant decline in the late 1970s and an increase in response to protective legislation in the early 1980s. A more recent decline in numbers since the late 1990s is due to a continuing decline in annual recruitment, which now fails to balance adult mortality. The population breeds in western Greenland and winters almost exclusively in Britain and Ireland. During spring and autumn, en route between breeding and wintering areas, the population stages in Iceland for several weeks. The farmland at Hvanneyri and areas surrounding Borgarfjörður in west Iceland is a well-known staging site for Greenland White-fronted Geese. It is the largest known single aggregation of these geese anywhere in their flyway and this significantly influenced the designation of the area by the Icelandic Government as a Wetland of International Importance, under the Ramsar Convention on Wetlands, in 2013.

The primary aim of this project was to describe the timing and duration of the spring and autumn staging periods in Hvanneyri in 2017, as well as to assess body condition during spring, determine the proportion of juveniles in flocks in autumn, and monitor individually identifiable geese throughout both periods. Therefore, the study encompassed the entirety of both the spring and autumn staging periods: between 12th March and 10th May, and between 31st August and 8th November. Daily censuses of overall numbers were supplemented by almost daily assessments of the birds' abdominal profiles in spring, and assessments of the proportion of juveniles in the flocks in autumn. The inscribed collars on individually identifiable geese were read on an almost daily basis in both seasons.

Excluding the particularly early observation of a family of five Greenland White-fronted Geese on 12th March, the spring staging period ran from 24th March to 10th May. An average of 648 geese was recorded during daily censuses in the core staging period in spring, and a peak count of 1,054 geese was recorded on 7th April. In autumn, the staging period lasted from 6th September to 8th November. An average of 1,324 geese was recorded on daily censuses. A peak count of 1,835 was recorded on 27th September, which represents 9% of the total flyway population of 20,556 birds.

Four other species of wildfowl: Greylag Goose *Anser anser*, Whooper Swan *Cygnus cygnus*, Pink-footed Goose *Anser brachyrhynchus* and Barnacle Goose *Branta leucopsis* were recorded in the survey area.

During 33 observation sessions, abdominal profile scoring was undertaken on 2,134 geese to chart the rate of fat accumulation throughout spring staging. A general increase in abdominal profile scores was evident during the spring staging period.

A total of 169 individually marked geese were resighted on Hvanneyri farm during both staging periods. Resightings of these geese show that there is considerable turnover throughout the spring and autumn staging periods. There were 22 individuals that were resighted during spring staging only, 35 that were resighted during autumn staging only, and 46 birds resighted during both staging periods. The remaining 66 birds were those that were newly ringed in Hvanneyri during September. During the spring, 390 sightings of 68 individuals were recorded, and in the autumn, 1,469 sightings of 147 individuals were made. In spring, the mean duration of stay of 68 marked individuals was 17.6 days, with individuals being present on the site for between 1 and 38 days. The mean duration of stay of 81 marked individuals in autumn was 21.3 days, with individuals staging for between 1 and 42 days. In terms of their arrival time and duration of stay, individually marked birds used different strategies during both staging seasons. For individuals that were recorded more than once, most birds (60%) arrived within the first 20% of the staging period in spring, and regardless of their arrival date, most (66%) stayed for greater than 75% of the remaining staging period. And in the autumn, 27 birds (42%) arrived within the first 20% of the staging period, but regardless of their arrival date, 62% of all individuals recorded stayed for greater than 75% of the remaining staging period.

The proportion of juveniles in flocks during the autumn was estimated to be 4.4%, which is considerably lower than the already low proportions recorded on wintering grounds in previous years, and a continuing cause for concern.

Disturbance events were observed on 40% of daily censuses. Farming activity was the most frequently observed activity in, or in the vicinity of, the survey area.

The importance of continued monitoring in future years is highlighted, given the importance of this area for Greenland White-fronted Geese and the fact that the site is particularly favourable for studying staging flocks. A series of actions from the International Species Action Plan for Greenland White-fronted Geese that are relevant to Hvanneyri are listed.

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1. Introduction

The Greenland White-fronted Goose *Anser albifrons flavirostris* is the most distinct sub-species of the circumpolar Greater White-fronted Goose *Anser albifrons* both morphologically and geographically (Fox & Stroud, 2002; Ely *et al.,* 2005). The population winters almost exclusively in Britain and Ireland, stages in Iceland in spring and autumn and breeds in Greenland (Fox *et al*., 2003, 2012; Stroud *et al.*, 2012), where their range extends from 66° – 72° N in the ice-free regions of the west (Malecki *et al.,* 2000) (Figure 1-1). Migration includes an over-sea flight of 1,000 – 1,500 km between Britain/Ireland and Iceland, and a similar distance over the sea and the Greenland Ice Cap (a 1.7 million km^2 expanse of ice, peaking at 3,000 metres in elevation (Comiso & Parkinson, 2004)) between Iceland and western Greenland.

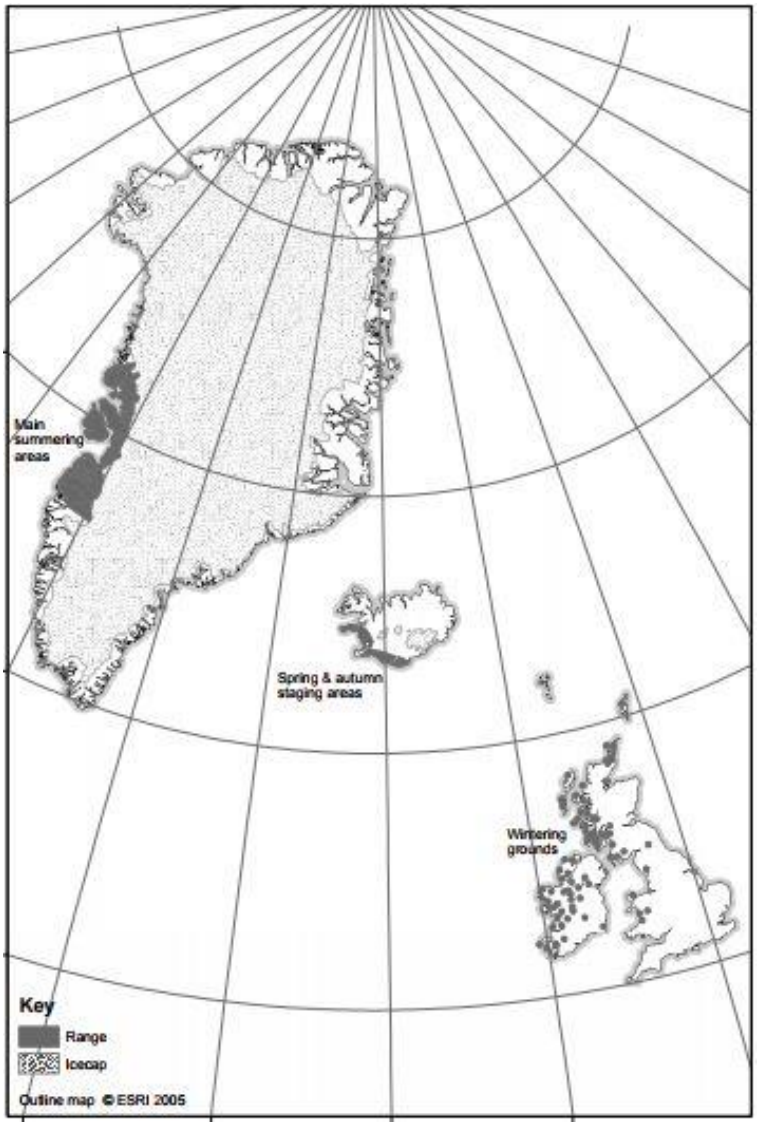

Figure 1-1. Global range of the Greenland White-Fronted Goose (from Stroud *et al*., 2012) showing wintering areas in the UK and Ireland, staging areas in southern and western Iceland and breeding areas in western Greenland.

Greenland White-fronted Geese are categorised as 'Endangered' under IUCN Red List criteria [criteria A4abcd, C1] (Boertmann, 2007), listed in Annex I of the EC Birds Directive (EC Birds Directive, 2009), as a priority species in the Biodiversity Action Plan in the UK (Eaton *et al.* 2009), are Amber listed on the Birds of Conservation Concern List in Ireland (Colhoun & Cummins, 2013), and are managed under a Species Action Plan through the African Eurasian Migratory Waterbird Agreement (Stroud *et al*., 2012).

The global population showed a significant decline from a maximum of 23,000 individuals in the 1950s to between 14,300 and 16,600 in the late 1970s, as a result of the reduction of the peatland habitat that is traditionally used by the geese in Ireland (Ruttledge & Ogilvie, 1979). Protective legislation halted shooting on most of their wintering grounds (exception: Wales), and conservation measures in the early 1980s lead to an increase in numbers to 27,000 by November 1989 (Wilson *et al*., 1991), and a further increase to peak at 35,600 in 1999 (Stroud *et al*., 2012). However, in the years since then, numbers have fallen dramatically: 18,879 in spring 2016 and 20,556 in spring 2017 (Fox *et al*., 2016; 2017).

The recent declines in numbers is due to a continuing decline in annual recruitment, which now fails to replace normal annual losses (Fox, 2003; Fox *et al*., 2006). In Wexford, south-eastern Ireland, the principal Irish wintering site for the geese, Weegman *et al*. (2016) have shown that only 8% of individuals ever reproduce successfully (in terms of returning to winter in Wexford with one or more juveniles) and just 2% reproduce more than once in their lifetime. Breeding success continues to fall below what is necessary to maintain a stable population or reverse the declines. The percentage of young amongst flocks in Wexford in winter 2015/16 was 12.2%. Since the mid-1990s, the average annual proportion of young has been 8%, considerably lower than the long-term (1970 – 2015) average of 13% (Fox *et al*., 2017).

Greenland White-fronted Geese use two main staging areas in Iceland, the southern lowlands (Árnessýsla, Rangárvallasýsla and Vestur-Skaftafellssýsla) and the western lowlands (Kjósarsýsla, Borgarfjarðarsýsla, Mýrasýsla and Snæfellsnes-og Hnappadalssýsla) (Fox *et al*., 2002). Resightings and recoveries show that the geese staging in the south of Iceland are more likely to winter in Scotland, while birds wintering in Wexford were more likely to be resighted in the western staging area (Fox *et al.,* 2002). The farmland at Hvanneyri and areas surrounding Borgarfjörður in west Iceland is a well-known staging site for Greenland White-fronted Geese (Francis & Fox, 1987, Fox *et al*., 1994), and remains the largest known single aggregation of these geese anywhere in their flyway (Fox *et al*., 1999).

A habitat protection area for Greenland White-fronted Geese was established in Hvanneyri in 2002. In 2011 the area was enlarged to include important bird areas of the farms surrounding the original habitat area. In February 2013, the Andakíll Ramsar site was designated fulfilling four of the nine criteria for identifying Wetlands of International Importance, as agreed by the Ramsar Convention on Wetlands (Ramsar Convention Secretariat, 2013).

Monitoring and research of Greenland White-fronted Geese has been carried out throughout their range for many decades. First, sporadic counts were made in the 1950s in Britain and Ireland, and aerial surveys, ringing and research have been conducted in Greenland since 1979. A marking scheme for Greenland White-fronted Geese, coordinated jointly by Greenland White-fronted Goose Study (GWGS) and the National Parks and Wildlife Service (NPWS) in Ireland has been in operation since 1983.

Monitoring of Greenland White-fronted Geese has been ongoing in Iceland since 1986 when GWGS first started visiting Hvanneyri. These studies have explored aspects of both the spring and autumn staging periods both in western Iceland (mainly Hvanneyri) and the southern lowlands. Research on spring staging geese at Hvanneyri was undertaken in 1986, 1997, 1998, 1999, 2007, 2012, 2013 and 2017, whilst autumn studies were made in 2001, 2004, 2005, 2008, 2016 and 2017. In all years, a central element of study has been the description of numbers and distribution of staging Greenland White-fronted Geese, but other aspects such as: health screening, post-mortem studies, feeding ecology, behaviour and implication of disturbance or land change have also been explored.

During spring and autumn staging in Iceland, the geese traditionally fed in natural saltmarshes and other wetlands, especially traditionally managed *Carex lyngbei* hay meadows, but they now feed largely on farmland grasses (Stroud *et al*., 2012). The length of the spring staging period in Iceland increased between 1969 and 2012, as the geese have advanced their mean departure date from Ireland by 15 days, but the mean departure date from Iceland (to Greenland) has seemingly not changed (Fox *et al*., 2014).

Given the continued decline in the population, and these changes in phenology, it is important that data are gathered on the geese during their staging periods. It is also vital to ensure that this important staging area is managed to provide the best conditions for the geese during their stay, and that all sources of unnecessary disturbance are minimised.

Here, we describe the timing and duration of the spring and autumn staging periods in 2017, as well as assessments of body condition (during spring), the proportion of juveniles in flocks in autumn, and monitoring of marked individuals, all of which are a continuation of long term monitoring by Greenland White-fronted Goose Study.

2. Methods

2.1 Study area

The Agricultural University of Iceland farm at Hvanneyri, Borgarfjörður, west Iceland (64°34' N, 21°46' W) lies within the Andakíll Ramsar site (Figure 2-1). This farm and the surrounding wetlands are the most important staging area in Iceland for Greenland White-fronted Geese. The survey area is *c*. 485 hectares and consists of drained and cultivated hay meadows, seasonally flooded (estuarine) hay meadows, intertidal mudflats, rough grassland, a freshwater lake, and the village of Hvanneyri.

2.2 Daily census

A daily census was undertaken during spring and autumn 2017 to coincide with the staging periods of the geese. Surveys took place between 12th March and 10th May, and between 31st August and 3rd November. All surveys took place during daylight hours, between 08:00 and 20:00. Surveys were completed in as short a time as possible (usually 35-40 minutes) to reduce the possibility of bird movements resulting in double counting or missing birds.

Equipment used included:

- binoculars (Zeiss Victory 8 x 42, Zeiss Dialyt 10 x 40 B)
- telescope and tripod (Swarovski ATS-65 HD 20-60 x 65mm, Hawke Endurance 16-48 x 68)
- clicker-counter
- Field Recording Form

On each survey, the date, survey type, observers present, start and finish times and extent of coverage were recorded. Weather and visibility were recorded by assessing rain, wind, cloud cover and snow/frost cover (see Field Recording Form in Appendix I). All human activities in the vicinity of the survey area were recorded, and all instances of disturbance to the birds, by human activity or birds of prey, were recorded during all censuses.

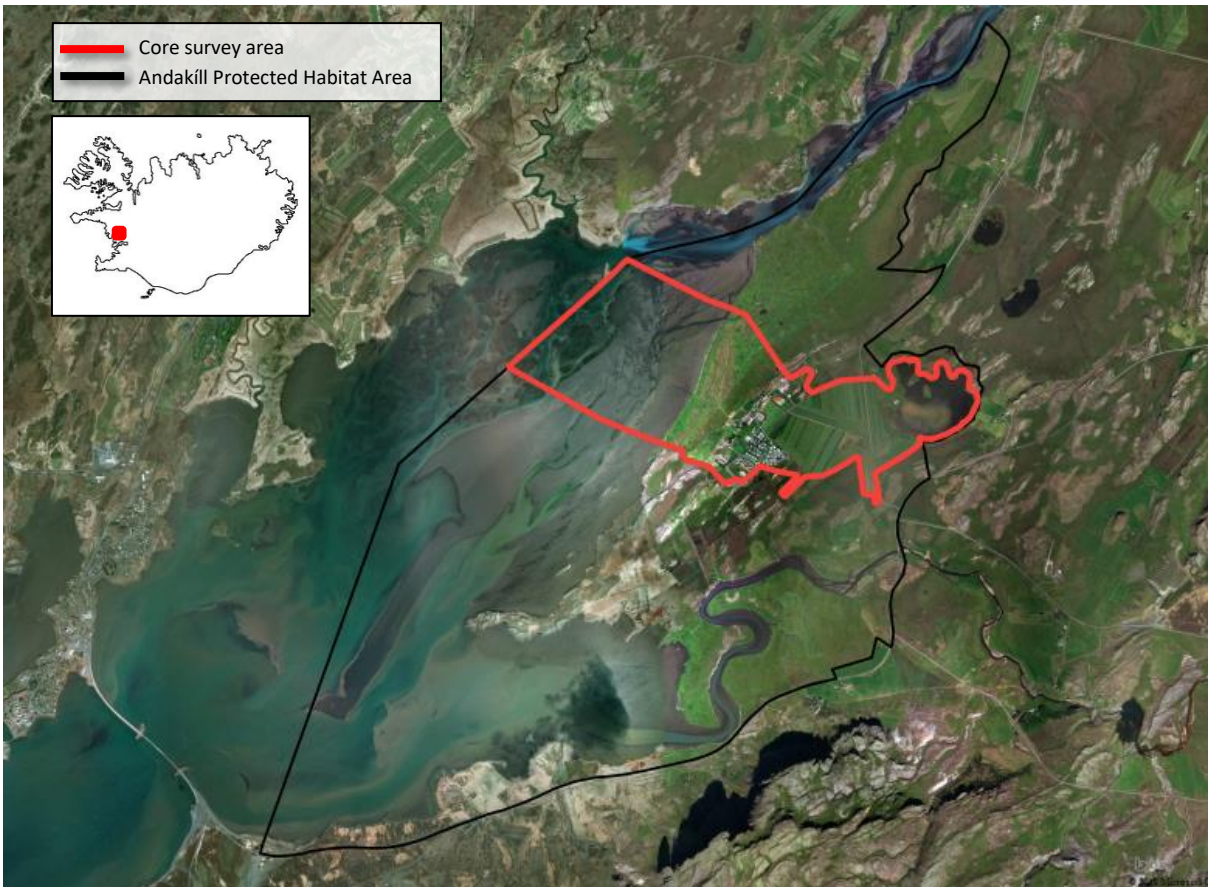

Figure 2-1. Location of the survey area at Hvanneyri, Borgarfjörður, within the Andakíll Ramsar site. Map of Iceland inset.

A standard route, which included 60 fields and lake Vatnshamravatn, was driven on each survey. The rationale behind the survey route chosen is that it starts in the outer areas of the site and works inwards towards the middle of the farm. As much of the count as possible is performed from the main roads, as the geese are more used to traffic on these roads, and therefore are less likely to flush when a vehicle pulls over. Depending on the distribution of the birds on the farm, the observer's vehicle can cause the birds to flush, especially if they are foraging close to the farm tracks. Counting from the peripheral areas inwards, towards the central complex of fields ensures that the areas most sensitive to disturbance are covered last, when most of the birds have already been counted, and therefore is likely to reduce potential double-counting or missing birds. The survey route is outlined in Figure 2-2 and full details on the route and the areas covered from each vantage point are provided in Appendix I.

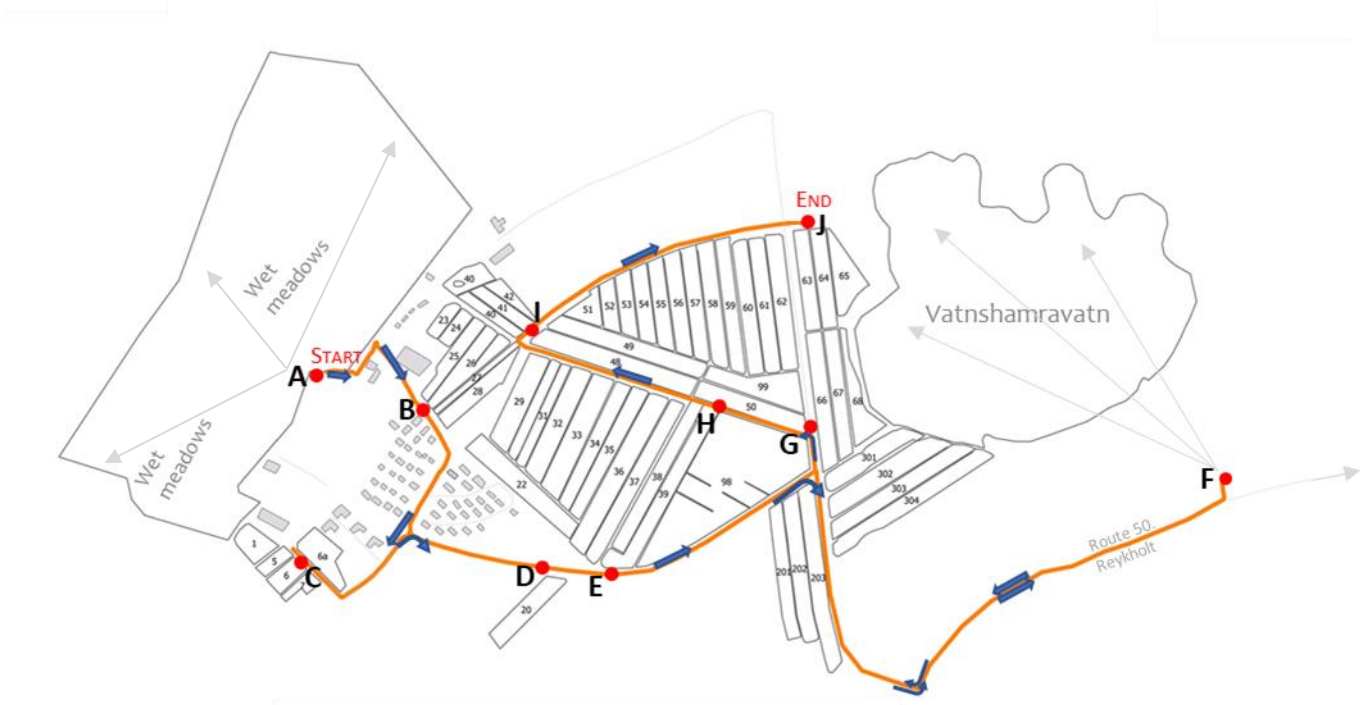

Figure 2-2. The survey area in Hvanneyri, showing the standard route used during daily censuses in the spring and autumn staging periods for Greenland White-fronted Geese in 2017. Letters refer to the principal vantage points. Fields are numbered according to Hvanneyri farm field numbers.

The following data were recorded on each survey:

i. the total number of all wildfowl present in each field;
ii. the identity of individually marked birds;
iii. a sample of Abdominal Profile Indices (API) as a measure of body condition (in spring only);
iv. an assessment of the proportions of juvenile birds in a sample of the flock (in autumn only); and
v. any activities in the vicinity of the survey area, and sources of human or other disturbance.

2.3 Abdominal profile scoring

Abdominal Profile Indices (API) (Owen, 1981) of a sample of Greenland White-fronted Geese were assessed on an almost daily basis between 24th March and 5th May. Observation sessions were undertaken at various locations around the farm while the geese were foraging. Each goose was scored on a 9-point scale according to the Greenland White-fronted Goose Study chart (Fig. 2-3). When sampling from different fields, the movements of flocks of birds was tracked to ensure that individuals were not sampled more than once a day.

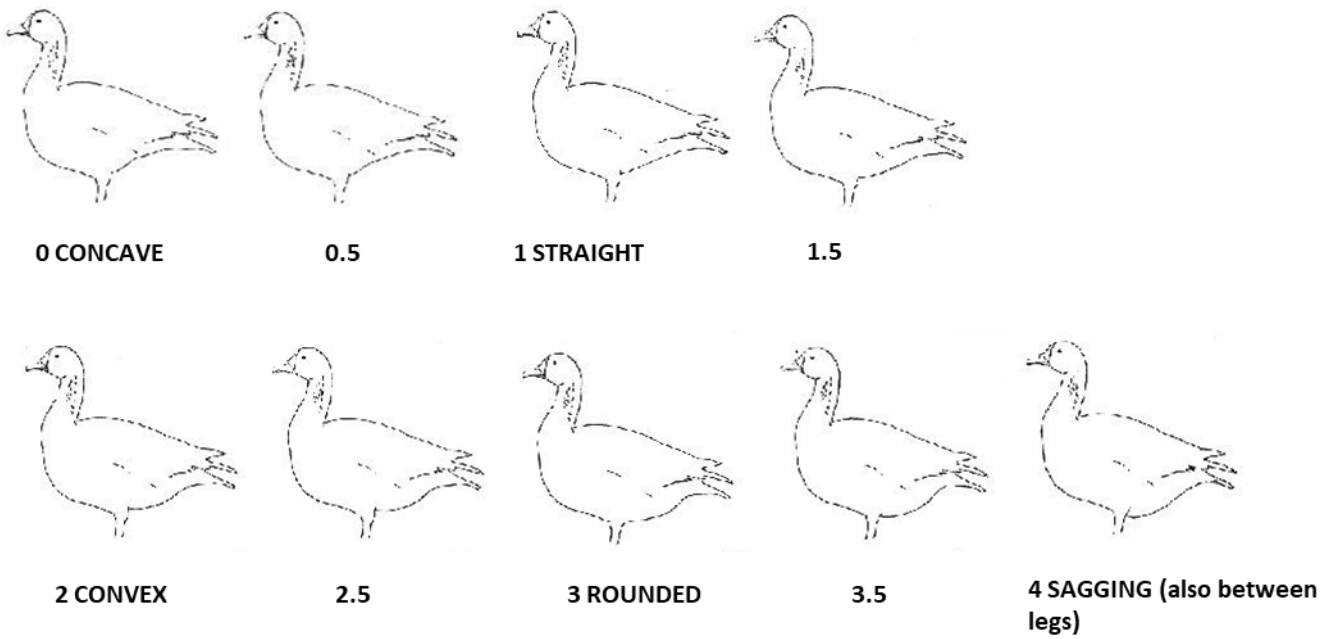

Figure 2-3. Abdominal Profile Index for Greenland White-fronted Geese. Note the varying levels of subcutaneous fat accumulation on the abdomen, posterior to the legs.

2.4 Tracking individually identifiable birds

The population has been subject to a long-term study of population dynamics and migration ecology using individually identifiable collars. Ringing of Greenland White-fronted Geese with collars started in 1983, and since then a total of 3,005 individual geese have been captured and marked. On each session, the presence of individually marked birds and their associates were recorded along with the Hvanneyri farm field code in order to derive: family relationships; breeding success; home-ranges on the farm; and the duration of their staging periods.

2.5 Age sampling

As a measure of reproductive success, flocks were age-sampled during the autumn staging period, between 12th September and 25th October, to determine what proportion were juveniles. Geese were observed through a telescope at a range of 50 - 400 metres in favourable light conditions. Juveniles were identified based on plumage characteristics, mainly the absence of white feathers on the face or black markings on the breast or belly. Given the strong social bonds in families of this species, juveniles are likely to be distributed heterogeneously throughout flocks (i.e. with their siblings in family groups). For this reason, in order to prevent an underrepresentation of juveniles, if a juvenile or juveniles were detected close to an area where adjacent birds were obscured from view (by topography or other

birds), the sample was aborted. Where it was possible to sample flocks in multiple locations with confidence that the groups were discrete and had not mixed, these data were brought together as one sample. Samples were easiest to record when the geese congregated on Lake Vatnshamravatn, usually after being flushed by a bird of prey or by farm activity.

View from the Andakíll Ramsar site. *Rachel Stroud.*

3. Results

3.1 Daily Census

Greenland White-fronted Geese

Spring

The first Greenland White-fronted Goose sighting occurred on 12th March, when a family of five individuals was recorded. There was a mass arrival on 27th March, and 843 birds were counted on 28th March. Then, the number of birds recorded on the farm declined to 364 and 116 on 2nd and 3rd April, respectively. During this period, the weather was characterised by strong winds and precipitation, and the fields were covered with fresh snow. After this, the snow melted in the afternoon of 5th April, the number of birds counted increased, and then peaked at 1,054 on 7th April. The average number of birds during the core staging period, between 27th March and 3rd May, was 648 (SE = 34). The core staging period is considered to be the period when the daily count is greater than 50% of the season maximum, which was 808. The seasonal maximum is calculated as the average of the highest 20 daily totals. There were two phases of departure; between 22nd and 27th April, and 29th April and 5th May. In the first period, the biggest reduction in birds occurred between 25th and 26th April, at a time of strong south-westerly winds. And in the second phase, the biggest reduction in birds occurred between 3rd and 4th May, during a period of fresh south-easterly winds. The last spring sighting occurred on 10th May, when ten birds were seen.

The entire staging period spanned 48 days, ranging from 24th March to 10th May (Fig. 3-1). The core staging period was 38 days long, ranging from 27th March to 3rd May (Fig. 3-2). Due to arrivals and departures of birds throughout the staging period, the birds that use the farm cannot be considered a single unit, but Figure 3-2 serves to demonstrate the timing of the first arrivals and final departures to and from Hvanneyri in spring.

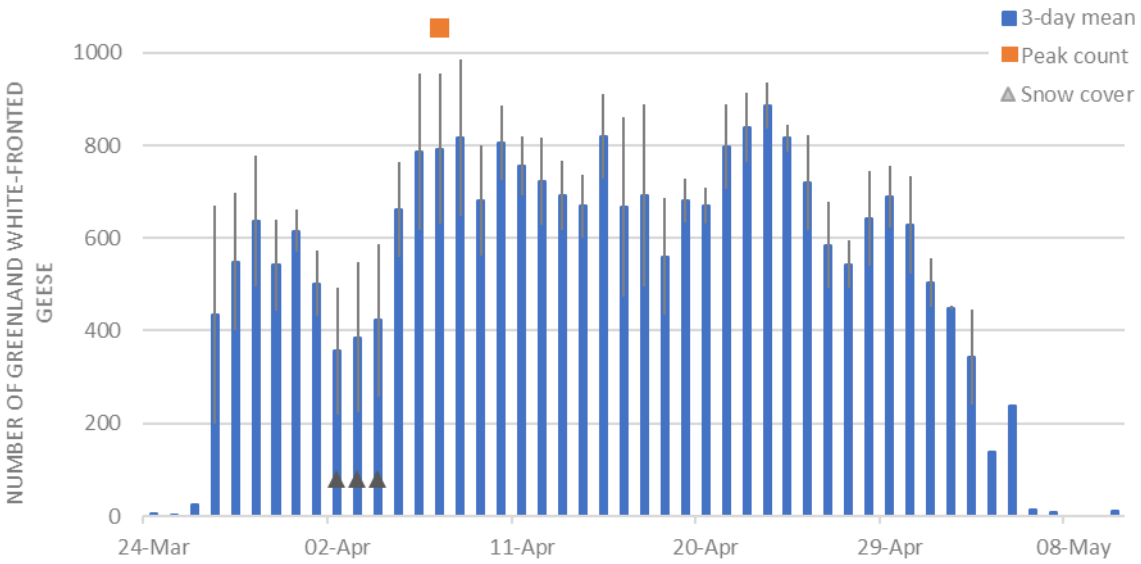

Figure 3-1. Number of Greenland White-fronted Geese during daily surveys in the Hvanneyri survey area between 24th March and 10th May 2017. Number of geese is the three-day moving average (± standard error). At the start and end of the staging season, when counts were less than 400, the daily total (rather than the three-day moving average) is shown. Triangles refer to three days when the survey area was covered in snow.

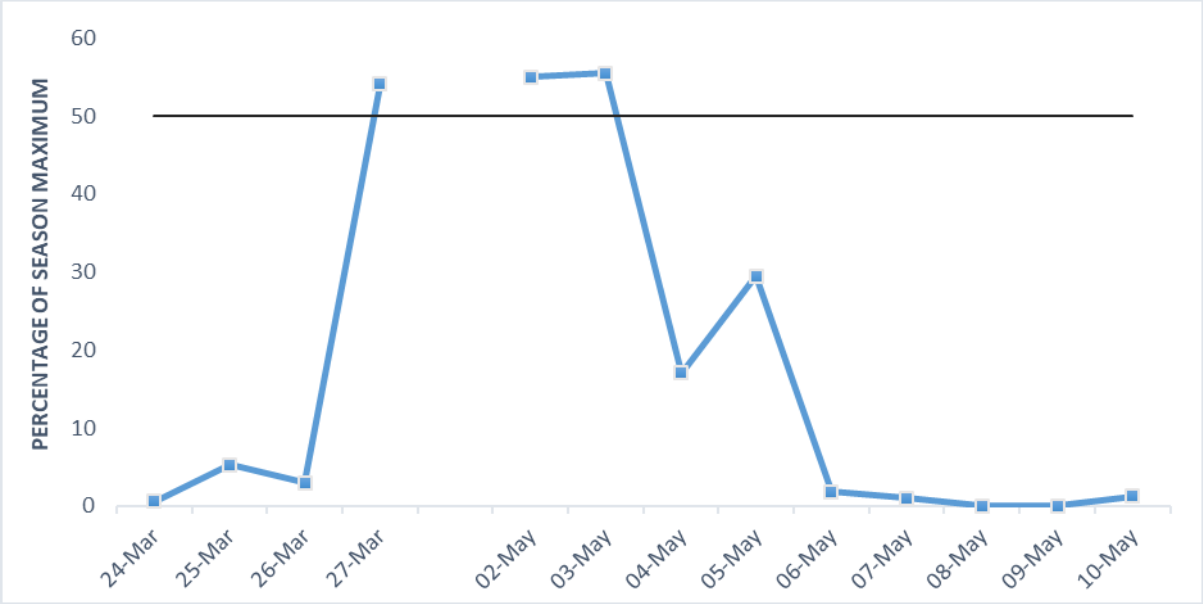

Figure 3-2. Arrival and departure dates of Greenland White-fronted Geese in Hvanneyri during spring 2017. Goose numbers are represented as a percentage of the season maximum. Arrival date is considered to be the date when the number of geese is equal to or greater than 50% of the season maximum, and departure date is when the number of geese is less than 50% of the season maximum. The season maximum, 808 birds, is the average of the highest 20 daily totals. The black line represents 50% of the season maximum (404 birds). Note discontinuous x-axis.

Autumn

In the autumn, the first sighting of Greenland White-fronted Geese was on 6th September, when 21 birds were recorded. Over the next week, the numbers increased gradually and plateaued at *c.* 750 birds. A large influx was observed on 21st September, bringing the total count to 1,524. The average number of birds during the core staging period, between 15th September and 27th October, was 1,324 (SE = 49). The core staging period is considered to be the period when the daily count is greater than 50% of the season maximum, which was 1,584. The seasonal maximum is the average of the highest 20 daily totals. A peak count of 1,835 geese was recorded on 22nd September. Numbers declined gradually from 25th October onwards, and there was large scale departure between 27th and 28th October, when the number of geese declined from 1,205 to 366. The last autumn sighting of a flock was on 3rd November, when 72 birds were seen. A single adult goose was observed in Hvanneyri on 8th November.

The autumn staging period lasted 64 days, from 6th September to 8th November. The core staging period was 43 days long, ranging from 15th September to 27th October.

There was farm vehicle activity (mowing, turning, baling and ploughing) in many of the fields between 6th and 13th, and 24th and 26th September, and slurry spreading on 31st October. These activities were largely confined to single fields or groups of fields on each day, and due to the layout of the farm, there were always several undisturbed areas available for foraging geese. Between 16th and 24th September, there was road resurfacing works on the road that serves Hvanneyri (see vantage points D and E in Fig. 2-2), which involved heavy machinery. Furthermore, as the road was closed periodically during this period, there was increased traffic using the farm tracks (to access the village), which is likely to have caused some disturbance to the geese.

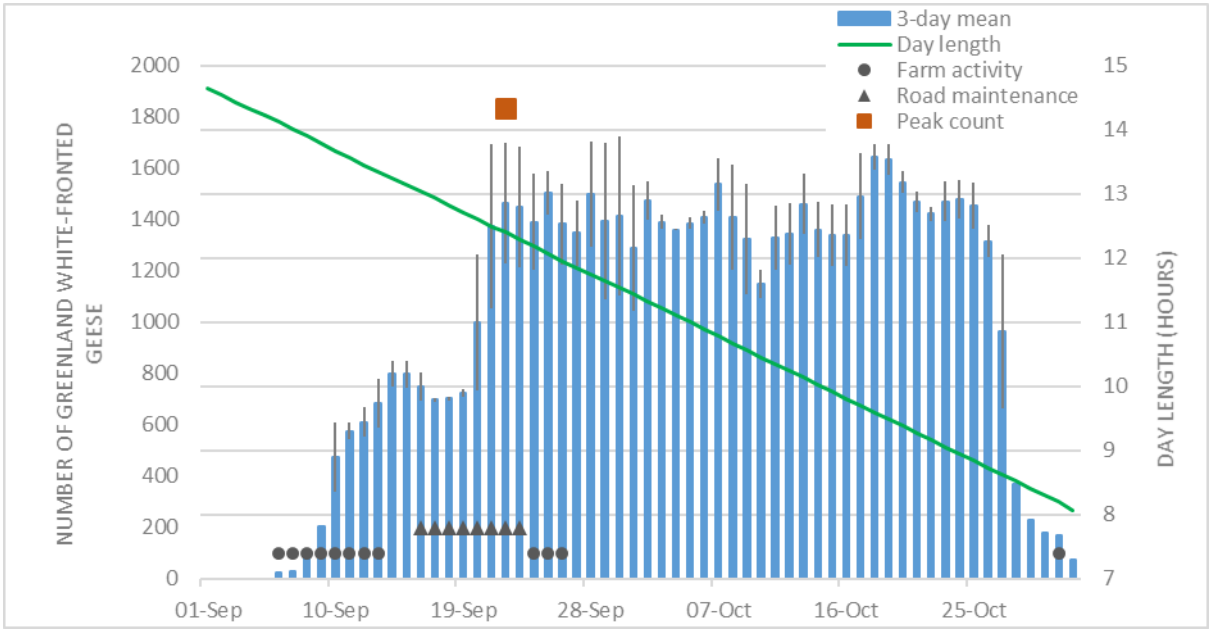

Figure 3-3. Number of Greenland White-fronted Geese during daily surveys in the Hvanneyri survey area between 31st August and 3rd November 2017. Number of geese is the three-day moving average (± standard error) for all days when counts were greater than 400, otherwise the daily total.

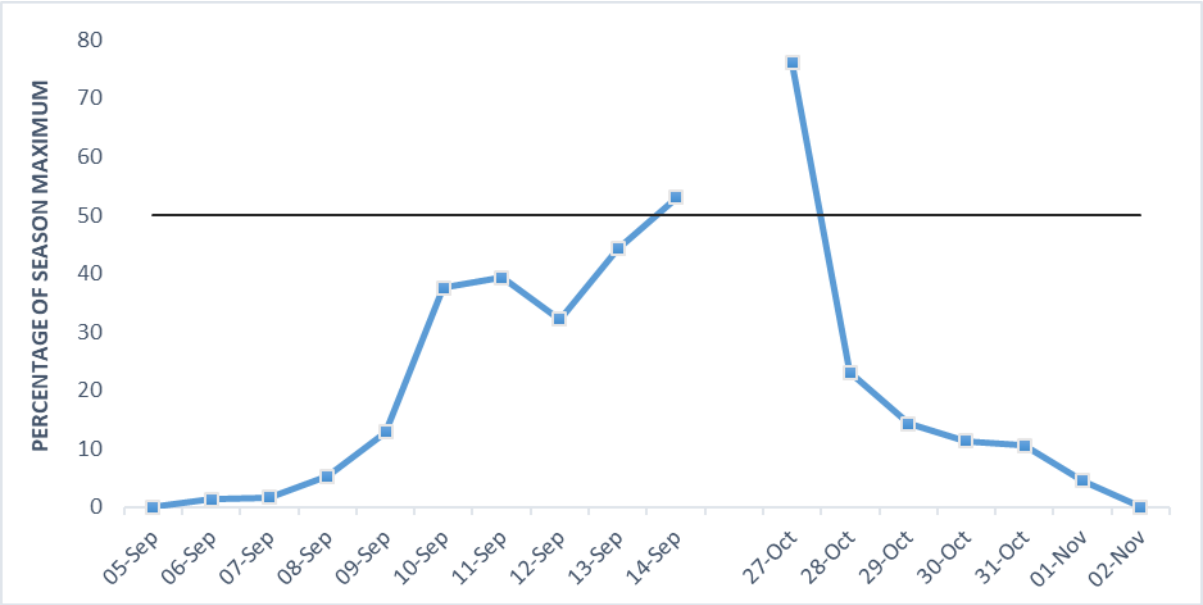

Figure 3-4. Arrival and departure dates of Greenland White-fronted Geese in Hvanneyri during autumn 2017. Goose numbers are represented as a percentage of the season maximum. Arrival date is considered to be the date when the number of geese is equal to or greater than 50% of the season maximum, and departure date is the date when the number of geese is less than 50% of the season maximum. The season maximum (1,584 birds) is the average of the highest 20 daily totals. The black line represents 50% of the season maximum (792 birds). Note discontinuous x-axis.

Greenland White-fronted Geese in Hvanneyri. *Rachel Stroud.*

Other wildfowl

Four other species of wildfowl: Greylag Goose *Anser anser*, Whooper Swan *Cygnus cygnus*, Pink-footed Goose *Anser brachyrhynchus* and Barnacle Goose *Branta leucopsis* were recorded in the survey area.

During the spring, Greylag Geese and Whooper Swans were recorded in most weeks, with peak numbers of 30 and 28, respectively. The numbers of both species gradually declined throughout the survey period. Pink-footed Geese were present on the site between 2nd and 7th May, with a peak count of nine individuals being recorded on 4th May.

Figure 3-5. Peak weekly counts of wildfowl, excluding Greenland White-fronted Geese, in the Hvanneyri survey area between 12th March and 10th May 2017.

During the autumn, Greylag Geese, Whooper Swans, Pink-footed Geese and a single Barnacle Goose were recorded. Greylag Geese occurred in highest numbers, and flocks greater than 100 birds were recorded during September, with a peak count of 332 recorded on 12th September. There were no Greylag Geese recorded in the survey area during October or November. The peak count of 26 Whooper Swans was recorded on 7th September.

Whooper Swans were not recorded in the hay meadows during October, with all birds being recorded on Lake Vatnshamravatn. Several groups of Pink-footed Geese were recorded throughout September and October, with a peak of 14 birds being recorded on 13th September.

A single Barnacle Goose was recorded with the Greenland White-fronted Geese between 13th September and 2nd October.

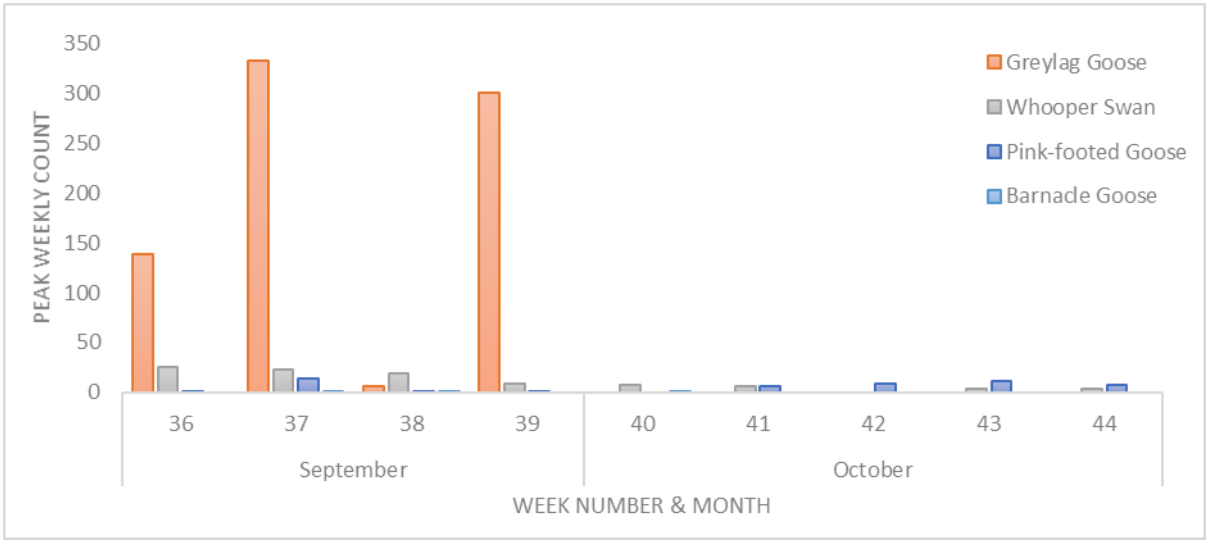

Figure 3-6. Peak weekly counts of wildfowl, excluding Greenland White-fronted Geese, in the Hvanneyri survey area between 31st August and 3rd November 2017.

3.2 Abdominal profile scoring

Thirty-three observations took place throughout the spring staging period, starting immediately after the geese arrived on 24th March and continuing on an almost daily basis until 5th May, when most of the geese had departed. In total, abdominal profiles were assessed on 2,134 geese and the average daily sample was 49 birds (range = 2-149, SD = 46.4). A general increase in abdominal profile scores was evident during the staging period (Fig. 3-7), but there was some fluctuation. For instance, there was a decline in mean daily API scores from 2.2 to 2.0 between 24th and 26th April, during a period when the daily total of birds reduced from 923 to 522.

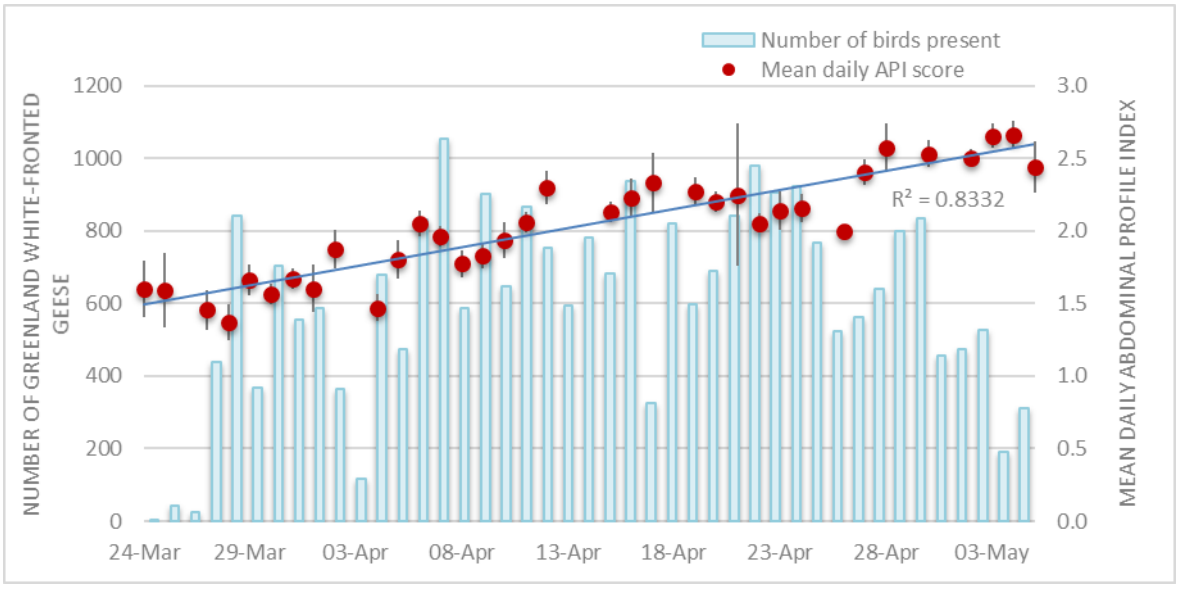

Figure 3-7. Relationship between mean daily abdominal profile index (± 95% CI) and date amongst Greenland White-fronted Geese in Hvanneyri during spring (24th March to 5th May) in 2017. Blue bars represent the total number of geese counted in each daily census.

3.3 Tracking individually identifiable birds

During the spring, 390 sightings of 68 individuals were recorded in Hvanneyri. In the autumn, 1,469 sightings of 147 collared geese were recorded, including 66 birds that had been captured and marked by a University of Missouri/Greenland White-fronted Goose Study team in September.

Spring

Mean duration of stay of 68 marked individuals was 17.6 days (SE=1.7, range 1 - 38 days). Many birds (22%) were recorded only once on the farm, but the majority (59%) were re-sighted on the farm over 10 days or more (Fig. 3-8). There were 18 collared birds (26%) resighted on the farm over 31 days or more.

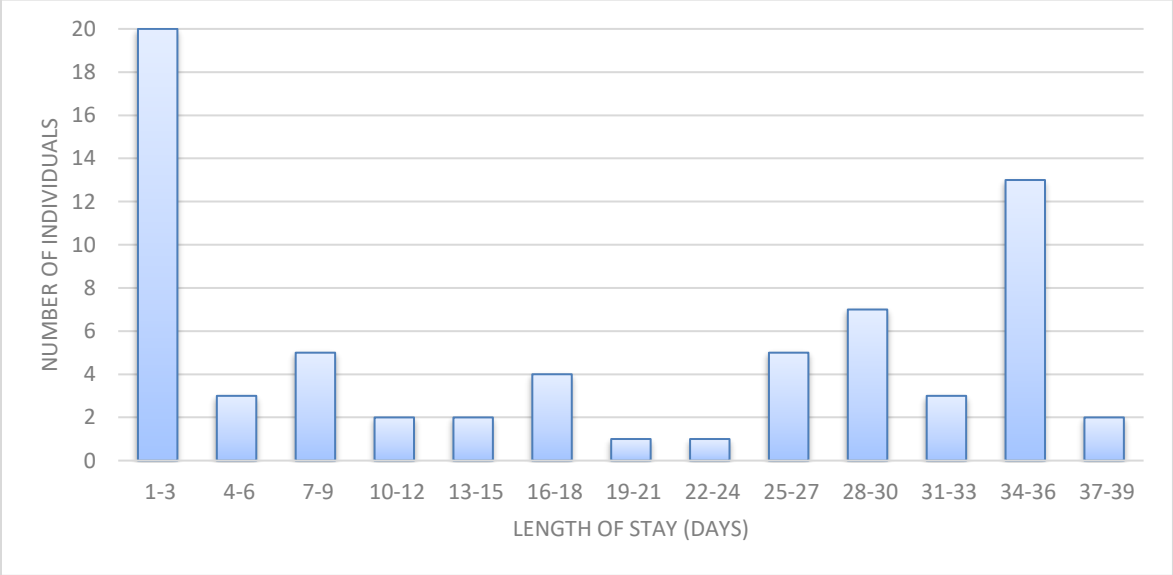

Figure 3-8. Frequency distribution of length of stay of individually marked Greenland White-fronted Geese staging at Hvanneyri during spring (24th March to 10th May) in 2017 (n=68).

For the 53 individuals that were re-sighted more than once, and could therefore be assigned an arrival and departure date, over half of the first sightings occurred in the early part of the season, by 30th March, and the majority of the subsequent arrivals occurred during four arrival phases between 3rd and 21st April. Less than 5% of first sightings occurred after 21st April (Fig. 3-9). There were waves of arrivals and departures throughout April, but the biggest departure event, accounting for 55% of the individually marked birds, occurred between 1st and 5th May.

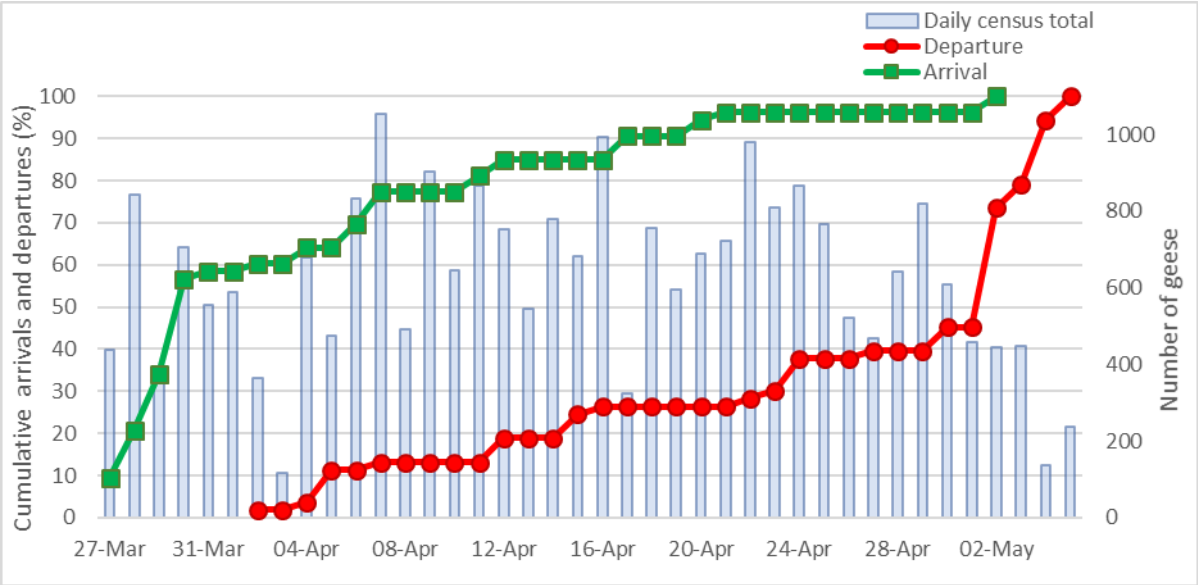

Figure 3-9. Patterns of arrival (squares, green line) and departure (circles, red line) of individually marked Greenland White-fronted Geese staging at Hvanneyri during spring (24th March to 10th May) 2017. Data are expressed as the cumulative percentage of all individually marked birds that were resighted (n=53, and excludes any individuals that were resighted once only). Blue bars represent the total number of Greenland White-fronted Geese counted in each daily census.

Looking at both duration of stay and arrival date, it is apparent that birds use Hvanneyri in different ways. For birds re-sighted on more than one occasion (n=53), Figure 3-10 shows the duration of their stay against arrival date, and is annotated to highlight three main strategies: group A - birds that arrived early in the season and stayed for various time periods; group B - birds that arrived later in the season and stayed for most of the remaining staging period; and group C – birds that arrived after the early period and stayed for short periods (C). Thirty-two individuals (60%) (group A) were first-resighted early in the season (in the first *c*. 20% of the season (first 10 days, i.e. before 3rd April)). Thirteen (25%) (group B) arrived after this period, but stayed on the farm for greater than 75% of the remaining staging period. The remaining 8 individuals (15%) (group C) were first sighted after the first *c*. 20% of the season (10 days) and stayed for less than 10 days. Regardless of their arrival date, 35 individuals (66%) stayed for greater than 75% of the remaining staging period.

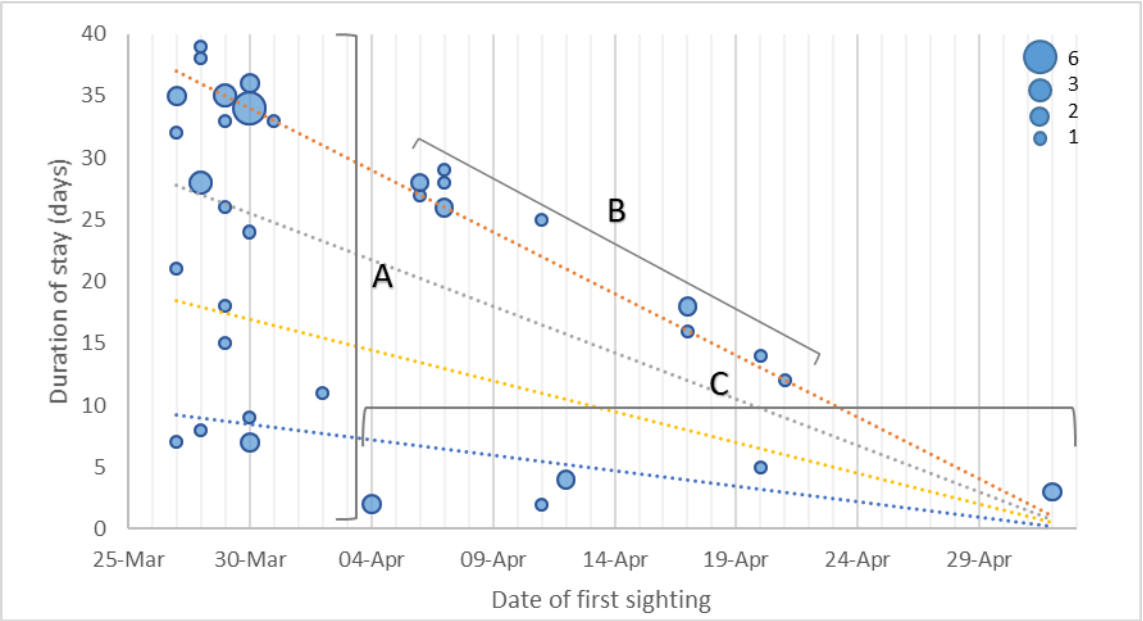

Figure 3-10. Date of first sighting and duration of stay of 53 individually marked Greenland White-fronted Geese staging at Hvanneyri during spring (24th March to 10th May) in 2017. The size of the marker refers to the number of individuals (1, 2, 3 or 6) with identical staging strategies, i.e. arriving/first sighted on the same day, and staging for the same number of days. Dotted lines represent the proportion (from top: 100%, 75%, 50% or 25%) of the core staging period (27th March to 3rd May) remaining at each date. Some markers are higher than the 100% line as the core staging period (when greater than 50% of the total staging flock are present, see Section 3.1) is shorter than the complete staging period (the period between the first arrival and final departure). **A**: individuals that arrived within the first 20% of the staging period, i.e. on or before 3rd April. **B**: individuals arriving later than those in group A and staying for most (>75%) of the remaining staging period. **C**: individuals arriving after the those in group A, and staying for short (<10 days) periods.

Autumn

The mean duration of stay of the 81 marked individuals (that were captured and ringed prior to autumn 2017) was 21.2 days (SE=1.5, range 1 - 42 days). Of these birds, many (20%) were recorded only once on the farm, but the majority (77%) were re-sighted on the farm over 10 days or more. There were 23 collared birds (28%) resighted on the farm over 30 days or more (Fig. 3-11).

The mean duration of stay for the 66 birds ringed in Hvanneyri between 21st and 25th September 2017 was 22.6 days (SE=1.0, range 1 – 32), but this must be considered a minimum as it is very unlikely that birds were captured for ringing immediately on arrival at Hvanneyri.

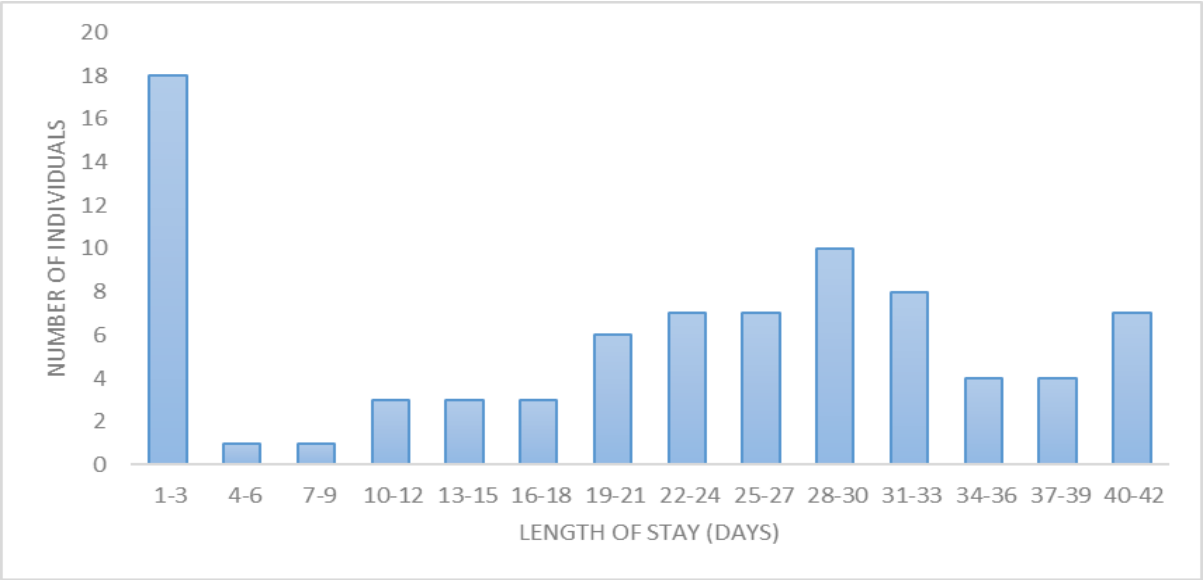

Figure 3-11. Frequency distribution of length of stay of individually marked Greenland White-fronted Geese staging at Hvanneyri during autumn (6th September to 3rd November) in 2017 (n=81). 66 birds ringed during the staging period (between 21st and 25th September) are not included.

For the 66 individuals that were ringed prior to September 2017 and re-sighted more than once, and could therefore be assigned an arrival date, over half of the first sightings occurred in the early part of the season, by 22nd September. The majority of the subsequent arrivals occurred during three arrival phases between 23rd and 30th September. Less than 5% of first sightings occurred after the 8th October. There were two distinct departure episodes; between 10th and 13th, and 23rd and 26th October, which accounted for 24% and 40% of the total departures, respectively (Fig. 3-12).

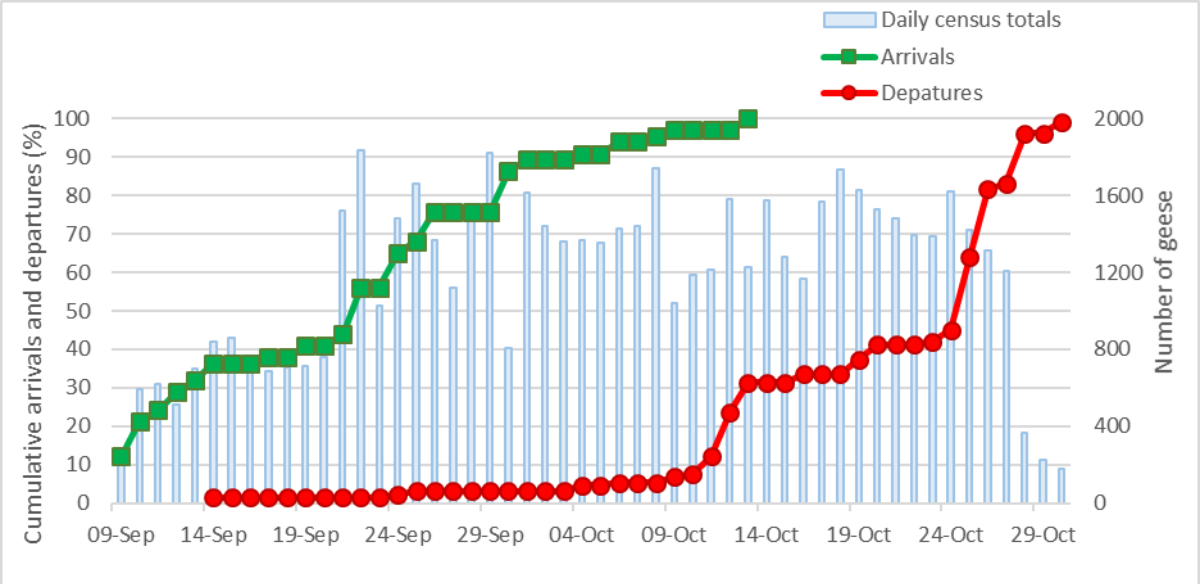

Figure 3-12. Patterns of arrival (squares, green line) and departure (circles, red line) of individually marked Greenland White-fronted Geese staging at Hvanneyri during autumn (9th September to 31st October) in 2017. Data are expressed as the cumulative percentage of all individually marked birds that were resighted. Sample sizes were 65 for arrivals, but 131 for departures as this curve includes the 66 geese captured and released at Hvanneyri in September 2017. Individuals resighted only once were excluded.

With regard to both duration of stay and arrival date, it is apparent that birds use Hvanneyri in different ways during the autumn. For birds resighted on more than one occasion (n=65), Figure 3-13 shows the duration of their stay against the date of first sighting. Twenty-seven individuals (42%) were first resighted early in the season (in the first *c*. 20% of the season (first 13 days, i.e. on or before 19th September)). Twenty-six individuals (40%) arrived after this period, but stayed on the farm for greater than 75% of the remaining staging period. There were two individuals (3%) that were first sighted after the first *c*. 20% of the season (13 days) and stayed for less than 10 days. The remaining 10 individuals (15%) were first sighted after the first *c*. 20% of the staging season and stayed for less than 75% of the available staging period. Regardless of their arrival date, 40 individuals (62%) stayed for greater than 75% of the remaining staging period.

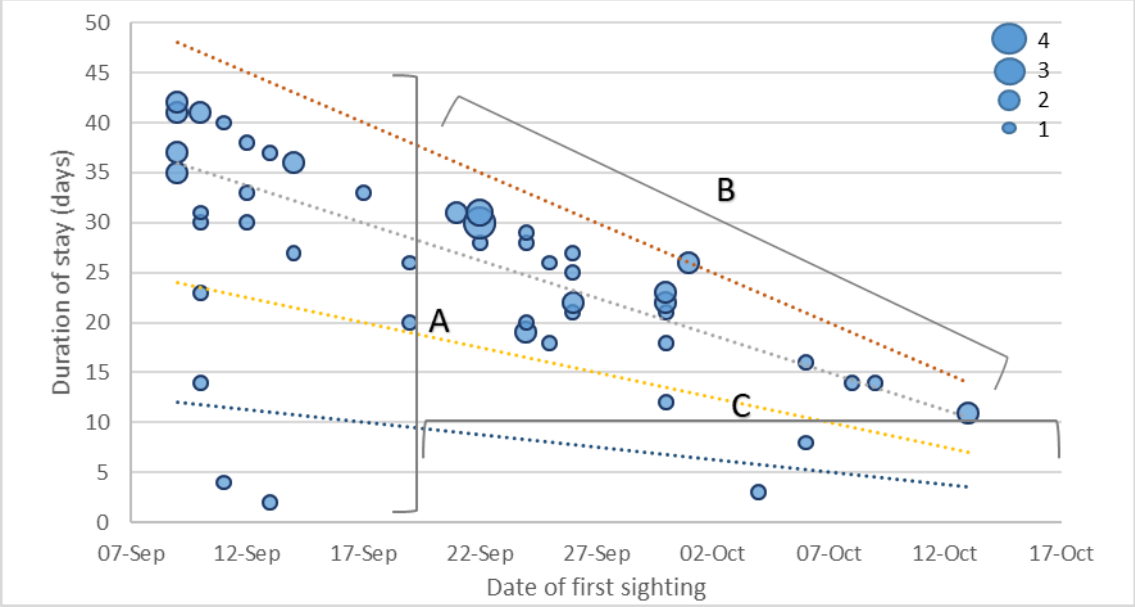

Figure 3-13. Date of first sighting and duration of stay of 65 individually marked Greenland White-fronted Geese staging at Hvanneyri during autumn (6th September to 8th November) in 2017. The size of the marker refers to the number of individuals (1, 2, 3 or 4) with identical staging strategies, i.e. arriving/first sighted on the same day, and staging for the same number of days. Dotted lines represent the proportion (from top: 100%, 75%, 50% or 25%) of the core staging period (15th September to 27th October) remaining at each date. **A**: individuals that arrived within the first 20% of the staging period, i.e. on or before 19th September. **B**: individuals arriving later than those in group A and staying for most (>75%) of the remaining staging period. **C**: individuals arriving after the those in group A, and staying for short (<10 days) periods.

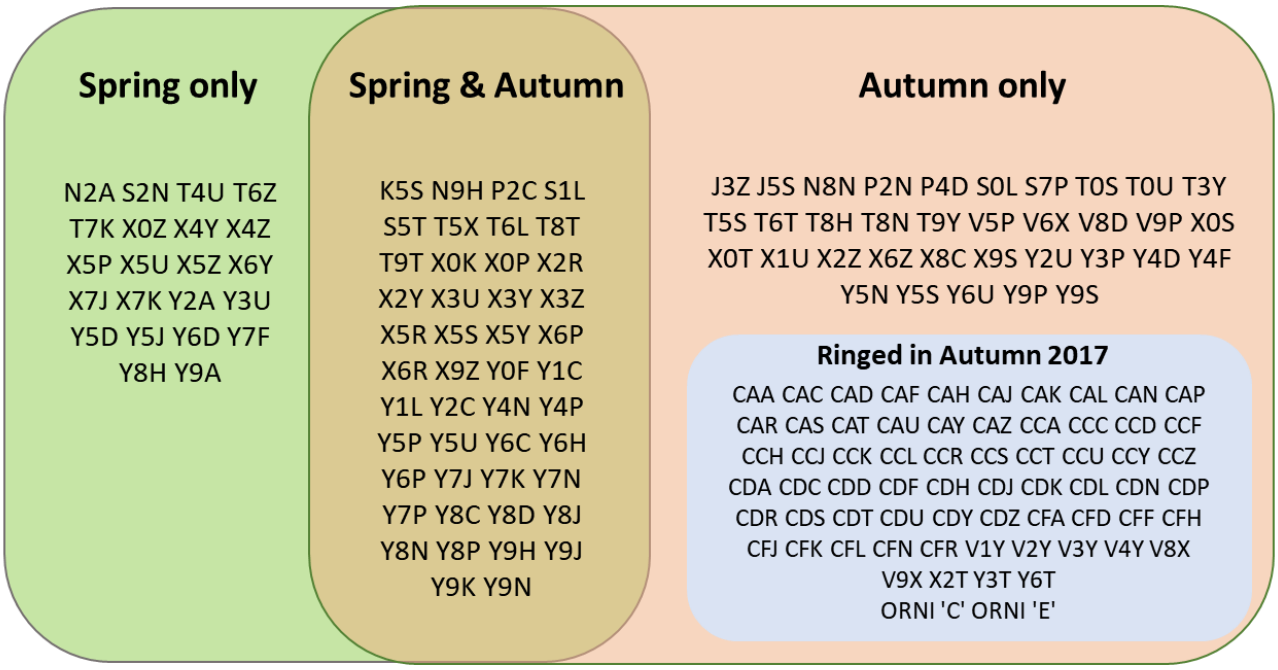

Figure 3-14. Individually marked Greenland White-fronted Geese resighted in Hvanneyri during spring and autumn in 2017, showing the birds that were resighted in spring only, autumn only, in both spring and autumn, and those newly ringed during the autumn staging period. Orni 'C' and Orni 'E' refer to birds tagged with *Ornithela* GPS collars. 'C' or 'E' was printed in black on each collar reading left to right on one side.

A total of 169 individually marked geese were resighted on Hvanneyri farm during both staging periods in 2017 (Fig. 3-14). There were 22 individuals that were resighted during spring staging only, 35 that were resighted during autumn staging only, and the 46 birds that were resighted during spring and autumn staging. The remaining 66 birds were those that were newly ringed in Hvanneyri during September. For the geese that were resighted during both staging periods, the length of their stay in Hvanneyri in spring and autumn is shown in Figure 3-15. The majority of these geese (65%) staged for longer in autumn than in spring.

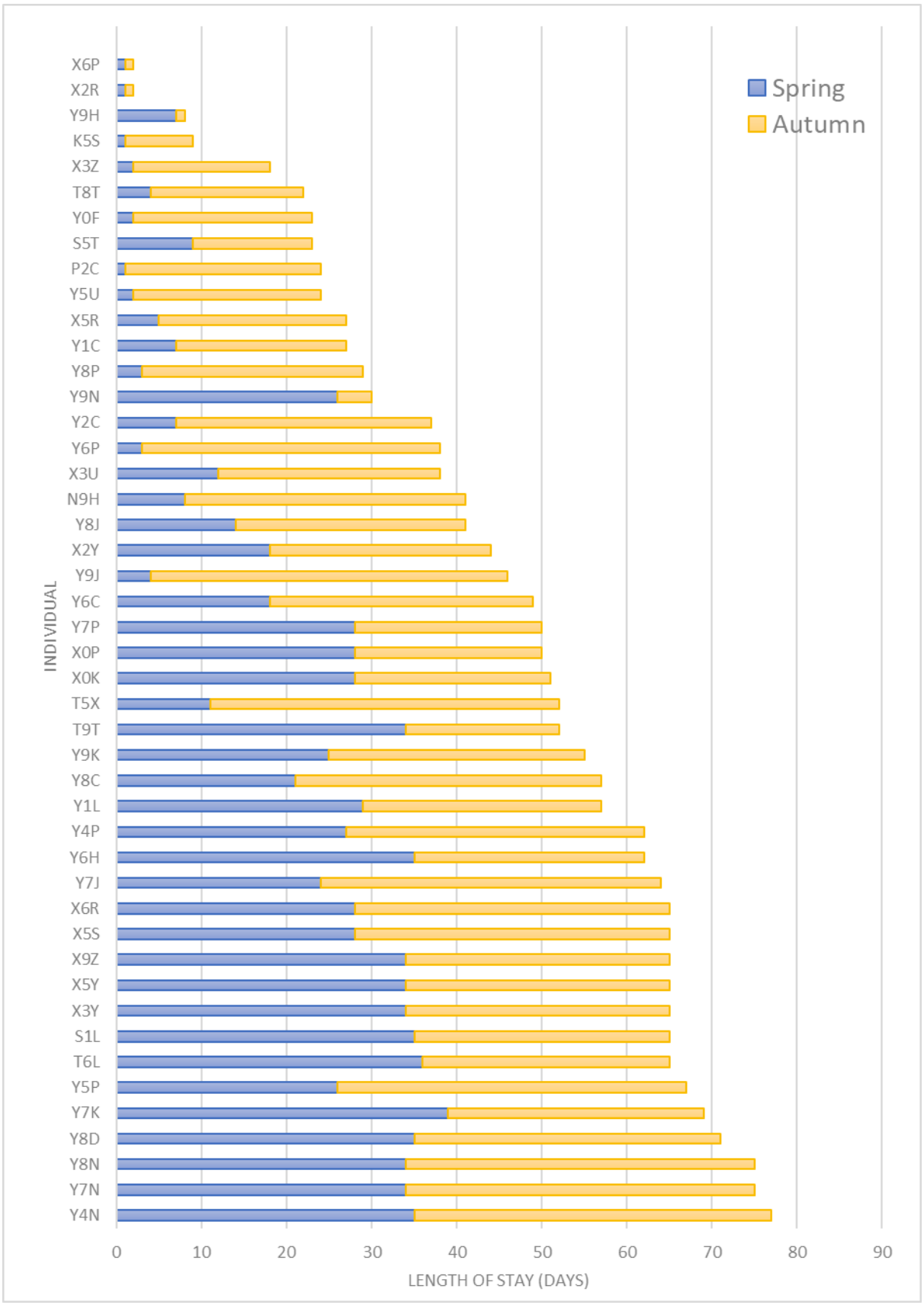

Figure 3-15. Length of stay for all individuals recorded in Hvanneyri during both spring and autumn staging periods in 2017. Individuals are identified by the three-character collar inscription.

The repeated resightings of individual birds and their associates allowed the collation of information on pairs, family groups and larger social groups throughout both staging periods (Table 3.1). While many of these relationships are already known (by GWGS) from resightings by observers throughout the flyway, family groups were gleaned from multiple resightings of the newly ringed birds, and the persistence (or otherwise) of other pairs or family groups was documented.

Table 3.1. Close associations of marked geese attained through multiple resightings of individuals and their associates throughout spring and autumn staging in Hvanneyri and surrounding areas in 2017.

Pairs	Y6T, CAL	Y8D, Y5D
	T9Y, T3Y	Y6H, Y8H
	Y9A, UNR	CFA, ORNI 'C' [1]
	Y6U, X2Z	X6Y, 1 unringed
	X3Z, Y5U	Y3P, X6Z
	X4Z, Y7P	
Groups of three	X0Z, Y8P, Y6P	CDC, V9X, CDD
	X5Y, X3Y, X9Z	CDU, CDY, 1 unringed
	Y9K, Y7K, Y1L	
Groups of four	CAD, CCR, CCS, V4Y	X0T, Y9P, X9S, X0S
	CAF, CAT, CAJ, Y3T	Y7N, Y4N, Y8N, Y9N
	CAY, CDT, CDP, CDS	Y4P, Y5P, Y6P, Y8P
	CCD, V2Y, CCF, CCJ	CCR, CCS, V4Y (CAD) [2]
	X0P, X5R, X6R, X5S	CDH, CDK, CDJ, ORNI '?' [3]
	CAH, 3 unringed	
Larger groups	Y2C, Y1C, x5 juveniles	
	CAK, CCT, CAN, CAU, CAS	
	V3Y, CDZ, 5 unringed adults, 1 unringed juvenile	
	X3U, X4Y, X5Z, X5U, X2Y, 2 unringed	
	CAA, CCU, X2T, CAP, CCZ, CAC, CCY	
	CCL, CCC, CCK, CCA, CCH, V8X, V1Y	
	CAR, CDR, CDN, CDL, CAZ, CDF, ORNI x2	
	CFD, CFF, ORNI 'E' [1], CFR, CFJ, CFH, CFK, CFL, CFN	

[1] ORNI 'C' and ORNI 'E' refer to birds tagged with *Ornithela* GPS collars. 'C' or 'E' was printed in black on each collar reading left to right on one side.

[2] CAD is included in parenthesis as it was closely associated with CCR, CCS and V4Y on many occasions, but recorded away from this group many times too.

[3] ORNI '?' refer to *Ornithela* GPS collars that do not have a unique identifying letter printed on them (and therefore their identity can only be inferred from their close associates).

3.4 Age sampling

The average proportion of juveniles in flocks sampled on 21 occasions was 4.4% (SE = 0.40) (Table 3.2). Sample sizes ranged from 134 to 757 individuals (average = 351) and those that accounted for less than 10% of the total number of geese (calculated from the 3-day mean) in the survey area on that day were excluded. No seasonal effects on the proportion of juveniles in the flocks was apparent (Fig. 3-16).

Table 3.2. Proportion of juvenile Greenland White-fronted Geese in flocks on Hvanneyri farm during autumn in 2017.

Date	Location / Field code [1]	Sample size	% of total [2]	% juveniles
12-Sep	55	183	30	5.2
13-Sep	Lake Vatnshamravatn	134	20	3.9
14-Sep	Lake Vatnshamravatn	379	47	5.6
14-Sep	Lake Vatnshamravatn	152	19	3.4
14-Sep	301, 302, 303	142	18	7.6
15-Sep	38	277	35	3.4
22-Sep	32	250	17	3.3
24-Sep	Lake Vatnshamravatn	194	14	3.7
30-Sep	Lake Vatnshamravatn	651	46	3.7
01-Oct	Lake Vatnshamravatn	305	24	1.0
02-Oct	302, 303	757	51	6.2
04-Oct	Lake Vatnshamravatn	744	55	4.3
04-Oct	Lake Vatnshamravatn	395	29	7.6
04-Oct	100	132	10	3.9
05-Oct	Lake Vatnshamravatn	357	26	5.3
06-Oct	63	432	31	4.6
06-Oct	Lake Vatnshamravatn	291	21	0.7
06-Oct	Lake Vatnshamravatn	145	10	5.8
08-Oct	Lake Vatnshamravatn	644	46	2.1
15-Oct	Lake Vatnshamravatn	238	18	4.4
25-Oct	56	571	39	5.9
Average				**4.4**

[1] Hvanneyri farm field code.

[2] Percentage of the total number of birds in the survey area on that day (from the daily census).

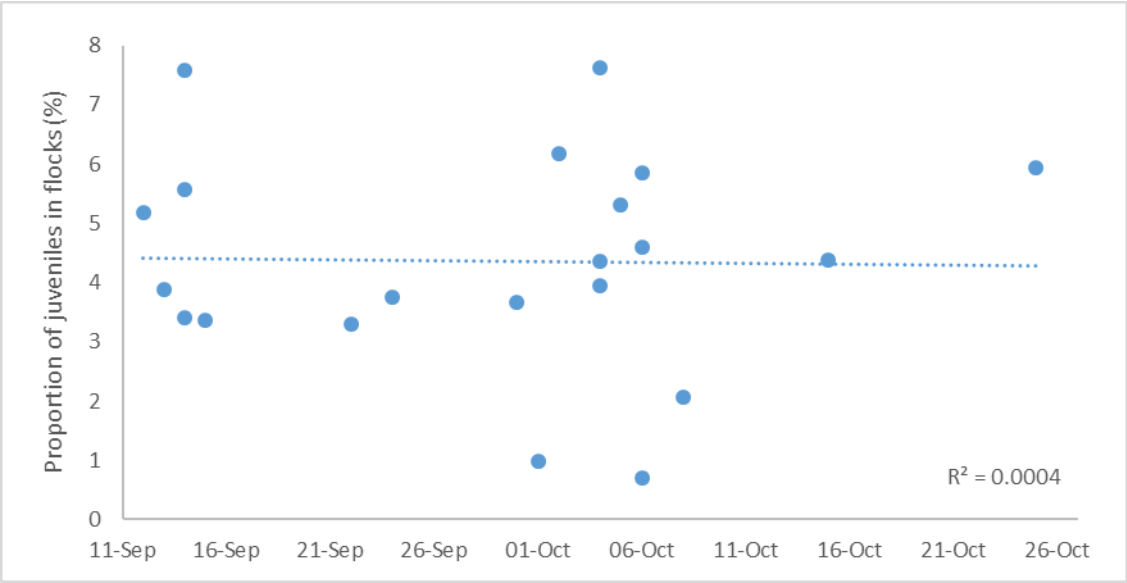

Figure 3-16. Relationship between the proportion of juvenile Greenland White-fronted Geese in flocks on Hvanneyri farm and date during autumn 2017. Only samples that accounted for >10% of the daily total number of geese (from the daily census) are included (n=21).

Greenland White-fronted Geese in hay meadow in Hvanneyri. *Rachel Stroud.*

3.5 Activities and disturbance

The presence or absence of disturbance, activities and birds of prey was recorded during the 110 daily censuses conducted in the spring and autumn. There were no activities or disturbance recorded on most of the surveys (60%). Activities were recorded on 44 surveys (40%), and on 19 surveys (17%) the activity prompted the geese to fly away.

Farming activity was the most frequently observed activity in (or in the vicinity of) the survey area, followed by light aircraft, humans (on foot or on a bike) and birds of prey (Fig. 3-17).

The only bird of prey recorded during goose censuses was White-tailed Eagle *Haliaeetus albicilla.* In less than half of cases, the presence of farm vehicles, aircraft or humans caused the birds to relocate, but all of the times that one or more White-tailed Eagles were observed, all of the birds on the farm temporarily relocated to Lake Vatnshamravatn. There were two occasions during the autumn staging period when all of the birds flushed to Lake Vatnshamravatn, but the stimulus was not detected.

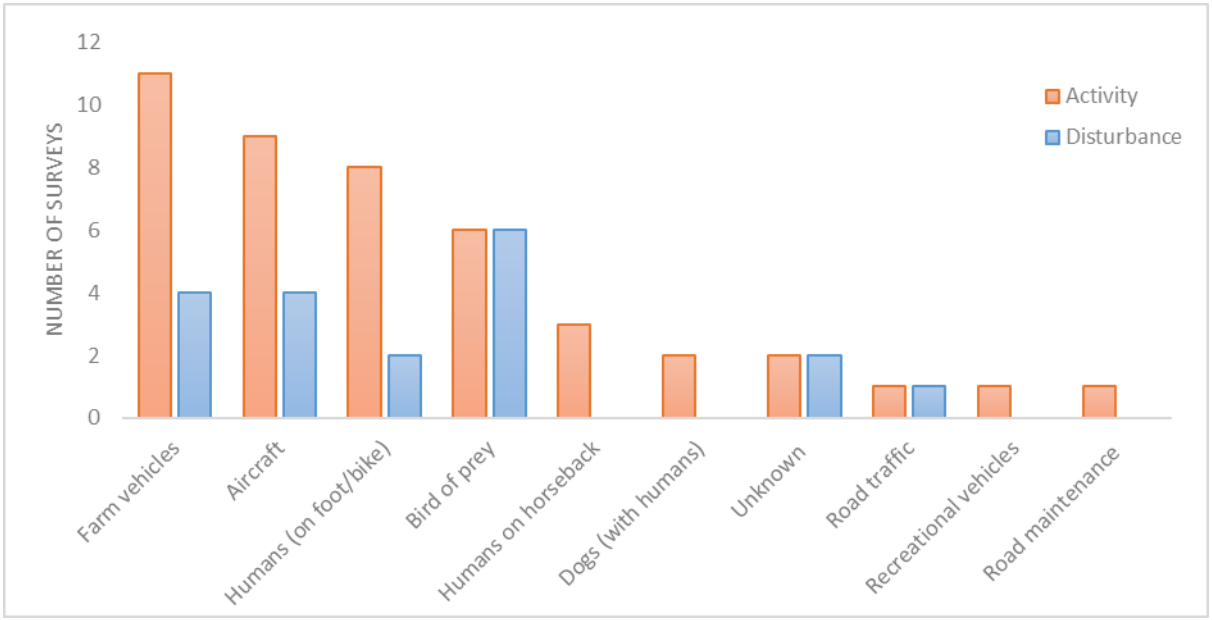

Figure 3-17. Frequency of activities occuring during daily goose censuses during spring and autumn 2017, including the number of times that disturbance (i.e. when the activities caused the birds to relocate within the farm or leave the site) was caused.

4. Discussion

For the first time, daily censuses and regular resighting of individually identifiable birds were undertaken on Greenland White-fronted Geese during the entirety of both spring and autumn staging periods in the same year.

Spring arrivals

The first record of Greenland White-fronted Geese in the spring was particularly early, a family of five recorded on 12th March. There was an unconfirmed report of a group of Greenland White-fronted Geese in the area throughout the winter and, while this has not been recorded before to our knowledge, the possibility that these birds were not early arrivals, but over-winterers, cannot be ruled out.

Aside from these birds, the next observations of geese were a family of five on 24th March, and then 43 birds on 25th March. The spring staging period for Greenland White-fronted Geese has been reported to be from *c*. 10th April to *c*. 13th May (Fox *et al*., 2002). However, this population has shown remarkable plasticity in the timing of departure from their wintering areas in Britain and Ireland, and consequently their arrival in staging areas in Iceland. In 1973, the average departure date from Wexford, south-east Ireland, where the birds that stage in Hvanneyri originate (Fox *et al*. 2002), was 24th April (Fox & Walsh, 2012). By 2007, the departure date was the earliest on record at the time, with half of the wintering numbers in Wexford having departed by 3rd April (Fox & Walsh, 2012). These birds arrived in Hvanneyri during 5th - 7th April, *c*. 10 days earlier than during 1997 - 1999 (Fox *et al*., 2012). In fact, between 1969 and 2012, the geese advanced the mean departure date from Ireland by 15 days (and by 12 days for Scottish wintering birds), and between 1997 and 2012, arrival dates in Hvanneyri advanced from 17th April to 26th March (Fox & Walsh, 2012; Fox *et al*., 2014).

Spring arrival, calculated as the date when half of the spring numbers had arrived in Hvanneyri, was 27th March, one of the earliest years on record. The arrival coincided with a period of snowmelt, and the birds foraged almost exclusively on the intensively managed hay meadows. Fox *et al.* (2012) argue that it is this novel food source, which offers fresh grass growth despite sub-zero temperatures, that allows the advancement in the timing of spring staging, as their traditional food source, below-ground plant storage organs, are still inaccessible in frozen soil.

Daylength is equal in Hvanneyri and Wexford on 19th March (after which daylength is longer in Hvanneyri), so birds arriving from Wexford to Hvanneyri in the last week of March are optimising their foraging potential by switching from feeding on improved grassland in Wexford to Hvanneyri as daylength becomes longer in Hvanneyri.

Overall numbers in spring

The number of birds recorded, and indeed the general pattern of arrival, in the spring are broadly consistent with previous observations in Hvanneyri. During 1997, 1998 and 1999, Fox *et al*. (1999) also observed a rapid build-up in numbers, followed by a trough in numbers, an early season peak, a sustained increase and then a rapid and synchronous departure. The reduction in numbers on the farm during the first few days in April coincided with a period of snow cover, and the birds that were in the area are likely to have been forced to forage elsewhere, before returning to the farm when the snow melted.

Spring departures

Half of the spring staging numbers had left by 4th May, which is consistent with Fox *et al*. (2014) who showed little variation in departure date during the springs of 1997, 1998, 1999, 2007, 2012 and 2013. The last departure varied by six days in those years, from 3rd to 9th May, in those years, and was 10th May in 2017.

Length of stay for individually identifiable birds in spring

Of course, the advancement in timing of spring staging (Fox & Walsh, 2012; Fox *et al*., 2014) reflects the behaviour of individual birds. The repeated resightings of individually identifiable birds in 2017 show that birds use a range of staging strategies at the site. Due to the intensity of re-sighting of marked birds, it is assumed that taking the first sighting of a bird to represent its arrival and the last sighting as its departure is reasonably accurate, and therefore serves as a proxy for the duration of stay.

The first collared birds arrived with the initial influx on 27th March, and 90% of collared individuals had arrived by 17th April. The first of the collared birds had departed by 2nd April.

Almost one third of the individually identifiable birds were seen for three days or less. These short-staying birds were recorded at various times in the staging season, showing that there is turnover throughout the season. However, it is not known whether this immigration and emigration reflects local passage, longer distance movements or both.

The importance of Hvanneyri farm during spring staging is demonstrated, as most of the marked birds staged in Hvanneyri for the majority of the staging period, rather than completing the staging period in several areas. Almost half of the birds stayed for 25 days or more and there were two individuals that were present for 39 days. It is not known whether those that arrived after the initial arrival period, departed from their wintering grounds later, or were staging elsewhere in Iceland before arriving in Hvanneyri, but once at Hvanneyri, the majority of these birds stayed for the majority of what remained of the staging season.

Autumn arrivals and departures

Historically autumn staging of Greenland White-fronted Geese in Iceland occurs between *c*. 30th August and *c*. 31st October (Fox *et al*., 1999). While this is mostly based on past recoveries of shot birds, as opposed to resightings, it is therefore less precise than the information gathered during spring. Nonetheless, it is broadly consistent with the timing of staging in 2017 - the first birds of the autumn arrived on 6th September and half of the wintering numbers had arrived by 14th September.

A low-pressure system over south-eastern Greenland between 16th and 18th September apparently delayed the arrival of others. While there was considerable human activity on and around the farm (regular farm activity and maintenance of adjacent roads) at this time, these activities were confined to single fields or groups of fields each day, and there were always undisturbed areas on the farm. Thus, the lag between the initial arrival of geese and subsequent arrivals on the farm is thought to be a result of weather conditions, rather than disturbance on the farm. A second influx occurred between 19th and 20th September. This increase was sustained throughout the staging period until a rapid and synchronous departure occurred between 27th and 28th October, and the last observation of a flock of

birds was on 1st November. A single Greenland White-fronted Goose was observed on 8th November, during a week of unseasonably cold temperatures (*c*. -10 °C) and the first snow cover of the winter. The point of final departure was later in 2016, when 76 geese remained until 16th November (Ragnhildur Helga Jónsdóttir, pers. comm.).

Overall numbers in autumn

The average number of geese in autumn was twice as many as in spring, which is consistent with previous years (Fox *et al*., 1999, A.D Fox. pers. comm.). Until the Icelandic hunting ban in September 2006, Greenland White-fronted Geese were legal quarry in Iceland during the autumn (Stroud *et al*., 2006). However, there was a voluntary hunting ban in Hvanneyri for several decades prior to this. While Greenland White-fronted Geese are no longer legal quarry, it is likely that they are subjected to some level of disturbance in autumn, during the open season for other species with which they co-occur at other sites. Therefore, the higher number of White-fronted Geese that stage in Hvanneyri each autumn (compared to spring) may be a consequence of Hvanneyri's long-term hunting-free status, as geese that use spring staging areas that are hunted in autumn may take refuge in Hvanneyri in autumn. Similarly, as these geese are relatively long-lived birds, with long-lasting parent-offspring relationships (up to up to eight years (Warren *et al*. 1993)), and the use of staging areas is reinforced through these relationships (Fox et al., 2002), there may exist a cultural memory of autumn hunting in particular places and its absence in Hvanneyri.

Given the global population was 20,556 individuals in March 2017 (Fox *et al*., 2017), 9% (1,835 geese) of the population was present on the site on a single day, 22nd September. However, our repeated resightings of individually identifiable birds show considerable turnover of birds throughout the staging season, which means that the proportion of the population that pass through the site in autumn is likely to be much higher.

Length of stay for individually identifiable birds in autumn

A fifth of the collared birds were seen for three days or less, and one third of the birds stayed for less than one third of the 41-day staging period. However, other birds were much less transient and over half of the collared birds stayed for longer than half of the staging period, with seven birds present for longer than 40 days.

The first collared birds were among the early arrivals, arriving on 9th September, and 90% of collared individuals had arrived by 4th October. Unlike in spring, there were very few departures in the first half of the staging period, and more than 90% of departures happened after 10th October. This is consistent with usual arrival dates in the principal wintering site for these birds in Wexford, Ireland (Fox *et al*. 2016, 2017).

It is clear that there are different individual strategies regarding choice of spring and autumn staging areas. Some birds staged at Hvanneyri during both spring and autumn in 2017, but others were only present in either spring, or in autumn. An explanation for the individuals staging in Hvanneyri only during autumn may be that these individuals spend their spring staging period in an area that is, or has previously been, subjected to hunting pressure during autumn (on Greenland White-fronted Geese prior to the 2006 ban, or other quarry species currently) as discussed above. But understanding these patterns is not straightforward, staging site choice and fidelity is likely to be influenced by several factors including the availability of patchily distributed food resources, intra-specific competition, the

availability of safe roost sites, and perceived predation threat. Further analysis of these patterns over multiple years would be required to determine levels of site-fidelity and migratory strategies between individuals.

Of the individually marked birds resighted on Hvanneyri farm during 2017 (that had not been ringed in 2017), 97 of the 103 individuals were ringed in Wexford (Ireland) or in Hvanneyri before 2017, which is consistent with the pattern that Wexford-wintering birds usually stage at Hvanneyri (Fox *et al.,* 2002). Of the remaining six birds, five were ringed in Scotland (three on Islay and two in Loch Ken, Dumfries and Galloway) and one was ringed in Ireland (Lough Swilly, Donegal).

Abdominal profile indices during spring

The increase in API score throughout the spring is broadly consistent with previous research in Hvanneyri (Fox *et al*., 2014) in that there is a linear increase as the season progresses, however there is considerable daily variation in the actual scores. Fox *et al*. (2014) reported final daily average scores between 2.7 and 3.1 prior to departure in 1997-99, 2007, 2012 and 2013, but in our study a daily average score of 2.3 was obtained in mid-April and the population score at departure was 2.4. There is no evidence that these lower scores reflect a constrained food supply, or increased disturbance. It is more likely that the differences arose due to inter-observer differences (between this and previous studies) in scoring the abdominal profiles.

Regardless of the actual scores, the average daily API score declined before the final departure date, which is presumably a consequence of the birds with highest API scores departing before those with lower scores. Specifically, the decrease in average daily API scores between 19th and 26th April coincided with a departure of *c*. 10% of the individually marked birds, between 22nd and 24th April.

As a result of these potential differences in scoring technique, it is not possibly to directly compare fat accumulation rates collected in this study with previous years. For the 18 individuals that were present in Hvanneyri for longer than 30 days, it is implausible that they would need to sustain a daily accumulation of 25 - 30 g body weight for this period, as calculated by Fox *et al*. (2003). Rather, as shown by Fox *et al*. (2014), the staging period is now longer than the birds require to replenish energy stores and they now accumulate fat at a slower rate than when the staging period was considerable shorter.

Proportion of juveniles in flocks in autumn

The proportion of juveniles in flocks of Greenland White-fronted Geese at Hvanneyri in the autumn was estimated to be 4.4%, which is lower than that observed in the wintering flocks in Ireland in recent years. An assessment of the proportion of juveniles in flocks across the wintering range in Ireland and Scotland is coordinated by the Greenland White-fronted Goose Study and the National Parks and Wildlife Service (in Ireland) annually. The percentage of young amongst aged flocks in Ireland (where most of the Hvanneyri geese winter) was 12.5% in the 2016/17 winter (Fox *et al*., 2017), and between 6% and 7% in the preceding three winters (Fox *et al*., 2016).

The reduced production of young in this population has contributed to the overall population decline (Stroud *et al*., 2012), and the population fell below 20,000 birds for the first time since 1989 in 2015 (Fox *et al*. 2015). This triggered action under the AEWA International Single Species Action Plan for the Conservation of the Greenland White-fronted Goose due to the continued declines of the global

population and as annual productivity had fallen below the 7% alert limit for three consecutive breeding seasons at Wexford. While the global population had increased to 20,556 in spring 2017, the low productivity recorded in this study is cause for concern.

Proportions of young differ widely between wintering flocks (Fox *et al*. 2015, 2016, 2017), so despite the importance of Hvanneyri for the population as an autumn staging area, it may be the case that these geese are not representative of the population as a whole. Indeed, a flock of 165 birds foraging in barley stubble at a farm *c*. 4 km from Hvanneyri, contained 21.8% juveniles on 13th October. In any case, the annual assessment of the success or otherwise of the 2017 breeding season will be coordinated by the Greenland White-fronted Goose Study and the National Parks and Wildlife Service throughout the wintering grounds during the 2017/18 winter.

Importance of Hvanneyri

Hvanneyri is an ideal location to study these geese as the topography and their behaviour at this site facilitates observation. There is also unique potential in Hvanneyri, given the role that the Agricultural University of Iceland plays in training the next generation of Icelandic farmers, to engage and enthuse people about this declining population. And given the length of time that the geese stage in Hvanneyri during spring and autumn, and the high proportion of the world population that use the site at these times, it is an extremely important study site. While the principal driver of the declines is poor reproductive performance on the breeding grounds in Greenland, and it is unlikely that reproductive success can be enhanced in the short-term (Stroud *et al*., 2012), it is vital that we remain vigilant for pressures or threats that may affect the geese during their staging periods in Hvanneyri and the surrounding areas.

A subset of the actions within the Single Species Action Plan for the Conservation of the Greenland White-fronted Goose (Stroud *et al*., 2012) are especially relevant to Hvanneyri and the surrounding areas, and offer opportunities for staff, students, residents and land-managers at Hvanneyri and at the Agricultural University of Iceland to contribute to the continued protection of these geese.

The actions include: Limiting and trying to avoid disturbance in the prelude to migration at spring staging areas so as to optimise the condition of potentially breeding geese; Identifying and protecting critical sites used in the staging and pre-breeding period; Managing sites used in the pre-breeding period to optimise the quality and quantity of food for potentially breeding geese; Undertaking extensive surveys of staging areas to identify further sites of nature conservation importance and secure their adequate protection. And regarding designated sites of importance, these actions include: Informing central and local government of the importance and location of protected sites; Enhancing knowledge of sites and requirements among user-groups (e.g. hunters, farmers); and Using sites wisely sensu the Ramsar Convention, through the preparation and implementation of management plans.

The levels of disturbance recorded during 2017 are not likely to have had a considerably effect on the birds' ability to locate disturbance-free foraging or roosting areas. However, disturbance was just recorded during the daily censuses, and a longer-term appraisal of disturbance events was not carried out. Increases in the frequency of these disturbance types could result in energetic costs to foraging or roosting geese. Due to the importance of the area, disturbance should be minimised and changes in land use, such as changes in crop types in the fields or afforestation, should be protected against.

While this comprehensive assessment of both of the 2017 staging periods, is a very useful dataset, it is important that these kinds of data collection are continued in subsequent years. It is recommended that a series of counts should be carried out in during both the spring and autumn staging periods in future years so that the trends in arrival and departure dates can continue to be investigated. These data are especially valuable given the plasticity that this population is showing in the timing of departure from their wintering areas and subsequent arrival in Iceland in spring (Fox & Walsh, 2012; Fox *et al*., 2014).

This plasticity in migratory timing is the result of individual decision-making, and while there have been significant advances in the use of GPS telemetry (to track individual geese) in recent years, regular monitoring and reading of 'regular' collars is still necessary, as there will always be more birds fitted with these collars than GPS-collars, and a great deal can be learned from repeated observations of individuals at a particular site over time. Also, continuing to take age-samples from flocks during the autumn will provide invaluable information on the level of breeding success attained by the flocks staging at Hvanneyri.

In order to facilitate this continued monitoring of Greenland White-fronted Geese at Hvanneyri, Tierney and Stroud (2018) have produced a *Survey Handbook*, which includes detailed instructions on how to collect census and other data types in a way that will be comparable to those collected in 2017.

5. References

Boertmann, D. 2007. Rødliste 2007 over planter og dyr i Grønland. [2007 Red List of plants and animals in Greenland]. Direktoratet for Miljø og Natur, Grønlands Hjemmestyre.

Colhoun, K. & Cummins, S. 2013. Birds of Conservation Concern in Ireland 2014–2019. *Irish Birds* 9, 523-544.

Comiso, J.C. & Parkinson, C.L. 2004. Satellite-observed changes in the Arctic. *Physics Today* 57, 38-44.

Eaton, M.A., Brown, A.F., Noble, D.G., Musgrove, A.J., Hearn, R., Aebischer, N.J., Gibbons, D.W., Evans, A. & Gregory, R.D. 2009. Birds of Conservation Concern 3: the population status of birds in the United Kingdom, Channel Islands and the Isle of Man. *British Birds* 102, 296–341.

Ely, C.R., Fox, A.D., Alisauskas, R.T., Andreev, A., Bromley, R.G., Degtyarev, A.G. *et al*. 2005. Circumpolar variation in morphological characteristics of Greater White-fronted Geese *Anser albifrons*. *Bird Study* 52, 104-119.

EC Birds Directive. Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. Available online at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0147

Fox, A.D. 2003. The Greenland White-fronted Goose *Anser albifrons flavirostris*. The annual cycle of a migratory herbivore on the European continental fringe. Doctor's dissertation (DSc). National Environmental Research Institute, Denmark. 440 pp.

Fox, A.D., Boyd, H., Walsh, A.J., Stroud, D.A., Nyeland, J. & Cromie, R.L. 2012. Earlier spring staging in Iceland amongst Greenland White-fronted Geese *Anser albifrons flavirostris* achieved without cost to refuelling rates. *Hydrobiologia* 697, 103–110.

Fox, A.D., Francis, I.S, Norris, D.W. & Walsh, A.J. 2015. Report of the 2014/2015 International Census of Greenland White-fronted Geese. Greenland White-fronted Goose Study & National Parks and Wildlife Service. 22 pp.

Fox, A.D., Francis, I.S, Norris, D.W. & Walsh, A.J. 2016. Report of the 2015/2016 International Census of Greenland White-fronted Geese. Greenland White-fronted Goose Study & National Parks and Wildlife Service. 18 pp.

Fox, A.D., Francis, I.S, Norris, D.W. & Walsh, A.J. 2017. Report of the 2016/2017 International Census of Greenland White-Fronted Geese. Greenland White-fronted Goose Study & National Parks and Wildlife Service. 18 pp.

Fox, A.D., Glahder C.M., Walsh A.J., 2003. Spring migration routes and timing of Greenland White-fronted Geese: Results from satellite telemetry. *Oikos* 103, 415–425.

Fox, A.D., Hilmarsson, J.O., Einarsson, O., Boyd, H., Kristiansen, J,N., Stroud, D.A., Walsh, A.J., Warren, S.M., Mitchell, C., Francis, I.S. & Nygaard T. 1999. Phenology and distribution of Greenland White-fronted Geese *Anser albifrons flavirostris* staging in Iceland. *Wildfowl* 50, 29–43.

Fox, A.D., Hilmarsson, J.O., Einarsson, O., Walsh, A.J., Boyd, H. & Kristiansen, J.N. 2002. Staging site fidelity of Greenland White-fronted Geese *Anser albifrons flavirostris* in Iceland. *Bird Study* 49:1, 42-49.

Fox, A.D., Norriss, D.W., Stroud, D.A. & Wilson, H.J. 1994. *Greenland White-fronted Geese in Ireland and Britain 1982/83-1993/94 - the first twelve years of international conservation monitoring*. Greenland White-fronted Goose Study Research Report No. 8. GWGS, Aberystwyth & National Parks and Wildlife Service, Dublin. 55 pp.

Fox, A.D. & Stroud, D.A. 2002. The Greenland White-fronted Goose *Anser albifrons flavirostris*. Birds of the Western Palearctic Update 4:2, 359-382.

Fox, A.D., Walsh, A.J., Norriss, D.W., Wilson, H.J., Stroud, D.A. & Francis, I. 2006. Twenty-five years of population monitoring — the rise and fall of the Greenland White-fronted Goose *Anser albifrons flavirostris*. Waterbirds around the world. Eds. G.C. Boere, C.A. Galbraith & D.A. Stroud. The Stationery Office, Edinburgh, UK. pp. 637-639.

Fox, A.D. & Walsh, A.J. 2012. Warming winter effects, fat store accumulation and timing of spring departure of Greenland White-fronted Geese *Anser albifrons flavirostris* from their winter quarters. *Hydrobiologia*, 697, 95–102.

Fox, A.D., Weegman, M.D., Bearhop, S., Hilton, G.M., Griffin, L., Stroud, D.A. *et al*. 2014. Climate change and contrasting plasticity in timing of a two-step migration episode of an Arctic-nesting avian herbivore. *Current Zoology* 60, 233–242.

Francis, I. S., and Fox, A. D. 1987. Spring migration of Greenland White-fronted Geese through Iceland. *Wildfowl* 38, 7-12.

Malecki, R.A., Fox, A.D. & Batt, B.D.J. 2000. An aerial survey of nesting Greenland White-fronted and Canada Geese in west Greenland. *Wildfowl* 51, 49–58.

Owen, M. 1981. Abdominal profile - a condition index for wild geese in the field. *Journal of Wildlife Management*. 45, 227- 230.

Ramsar Convention Secretariat, 2013. The Ramsar Convention Manual: a guide to the Convention on Wetlands (Ramsar, Iran, 1971), 6th ed. Ramsar Convention Secretariat, Gland, Switzerland. 53-54.

Ruttledge, R.F. & Ogilvie, M.A. 1979. The past and current status of the Greenland White-fronted Goose in Ireland and Britain. *Irish Birds* 1, 293-363.

Stroud, D.A., Fox, A.D., Urquhart, C. & Francis, I.S. (compilers). 2012. International Single Species Action Plan for the Conservation of the Greenland White-fronted Goose (*Anser albifrons flavirostris*). AEWA Technical Series No. 45. Bonn, Germany.

Warren, S.M., Fox, A.D., Walsh, A. & O'Sullivan, P. 1992. Age of first pairing and breeding amongst Greenland White-fronted Geese. *Condor* 94, 791-793.

Warren, S.M., Fox, A.D. & Walsh, A.J. 1993. Extended parent-offspring relationships amongst the Greenland White-fronted Goose. *Auk* 110, 145–148.

Weegman M.D., Bearhop S., Hilton G.M., Walsh A. & Fox, A.D. 2016. Conditions during adulthood affect cohort-specific reproductive success in an Arctic-nesting goose population. *PeerJ* 4:e2044.

Wilson, H.J., Norriss, D.W., Walsh, A., Fox, A.D. & Stroud, D.A. 1991. Winter site fidelity in Greenland White-fronted Geese: implications for conservation and management. *Ardea* 79:2, 287-294.

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7. Appendices

Appendix I: Field Recording Form for daily census

Hvanneyri Greenland White-fronted Geese Census

Date: __ / __ / ____
Start: ___:____
End: ___:____
Coverage: Full / Partial

Observers		
Wind	F__	☐ Frost on grass ☐ Partially snow covered ☐ Snow covered
Cloud cover	__ / 8	

Rain	None / Showers / Drizzle / Heavy
Visibility	Good / Moderate / Poor *Reason (if moderate or poor)* _____

Data entry date:
Initials:
File location:

Vantage Point A	
Wet meadows and Estuary	

Vantage Point B	
23	
24	
25	
26	
27	
28	

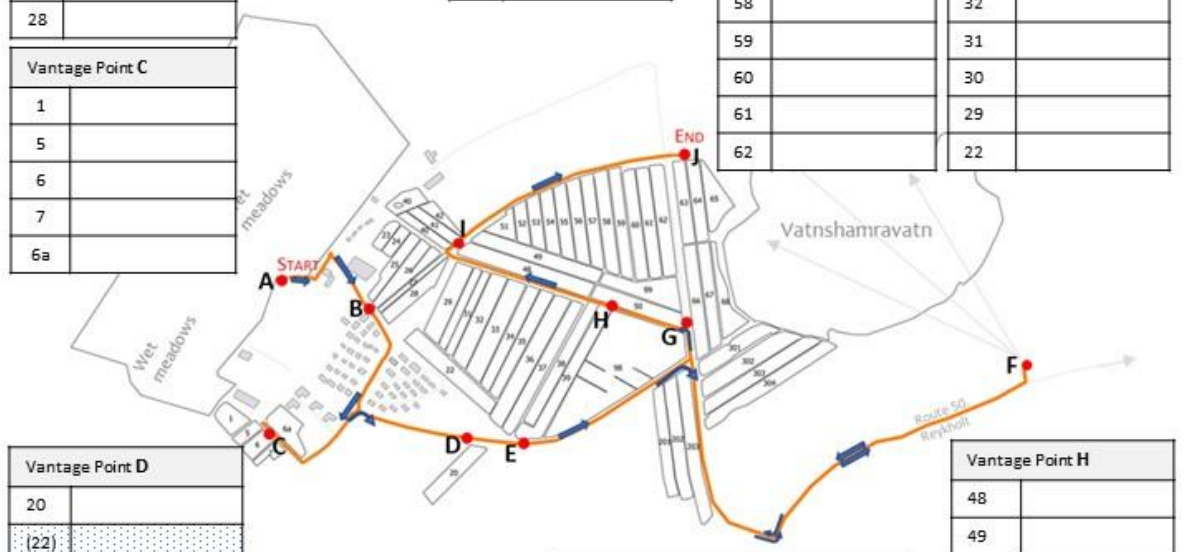
Vantage Point C	
1	
5	
6	
7	
6a	

Vantage Point J	
63	
64	
65	

Vantage Point I	
40	
41	
42	

Vantage Point I -> J	
51	
52	
53	
54	
55	
56	
57	
58	
59	
60	
61	
62	

Vantage Point H -> I	
39	
38	
37	
36	
35	
34	
33	
32	
31	
30	
29	
22	



Vantage Point D	
20	
(22)	
(35)	
(36)	
(37)	

Vantage Point E	
(38)	
(39)	

Count on way to F	
98	
201	
202	
203	

Vantage Point F	
Vatnshamravatn	
301	
302	
303	
304	

Vantage Point H	
48	
49	

Vantage Point G	
66	
67	
68	
50	
99	

Disturbance Type *(please circle)*

0 - No disturbance
1 - Humans (on foot)
2 - Humans (on bicycle)
3 - Dogs
4 - Horse riding
5 - Aircraft
6 - Farm Vehicles
7 - Bird of prey
8 - Other *specify in Notes*

Disturbance Duration *(please circle)*

1 - Discrete (short lived disturbance event)
2 - Ongoing (throughout survey period)

Bird Response *(please circle)*

0 - No apparent response (birds remain in situ)
1 - Moderate (some birds fly away (< 200))
2 - Significant (>200 birds fly away)

Count Confidence *(tick one)*

	My survey went well and I feel that I have accurately counted all of the geese on the farm
	There was some movement of geese (<150 birds) during my survey so I may have double-counted or missed some
	There was so many flocks moving around that I did not get a good estimate of the number of birds on the farm

Notes

TOTAL

Hvanneyri Greenland White-fronted Geese Census Route

Note: Hvanneyri is a working farm and there are likely to be changes in crop type and field use from year to year which may affect your view from these vantage points. Sometimes changes to the route may be required but the general approach should always be to start from the outside of the site and work your way inwards (usually towards the highest number of birds). You are most likely to flush birds when travelling between vantage points G and I and vantage points I and J. It makes sense to have most of the site covered before birds are disturbed and flying around.

Start

Vantage Point A
- Starting at the Church, count to the west and east covering the wet meadows, and what you can see of the estuary/intertidal areas.

Vantage Point B
- Next, drive through the village to count fields 23 - 28.

Vantage Point C
- Count fields 1, 5, 6, 6a and 7 from Hrafnaflöt.

Vantage Point D
- Count field 20 next to the tall trees at the sheltered area
- Count fields 22 and 35 - 37 (you will pass these fields from the other end later).

Vantage Point E
- Count fields 38 and 39 (you will pass these fields from the other end later too).

On your way to Vantage Point F
- Continue out of the village and count field 98.
- Count fields 201 – 203 as you drive to vantage point **F.**
- Make a quick estimate of fields 301 – 304 as you pass but you will confirm these from vantage point **F**.

Vantage Point F
- Park your car on the track that comes before the entrance to Vatnshamrar.
- Count Vatnshamravatn and the adjoining fields at Vatnshamrar farm and also fields 301-304.

Vantage Point G
- From here count fields 66 – 68, 50 and 99

Vantage Point H
- Count (or at least estimate) fields 58 - 62 on your right and then 48 and 49 straight ahead.
- There may also be additional geese in field 100 behind the large rock that could not be seen previously.

On your way to Vantage Point I
- Continue along this track to count fields 39 - 29 and 22. You will have estimated some of these already from Vantage Points **D** and **E** but you might have a better view from here.

Vantage Point I
- When you get to the junction in the track, have a quick look for any major changes in fields 28 – 23.
- Count fields 40 – 42.
- Confirm your counts of 48 and 49. Try to get an estimate of the numbers in fields 51, 52 and 53 from here and then confirm them as you drive past.

On your way to Vantage Point J
- Continue along the track counting fields 51 - 62.

Vantage Point J
- At the end of the track, cross the road and count fields 63, 64, and 65 from point **J**.

End