Svalbard Barnacle Goose distribution around the Solway Firth 2017-2018: Flock counts from the Solway Goose Management Scheme area

WWT Conservation Programmes Report

Author

Larry Griffin

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Wildfowl & Wetlands Trust
Slimbridge
Gloucestershire
GL2 7BT

Tel 01453 891900
Fax 01453 890827
Email conservation@wwt.org.uk

Reg. charity no. 1030884

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Contents

Executive Summary

A total of 14 counts were carried out in winter 2017-2018 within the Solway Barnacle Goose Management Scheme area. In a major change to the methodology of previous winters, the counts presented were taken 50:50 from the coordinated Solway population (JNCC) counts of the Svalbard Barnacle Goose *Branta leucopsis* and the SNH route counts specific to the Scheme area. This change in methodology, agreed with SNH, was made to increase count efficiency and reduce costs and emissions, while maintaining a good understanding of goose field use within the Scheme area. For the SNH route counts, the times of day, the days of the week and the starting points at which the counts were conducted were varied as much as possible to avoid bias in terms of when a section was surveyed. With the coordinated JNCC counts this is not possible as the volunteer count network is only typically available at a certain time and on a certain day and so all survey sections tend to be counted on a Wednesday from 10:00–12:00. For the SNH route counts, flock counts were made for all goose and swan species encountered, with flocks assigned to fields by code. Instances of direct disturbance clearly aimed at the geese and of conversations with farmers were also noted. Again for the JNCC counts, except where they were conducted by WWT, these extra data were not consistently noted across the count sectors, with barnacle goose flock counts being the focus of those surveys. Data collected under the JNCC contract on brood size and productivity estimates for this population are also presented.

The adopted total for the Barnacle Goose population wintering on the Solway Firth was 42,600 geese (the mean of the maximum count of 43,545 and the count within 10% of this figure, rounded up to the nearest 100), an increase of 900 birds on last winter's adopted estimate of 41,700 geese. This continued increase in the population was presumably due to good survival as reproductive success was quite low in 2017. Count conditions were reasonably good in 2017-2018 and the geese made little use of areas outside their usual range and were thus well covered by the counter network. Mean brood size was 1.8 (range 1-4 goslings; 151 families sampled) goslings per family – which is lower than the current ten year mean of 1.9 (S.E. ± 0.1), with an average productivity of 5.0% - which is significantly lower than the current ten year mean of 8.4% (S.E. ± 1.2; range 0.5-15.9% young; 14 flocks and 13,862 birds sampled). This compares to 1.9 goslings per family and 16.0% young for the previous winter.

1 Introduction

The Solway Firth is an internationally important site for a number of wetland bird species being a key site for the wintering Svalbard Barnacle Goose population. By mid-winter, ~99% of this flyway population utilise five main sites around the Solway, with three of those being on the north side of the Firth, including Caerlaverock, Kirkconnell (Nith) and Southwick. This century with the growth of the population to over 40,000 birds, the distribution has spread west towards the Outer Solway with geese now visiting the areas around Colvend, Auchencairn and Rascarrel in most winters, with significant flocks at Wigtown typically from late February to early April.

The Cumbrian saltmarshes west of Rockcliffe Marsh also accommodate a larger number of this increasing goose population for a longer duration. On Rockcliffe Marsh itself, gatherings of up to 30,000 barnacle geese have been recorded in late April/early May immediately prior to the spring departure north. Parts of this flock can utilise nearby fields and saltmarsh in the Gretna, Redkirk and Baurch area on the Scottish side of Solway.

During the winter, on the Scottish side of the Solway, the geese mainly feed within established nature reserves or within the Solway Barnacle Goose Management Scheme area, often choosing stubbles in early autumn and improved pastures and saltmarsh throughout the rest of the winter. SNH has run this management incentive scheme on the Solway since 1995 in order to integrate farming and goose grazing needs on areas of improved agricultural land. On land entered into the Scheme, tiered payments are made to help cover the extra costs of managing the land for Barnacle Geese. Fields are classified as 'Feeding', 'Buffer' (which receive a tiered payment) or 'Scaring' (non-payment) zones depending in large part on the typical level of winter goose use. Controlled scaring is encouraged in the non-payment zone during the winter to try to keep the geese within the feeding or buffer zones. Scaring is also permitted throughout April within the Scheme area, as due to budgetary constraints imposed since 2012 and then again in 2014, fields in the Scheme area no longer receive goose management payments for April.

Since about 2010, there has been an increasing tendency for large numbers of Barnacle Geese to remain at the autumn staging site around Budle Bay/Lindisfarne, Northumberland, until later in the winter; based on ring sightings and the timing of the initial increase in numbers at the site during the traditional migratory period it is now assumed that the majority of these birds are Svalbard in origin.

1.1 Objective

The overall objective of the survey is to assess the distribution and abundance of the Svalbard Barnacle Goose and other goose and swan species on the fields and saltmarsh of the north side of the Solway Firth in relation to the Solway Barnacle Goose Management Scheme area.

2 Methods

2.1 Management Scheme counts

Seven "SNH Route Counts" within the Goose Scheme area were carried out alongside the "JNCC Census Counts" on an approximately 14-day cycle between 1 October 2017 and 23 April 2018 (**Table 1;** the end date was changed from 21 April to 23 April to allow for the JNCC count cycle in future years due to the typical Wednesday count dates). For the SNH route counts, the starting points were varied as much as possible to prevent counting any area at the same time of day, with count days spread evenly throughout the week including weekends. For the JNCC census counts, the use of volunteers meant that count sections were surveyed between 10:00-12:00, typically on Wednesdays.

Table 1 – Summary of the sources of count data provided each month.

Count source	October	November	December	January	February	March	April	Total
JNCC counts	2	1	1	0	1	1	1	7
SNH counts	0	1	1	2	1	1	1	7

During SNH route counts, geese and swans in larger flocks were counted in tens on a tally counter, while those in smaller flocks of <100 were counted individually; all flocks being mapped and coded according to the SNH convention on the field maps provided. Each day was broken down into four counting periods to cover the four main count areas (**Table 2**), starting at first light with allowance made for weather conditions, e.g. geese tend to be slow to move off the roost during periods of frost such as those geese flighting off the Blackshaw Bank roost to utilise fields up the River Nith at Greenmerse and Kirkconnell. The time of observer arrival at each count section was recorded. Where significant numbers of geese moved during a count, the field the geese moved from and to was recorded with a "Comment" added within the Excel spreadsheet provided. Observations of leucistic geese and other goose species of note have also been added.

Table 2 – Count sections covered within the counting periods.

Count Period 1	Count Period 2	Count Period 3	Count Period 4
Caerlaverock	Gretna	Nith	Southwick
Southwick	Nith	Caerlaverock	Gretna
Nith	Caerlaverock	Gretna	Southwick
Gretna	Caerlaverock	Nith	Southwick

As agreed with SNH, in a modification to the methodology used in previous winters, the SNH route count data were supplemented with an equal number of days of JNCC census count data, along with reproductive success estimates, as provisioned under the Goose and Swan Monitoring (GSMP[1]) contract. The SNH count route covered areas to the east as far as Gretna and to the west as far as Mersehead, with JNCC counts extending as far west as Wigtown on the Scottish side of the Solway (**Figure 1**). Use of any fields out with the SNH Goose Management Scheme area was noted during the census counts.

Areas where there are difficulties observing the fields from the road are well known as are the high vantage points which can be utilised to count them from. Otherwise approach on foot was adopted with prior permission being sought for access. During the SNH route counts and the JNCC census count routes covered by WWT staff, the presence and nature of any disturbance to the geese, intentional or otherwise, was noted using the SNH field code system provided. Impromptu discussion with any landowners during the surveys was welcomed and a record of each conversation regarding the geese along with those had during arranged visits or calls to a farmer was logged. Care was taken in relation to biosecurity and disease prevention, and where access to fields was required there was compliance with any precautions required by the landowners, with gates being left as they were found.

[1] The GSMP is organised by the Wildfowl & Wetlands Trust (WWT) and funded in partnership with the Joint Nature Conservation Committee (on behalf of NRW, NE and DAERA Northern Ireland) and Scottish Natural Heritage.

As with last winter it soon became clear that the Priestside/Hurkledale area was being used quite often by the Barnacle Geese whereas the section to the northeast of Ward Law covering the Quay Hill was rarely being used and was therefore not surveyed on a regular basis although it was covered during the census counts. In previous years the Priestside/Hurkledale section has been dropped due to a lack of goose use but this winter it was again surveyed. During the co-ordinated counts of geese on the Solway, geese were rarely recorded in the Auchencairn/Rascarrel area in mid-winter and from February onwards small numbers of Barnacle Geese began using the Wigtown area but this could not be economically covered via the SNH route count budget.

Figure 1. The Inner Solway Firth showing the main areas surveyed during the SNH Solway Goose Management Scheme counts (black polygons – except Boreland of Colvend area which although surveyed in previous winters was replaced in winter 2017-2018 by a small area around Redkirk/Baurch near Gretna). Site names are referred to in the text and also cover those areas surveyed during the coordinated JNCC census counts. For mapping clarity, Wigtown Bay and RSPB Crook of Baldoon are not shown as they are 20km to the west of Borgue.

2.2 Coordinated Svalbard Barnacle Goose total population counts

Each winter WWT has conducted total population counts of the Svalbard Barnacle Geese present on the Solway from arrival to departure. This involves a network of staff and volunteers counting the geese in survey sections within a one- to two-hour time-period at the same time on the same day, typically 10:00-12:00 on Wednesdays. There are weekly counts during the arrival period in October and during the departure period in April/May, with monthly counts from November to March (except January) depending on the weather.

2.3 Brood sizes and juvenile productivity of the Svalbard Barnacle Goose

Each winter WWT carefully assesses the brood sizes and juvenile productivity of a large proportion of the Barnacle Geese from as many sites as possible around the Solway. The dates, land use types, and flock sizes used for sampling are varied as much as possible to avoid any bias in the average estimate obtained. Also the sampling units within the flocks are varied as much as possible if whole flock estimates cannot be made as families with young tend to associate at the edges of a flock, particularly at the front. All observations were carried out by an experienced observer.

2.4 High tide heights, times and dates

Table 3. Dates and times of high tides (≥ 9.5m as summarised from Laver's '*Liverpool and Irish Sea Tide Table 2017 & 2018*') for the months during which geese were present in the Barnacle Goose Management Scheme area.

Month	Period 1: From date/time	Period 1: To date/time	Period 1: tidal height range (m)	Period 2: From date/time	Period 2: To date/time	Period 2: tidal height range (m)
September	22:40 19/09/17	00:31 23/09/17	9.5 – 9.7	n.a.	n.a.	n.a.
October	22:51 05/10/17	01:33 10/10/17	9.5 – 9.9	22:57 19/10/17	23:31 20/10/17	9.5
November	22:23 03/11/17	01:20 08/11/17	9.6 – 10.0	n.a.	n.a.	n.a.
December	21:57 02/12/17	13:33 07/12/17	9.6 – 10.0	n.a.	n.a.	n.a.
January	22:30 01/01/18	14:09 06/01/18	9.5 – 10.0	10:47 31/01/18	23:12 31/01/18	9.6 – 9.7
February	11:35 01/02/18	13:48 04/02/18	9.5 – 10.0	n.a.	n.a.	n.a.
March	10:36 01/03/18	13:21 05/03/18	9.5 – 10.0	11:01 31/03/18	23:23 31/03/18	9.6
April	11:41 01/04/18	12:18 02/04/18	9.6 – 9.7	11:15 16/04/18	13:11 19/04/18	9.5 – 9.6

Figure 2. Mean goose use (total geese/number of goose count days) per hectare in winter 2017/18 (shaded symbols) compared to the previous five-year period from 2012/13 to 2016/17 (shaded fields plus SNH field codes) for the Priestside to Longbridgemuir area.

Figure 3. Mean goose use (total geese/number of goose count days) per hectare in winter 2017/18 (shaded symbols) compared to the previous five-year period from 2012/13 to 2016/17 (shaded fields plus SNH field codes) for the Glencaple to Ladyhall area.

3 Results

3.1 Barnacle Goose counts within the Management Scheme area

A field code system has been used by SNH to cover all of the fields within the Management Scheme area typically used by the geese (**Figures 2-5**), with new codes and field boundaries digitised for the Redkirk to Gretna area added to the SNH count route in October 2017. These are the codes also used in the results tables (**Tables 4 - 9**). Over the past decade, where geese were recorded in an uncoded field, the coding was extended in a logical and consecutive manner. The first five figures covering the Goose Management Scheme area are ordered in a sequence from east (Priestside area; **Figure 2**) to west (Mersehead area; **Figure 5**), with the final figure showing the new field surveillance area near Gretna and the border with England (**Figure 6**). The field and marsh compartments have been shaded from light to dark blue/purple depending on the average number of geese encountered on the count days over the previous five year period and the size of the field (as measured in the GIS). Those fields without shading but with a SNH code have never had Barnacle Geese observed in them during the Scheme counts carried out in the previous five year period. Other fields shown on the BING imagery are not part of the Barnacle Goose Scheme survey area.

Field use in winter 2017-2018 was fairly similar to that recorded in the previous five winters with core use being focussed on the Caerlaverock area at the WWT reserve, Newfield, Midtown and Newmains and in the Southerness area on the fields below West Preston and Cowcorse Farms; however some differences include:

- Heavier use of one of the Thwaite pastures SC22/23 near Brow Well (and to a lesser extent pasture SC35) probably due to many of the lower fields south of the road being converted to cereals, perhaps also leading to sustained use of the set of three Stanhope fields from SC15 to SC18 (**Figure 2**). Some of the Hurkledale fields further east were also used less heavily, though stubble PR04 at Ladyhall had heavy use early on with some Priestside fields and saltmarsh areas having intermittent use as usual;

- No recovery in goose numbers on the Powhillon Farm holding which is now almost completely unused by geese apart from the main saltmarsh compartment SC06, probably due to continued grazing by high sheep densities over the winter. The Locharwood fields had less goose use than typically recorded over the past five years, especially the pastures L36, L37 and L38 (**Figure 2**);

- Heavier use of some fields at Midtown such as S66 and S68 and Newmains such C28 and C31 was probably balanced by reduced use of others, and likewise at Newfield and Eastpark (**Figure 3**);

- Increased use of the Lantonside pastures S08/12 and S02/09/10/11 perhaps due to reduced use of hillside fields on the flanks of Ward Law (**Figure 3**);

- Greater use of some of the fields in the Islesteps area at KM33 and KM34, possibly due to large flocks being recorded in those fields during a single count in January. Pasture KM12 with a large bathing/drinking pool in it and neighbouring stubble KM18 at Netherwood Mains held increased numbers of geese possibly due to other fields on that holding being drained and converted from pasture to cereals and thus holding reduced numbers of geese (**Figure 4**);

- Although traditionally quite high use fields, there was continued very heavy use of fields at West Preston and at Cowcorse, including P21/22, with little use of fields north of the road this winter. Pastures N11, N13, N24 and N26 closer to Newmains Farm have attracted more geese again this winter due to the much improved swards in that area and large flocks of up to 5,000 Barnacle Geese were noted in the second half of the winter, often with Pink-footed Geese in association (**Figure 5**);

- Many of the rush dominated Southwick fields had low or zero goose use and Mersehead Farm regularly supported low to medium numbers of geese with regular small flocks (**Figure 5**). No goose flocks were recorded further west at Colvend during the JNCC counts;

- In the new goose surveillance area near Gretna, there was high use of the saltmarsh (RK38 and to a lesser extent RK44) and pastures (RK30 and RK37) closest to the shore at Redkirk, especially in the second half of the winter (**Figure 6**);

- Overall, the impression was of far fewer geese using feeding areas at the edge of the traditional distribution, except perhaps in the Islesteps and Newmains (near Kirkbean) areas with geese mostly accommodated within the Goose Management Scheme zones;

- The key pattern of 20 or so fields plus saltmarsh areas in each of the Southerness and Caerlaverock areas supporting the bulk of the goose use in those areas, attributable to about 10,000 birds each throughout the winter, remains consistent.

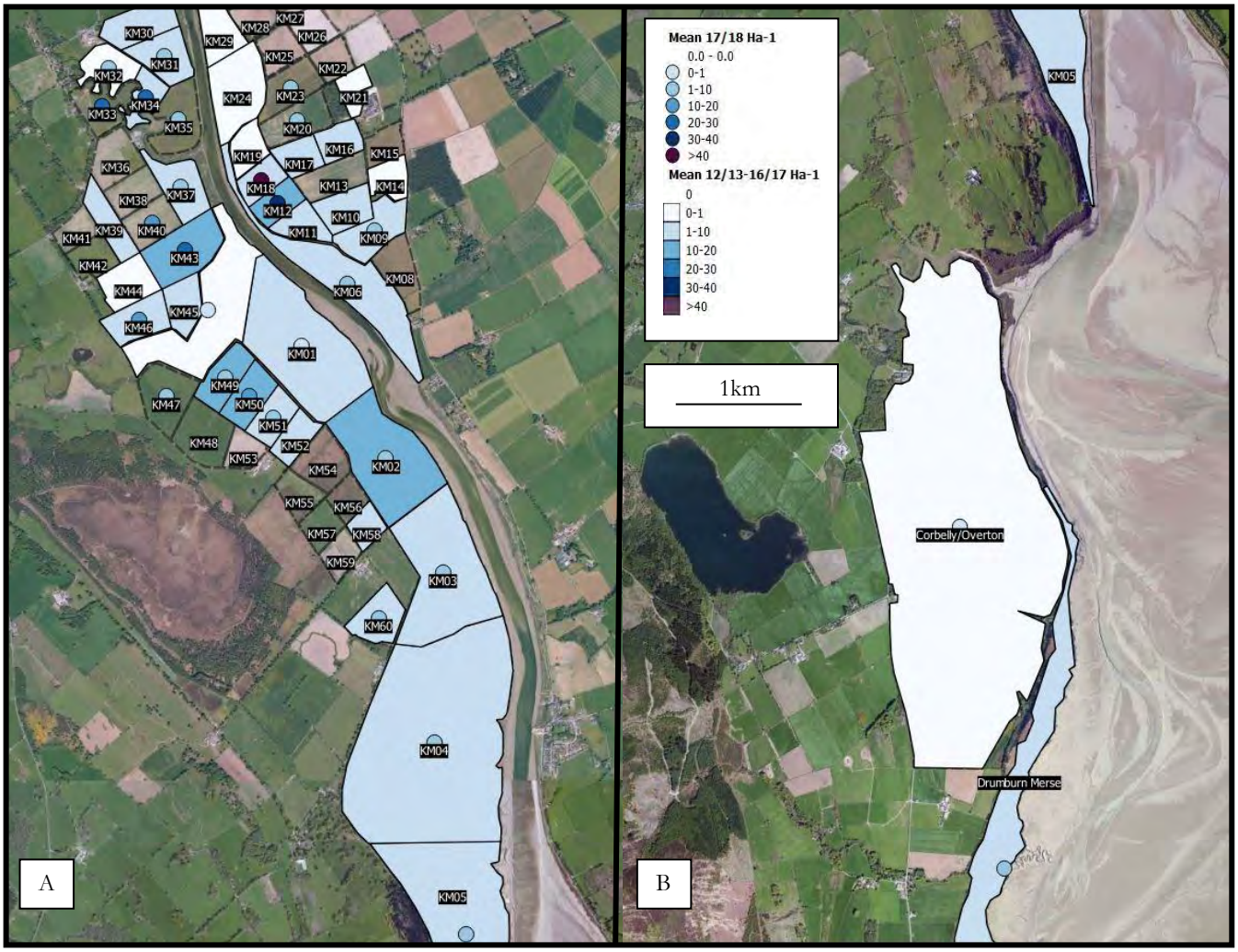

Figure 4. Mean goose use (total geese/number of goose count days) per hectare in winter 2017/18 (shaded symbols) compared to the previous five-year period from 2012/13 to 2016/17 (shaded fields plus SNH field codes) for the Kirkconnell and River Nith (A) south to the Corbelly/Overton and Drumburn Merse area (B).

Figure 5. Mean goose use (total geese/number of goose count days) per hectare in winter 2017/18 (shaded symbols) compared to the previous five-year period from 2012/13 to 2016/17 (shaded fields plus SNH field codes) for the Carsethorn to Southwick area.

Figure 6. Mean goose use (total geese/number of goose count days) per hectare in winter 2017/18 (shaded symbols) for the Redkirk to Gretna area, which although not part of the Goose Management Scheme area, was added to the SNH count surveillance route in October 2017 (the previous five-year data are not available for this area).

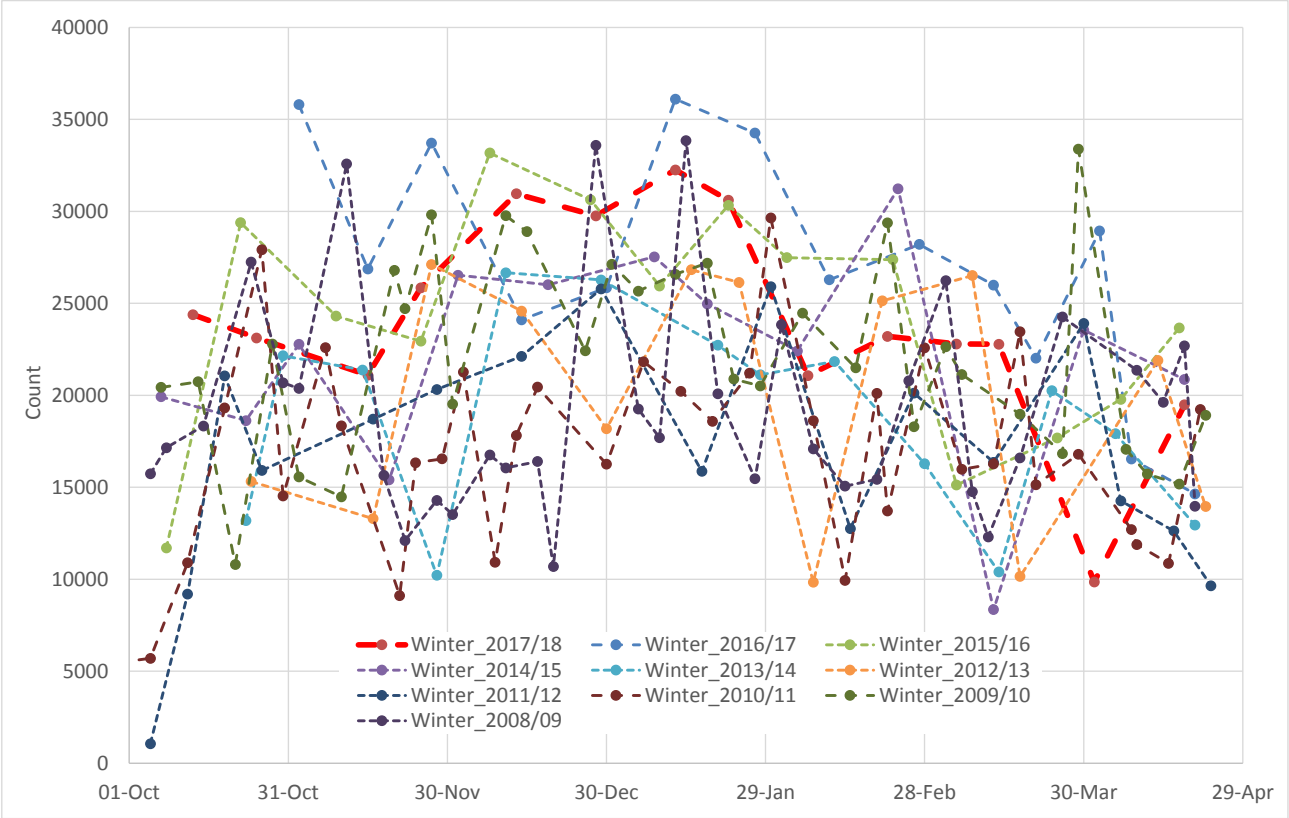

Figure 7. Svalbard Barnacle Goose flock count totals each winter within the SNH Solway Goose Management Scheme area from 2008/09 to 2017/18 (thick red dashed line).

Some goose count totals for the Scheme area are greater than others because double counting of flocks that move between fields often occurs over the course of a route count. The methodology of the SNH route counts does not seek to remove this bias as the aim is to record the numbers of geese using individual fields. IN contrast, the methodology of the JNCC census counts aims to remove this bias. Fluctuations in goose numbers within the Scheme area also occur due to the effect of high tides (see **Table 3**), coupled with weather conditions, pushing geese off low lying saltmarsh areas on the south side of the Solway and due to geese dispersing mid-winter, after peak arrival, to foraging areas outside the Scheme area (**Figure 7**).

The mean number of geese recorded during the route counts was 24,087 for the period from mid-October to mid-April (27,094 in 2016-2017) ranging from a minimum of 9,853 on 1 April 2018 (14,639 in 2016-2017) up to a maximum of 32,252 on 12 January 2018 (36,102 in 2016-2017). On the final route count on 18 April 2018, 19,482 geese were still present within the Scheme area. During further WWT counts and monitoring the last four barnacle geese were recorded on the WWT Caerlaverock Wetland Reserve on 6 May as the birds moved east to congregate on Rockcliffe Marsh, Cumbria, prior to spring departure. Overall within the Scheme area there tends to be a decline in goose use as food resources within the area are depleted by the end of January. This trend was very apparent this winter probably due to the cold conditions that developed in early 2018. Winter 2017-2018, unlike the previous two winters, was fairly harsh with some periods of prolonged snow or ice cover with 38 nights on which ground frosts (minimum temperature less than -1°C recorded at the WWT Caerlaverock weather station) were likely; the first being on the 30 October.

Flock sizes and field distribution of Barnacle Geese within the Management Scheme area are given in **Table 4**. Coded fields with zero counts have not been shown although these data are provided in the accompanying Excel file. Cells shaded light grey show flock counts on days of overlap with trail camera surveillance (see below).

Table 4. Svalbard Barnacle Goose flock sizes recorded during the Management Scheme route counts.

Field code	13/10/17	25/10/17	15/11/17	25/11/17	13/12/17	28/12/17	12/01/18	22/01/18	06/02/18	21/02/18	06/03/18	14/03/18	01/04/18	18/04/18	Total
A04/05								2							2
A18					110			3							113
A20b														6	6
A21											5				5
C01			1130	190	410		74								1804
C02	730		1470					46			290				2536
C03							120	260		11	17		210		618
C04/05		90		180			140	95				130	520		1155
C06												35			35
C07				1350											1350
C08		160		180				95		440	42				917
C09		1180		490		47								260	1977
C10/11					30		650	90						500	1270
C12			1080	920							16			250	2266
C13	140								460					390	990
C14				420										20	440
C15	330		220				770				710			80	2110
C16									7						7
C17							4		23						27
C19a		1700			30			160					380		2270
C19b						1410	380					10	110		1910
C19c												80			80
C20				700	80		930				630	130			2470
C21/22		60						1140						17	1217
C23a						1390								210	1600
C23b		10													10
C24		300		60						95		70			525
C25/26									260						260
C27			40							92		1120	9		1261
C28							950	410		3020					4380
C29	160	280													440
C30	80					220	2100		120			1930		42	4492
C31				1650		1100			2400	380					5530
C32									610						610
C33										380					380
C34							410								410
C42										11					11
C44										6					6
C51/S71	2850		1080		2350		390	660	510	180	2160		7	340	10527
C52	4170	340	570		800	80	580		270	470	1270	300	190	2400	11440
Corbelly/Overton											30	35			65
D61								15							15
Drumburn Merse									680		1100				1780
JP47												144			144
JP48											160	85			245
JP50				420		740									1160
JP52						710									710
KM01			250												250
KM02								1100							1100
KM03						260		2900		960	30				4150
KM04			4500					880	1860	42		940		8	8230
KM05												1300			1300
KM06	1200						16								1216
KM07											380				380
KM09													220	85	305
KM12		1550			85					1		1100		25	2761

KM18		3950		430											4380
KM20										330					330
KM23								860		12					872
KM31												1100			1100
KM32							220		2						222
KM33							2430								2430
KM34							1370								1370
KM35							790								790
KM37										1030				120	1150
KM40											1830				1830
KM43					2840						1260			410	4510
KM46													1820		1820
KM47													570		570
KM49						490									490
KM50					1330										1330
KM51					240										240
KM60										850					850
L12													1260		1260
L13										2					2
L14/15													180		180
L20/21						680								590	1270
L22														26	26
L23								24						120	144
L24/29														2	2
L25/28														165	165
L26/27						320									320
L30														130	130
M01											1090				1090
M03											1150				1150
M08					328										328
M12												1100			1100
M13a											460				460
M13b								275							275
M16							470	55				8			533
M19										105	920				1025
M20	140	940	150	260	2					113	25				1630
M21	5		345		9		50	170			70	13	22		684
M22												60			60
M23					262										262
M24					31		260					820			1111
M25		2			10						110	78			200
M26		910	2		312	270	570	20				610			2694
M27	3			1990	63			35							2091
M28				820	410		440								1670
M29	1040			370	166		90	620		54		230			2570
M30					46										46
M31		840	91		30	65				130	820	2	650		2628
M32	810	135	69			460		20		934					2428
M33		320	940		664	110	110	65	12		560	140	390		3311
M36/37/38/39		270									130		12		412
M45a			335												335
M45b								22							22
N05									800						800
N08												110			110
N11								4960				380			5340
N12												320			320
N13								4960			250				5210
N14											360				360
N15											85	120			205
N19			600												600
N24					2880	1960						600			5440
N25												2			2
N26						250			4200			2250			6700
N32					880	4									884

N34						380						2250			2630
N37					320										320
N46				210											210
N47											3800				3800
P09/12												2070			2070
P11					1970										1970
P13/18					312		240								552
P19												187			187
P20										8					8
P21/22			36			1670				4770		740			7216
P24							5400								5400
P25		3690				980									4670
P30			690												690
P31			1220												1220
P32			1220	1960											3180
P33					10										10
P34				3360				2450							5810
P35		90						620							710
P36					420										420
P37a			1050		1260						1030				3340
P40	2500	1140		710											4350
P41a	2500	1140					1300			2385					7325
P41b		1140		180		950	1720	730		2385					7105
P42a	320														320
P42b							970								970
P43a										30					30
P43b						1390									1390
P44						850						135			985
P45c	900					340									1240
P45d						1830									1830
PR04				670	2500										3170
PR07											670				670
PR29									280						280
PR30										700					700
PR40							610								610
PR48											250				250
PR54					14								205		219
PR58												40			40
PR59													1010		1010
PR68b			220			610									830
PR75					4		6								10
PR76							280		1340						1620
PR78					800										800
RK14													19		19
RK30							2410					160			2570
RK37					280			45							325
RK38							11	720				320	31		1082
RK40							30								30
RK44			800								15			220	1035
RK47													550		550
S02/09/10/11				2030					3800						5830
S08/12						4300									4300
S17/18a				320			4								324
S18b/24				1710											1710
S25							1130								1130
S26	300						300				280			35	915
S36										320					320
S37						710				1000					1710
S38						12									12
S39				760		3230								3	3993
S40/42														2850	2850
S41/43								460						90	550
S44/46	2300														2300

S45/47														980	980
S48														860	860
S52									8		18	12	13		51
S53								320						860	1180
S54/55												810		96	906
S59					48		9	65							122
S60/64				160			8	280	130					85	663
S61								170							170
S66	530								1670			130	25		2355
S67	170						410							260	840
S68	410				32		1640	580	32			570	1450		4714
S69														200	200
S70			940		770		110				210				2030
SC06							460								460
SC10														50	50
SC11														135	135
SC15				1200											1200
SC16									1460					2	1462
SC18														1960	1960
SC22/23				2150	4700			3120						190	10160
SC26														1080	1080
SC27					1970			7						1180	3157
SC28/29														50	50
SC35			1300											1960	3260
SC36								1100						140	1240
SC40						1690									1690
SC45	2800	2880	750		910	250	890			1960	560				11000
W06									140						140
W34					240										240
Total	24388	23117	21098	25850	30958	29758	32252	30609	21074	23206	22793	22776	9853	19482	337214

3.2 Pink-footed Goose counts for the Management Scheme area

Pink-footed Goose *Anser brachyrhynchus* counts are very variable as the extent to which geese remain in the area tends to be very weather and crop dependent. Typical peak times include the autumn as geese arrive back from Iceland into the UK and nearly 13,500 were recorded in the Scheme area in mid-October 2017 (**Table 5**). Peaks also tend to occur from February to April as birds from further south in the UK move north on migration. Small numbers of geese remained in the Hurkledale, Kirkconnell and Carsethorn area into early April. Pink-footed geese were seen in the usual wintering areas between Carsethorn and Powillimount, Priestside and to a lesser extent Kirkconnell Merse and Hurkledale, with occasional flocks elsewhere at Lands, Shearington, Bankend and the Locharwoods area.

Table 5. Pink-footed Goose flock sizes recorded during the Management Scheme route counts.

Field code	13/10/17	25/10/17	15/11/17	25/11/17	13/12/17	28/12/17	12/01/18	22/01/18	06/02/18	21/02/18	06/03/18	14/03/18	01/04/18	18/04/18	Total
A01/03							12		83	35		95			225
A02											440				440
A04/05								310							310
C33						4									4
C39						5									5
C41										3					3
C42							155			45					200
C44				70						330					400
C46										4					4
Corbelly/Overton											10				10
D61							1850	350							2200
Drumburn Merse											190				190
JP50				580		460									1040
KM03								95			100				195
KM04									4			10			14

KM09										18				2	20
KM18				3700								55			3755
KM20										150					150
KM23										140					140
KM31							180		85			240			505
KM32							5	42							47
KM33							65		45						110
KM34						190	18								208
KM39											270				270
KM46													60		60
KM56									25						25
KM60										20					20
L12													460		460
L13										9					9
L14/15													35		35
L16												7			7
LB15									800						800
N05									700						700
N08													240		240
N11								630							630
N12								350					120		470
N13											400				400
N14											210				210
N15											380				380
N19													2		2
N26									8						8
PR04														6	6
PR12														9	9
PR18									55						55
PR25	2100									160	85	6		9	2360
PR29									580						580
PR30										220					220
PR57												35			35
PR58												15			15
PR59													25		25
PR68a				120									16		136
PR68b			90			30									120
PR75					2		35								37
PR76											1				1
PR78					90										90
RK16									22						22
S26	7500														7500
S37						20									20
S38						85									85
S39	80					15									95
S44/46	300														300
S48														9	9
S52									2						2
S54/55												32			32
SC27				490											490
SC45	3500														3500
W06									530						530
W34					130										130
Total	13480	0	90	4960	222	809	2320	1777	2939	1134	2086	495	958	35	31305

3.3 Greylag Goose counts for the Management Scheme area

Small numbers of Greylag Geese *Anser anser* were recorded within the Scheme area, most records occurring on the ponds and fields at WWT Caerlaverock (**Table 6**). Post-moult flocks usually build up in this area during late summer, with numbers declining from a few hundred to less than ten over the course of the winter. The pattern this winter was fairly typical with a small number of birds remaining at the WWT Caerlaverock swan feeds until January with numbers then dropping off rapidly to less than ten.

Table 6. Greylag Goose flock sizes recorded during the Management Scheme route counts.

Field code	13/10/17	25/10/17	15/11/17	25/11/17	13/12/17	28/12/17	12/01/18	22/01/18	06/02/18	21/02/18	06/03/18	14/03/18	01/04/18	18/04/18	Total
C17				45		1	28		1	1	4				80
Total	0	0	0	45	0	1	28	0	1	1	4	0	0	0	80

3.4 Canada Goose counts for the Management Scheme area

Small numbers of Canada Geese *Branta canadensis* were recorded within the Scheme area, most records occurring on the ponds and fields at WWT Caerlaverock (**Table 7**). As with the Greylag Geese with which they often associate in mixed flocks, post-moult flocks usually build up in this area during the late summer, with numbers declining from a few hundred to less than ten over the course of the winter.

Table 7. Canada Goose flock sizes recorded during the Management Scheme route counts.

Field code	13/10/17	25/10/17	15/11/17	25/11/17	13/12/17	28/12/17	12/01/18	22/01/18	06/02/18	21/02/18	06/03/18	14/03/18	01/04/18	18/04/18	Total
A20a					50										50
C17		8	8	75	10	95	45	90	35	13	6	1	1	4	391
S33a														3	3
S66	35														35
Total	35	8	8	75	60	95	45	90	35	13	6	1	1	7	479

3.5 Whooper Swan counts for the Management Scheme area

The Scheme area and fields at its fringe especially around WWT Caerlaverock, Kelton and Thwaite generally hold between 400-500 Whooper Swans *Cygnus cygnus* throughout the winter, with numbers increasing gradually up to the end of November and into December as the swans arrive from Iceland and decreasing rapidly at the end of March as birds head north on migration. Some flocks occurring on fields outside the Scheme area are noted as comments on the Excel database but do not contribute to the totals given in **Table 8**. The swan numbers this winter followed the usual arrival and departure pattern, swans using the traditional feeding areas around Kelton, Caerlaverock, Thwaite and Ruthwell.

Table 8. Whooper Swan flock sizes recorded during the Management Scheme route counts.

Field code	13/10/17	25/10/17	15/11/17	25/11/17	13/12/17	28/12/17	12/01/18	22/01/18	06/02/18	21/02/18	06/03/18	14/03/18	01/04/18	18/04/18	Total
A02				5											5
A18				7											7
A20a					70										70
A20b		70						55							125
A22								21							21
A34											7				7
C06								16							16
C08										8	105				113
C16										1					1
C17	25	50	110	120	90	150	180	120	140	170	35	120	55		1365
C24	30														30
C30					10										10
KM01		80													80
KM16				140											140
KM20									40	80					120
KM51	11														11
L06												15			15
RK35							30								30
SC22/23						21									21
SC27									105						105
SC28/29				25		90			3			9			127
Total	66	200	110	297	170	261	210	212	288	259	147	144	55	0	2419

3.6 Mute Swan counts for the Management Scheme area

Mute Swans *Cygnus olor* mainly occur on the ponds at WWT Caerlaverock with scattered pairs elsewhere. This winter followed the usual pattern and after numbers built up at the Caerlaverock swan feeds to a peak in mid-winter, by early April the birds were dispersing to breeding territories elsewhere (**Table 9**).

Table 9. Mute Swan flock sizes recorded during the Management Scheme route counts.

Field code	13/10/17	25/10/17	15/11/17	25/11/17	13/12/17	28/12/17	12/01/18	22/01/18	06/02/18	21/02/18	06/03/18	14/03/18	01/04/18	18/04/18	Total
C08											2				2
C10/11										2					2
C16								2		2				2	6
C17	40	60	45	50	70	60	65	60	60	65	55	70	30		730
S33a									2			2		2	6
Total	40	60	45	50	70	60	65	62	62	69	57	72	30	4	746

3.7 Deliberate disturbance to geese in the Management Scheme area

Disturbance activities thought to be directed towards geese were as follows (further details in Excel spreadsheet):

- From the end of December 2017 to the start of April 2018, there was a set of 5-6 stakes with yellow bags deployed on sheep pasture PR12 at Priestside; sheep were present in the field on and off during the winter. Nine Pink-footed Geese were seen using this field in mid-April possibly because the bags had been removed;
- At the start of January 2018, four stakes with bags were noted on sheep pasture A21 at Locharwoods, by the start of February these had gone but three reappeared in March with one remaining until April 2018. Only five Barnacle Geese were noted on A21 at the start of March. In the neighbouring pasture A18 at the start of January there were 15 stakes with bags, this increased to 21 by the beginning of February and these were maintained until the final goose count in mid-April. In mid-December before the scaring equipment appeared, 110 Barnacle Geese used A18 with only three geese seen thereafter at the end of January;
- From January 2018 to April 2018 a piece of farm machinery was left in the centre of pasture JP51 at Carsethorn. Though geese were present in the surrounding area, no geese were seen using this field. In pastures JP43 and JP44 farm trailers were variously left in the fields from February to April and in pasture JP42 one blue barrel was noted from March to April. No geese were seen using these fields;
- From February to April 2018 a pallet stack was noted in stubble/pasture PR07 at Ladyhall. In early March, 670 Barnacle Geese were noted in this field;
- Barrels were noted on pastures N39 and N40 during March though no geese were recorded on these fields;
- Six blue barrels appeared in pasture C28 at Newmains Farm in April. Although popular with Barnacle Geese from January to February 2018, no geese were noted on this field during the April counts presented here;
- Single sources of possible unintentional disturbance on three different fields by tractors/diggers/fencing work were noted during some of the counts - details are given in the accompanying Excel file provided;
- From the beginning of April to mid-April 2018, very occasional banger rockets were fired from Newfield Farm and these were observed to have mixed effects on any goose flocks feeding on that farm or those surrounding it, sometimes it cleared birds from the fields on that farm, but sometimes they returned or moved onto it having been disturbed from neighbouring farms or the WWT reserve. Direct human/quadbike disturbance of goose flocks on that farm was also noted during this period.

3.8 Count section dates and times of coverage

Table 10. Survey dates, times and types for the SNH Goose Management Scheme count sections.

Type	JNCC	JNCC	JNCC	SNH	JNCC	SNH	SNH	SNH	SNH	JNCC	SNH	JNCC	SNH	JNCC
Day	Friday	Wednesday	Wednesday	Saturday	Wednesday	Thursday	Friday	Monday	Tuesday	Wednesday	Tuesday	Wednesday	Sunday	Wednesday
Date	13/10/17	25/10/17	15/11/17	25/11/17	13/12/17	28/12/17	12/01/18	22/01/18	06/02/18	21/02/18	06/03/18	14/03/18	01/04/18	18/04/18
Thwaite	10:30	10:00	10:15	12:45	11:15	14:45	15:00	09:00	15:15	10:30	16:30	10:15	09:45	11:00
Nith	09:00	08:30	09:00	10:30	08:45	13:00	12:30	12:45	13:30	09:15	14:15	08:45	16:00	09:00
Southerness	11:00	10:30	11:15	16:00	10:45	10:00	15:30	14:30	09:00	11:00	09:30	10:45	09:45	11:30
Gretna	11:30	11:15	11:30	n.c.	11:45	15:45	12:30	11:30	16:00	11:30	17:30	11:00	11:10	12:00

There were six Wednesday counts, two Tuesday and two Friday counts and one count on each of the other days of the week giving 14 counts in total (**Table 10**).

3.9 Farmer liaisons regarding geese

As counts were conducted within the Scheme area, any significant conversations with the farmers about goose numbers were noted. Sometimes these were on days on which a count was not being conducted. Farmers were also contacted by phone during the January to April period to discuss goose issues once they had received the field count data from SNH. All conversations were about goose numbers and whether or not the counts being conducted gave a good representation of what the farmer's impression of field use was like; generally the farmers felt that the counts probably gave a reasonable representation of what was happening on their land although many also felt that the reduced frequency of counts did not give a good representation of goose use but understood the limitations of the methodology. Farmers engaging in conversations about geese were noted (**Table 11**).

Table 11. Records of conversations with farmers regarding goose activity in the Scheme area.

28/12/17	Jamie Blackett said his fields were "getting hammered" by geese at Carsethorn. He felt there were less pink-footed geese and more barnacles and wondered if there was a relation between the two.
22/01/18	Stuart Brown noted how saturated the fields were after the snow and suggested there were few geese around on Hollands but that there had been; he asked about the use elsewhere and wondered why there was no simple direct assessment of grass damage in March/April to see which farms had most goose use at these critical times; "not rocket science, just look and see, there's no need for exclosures".
06/02/18	Alastair Wylie noted how there had been high use of fields C34 and C28 again this winter with some use of C35 with other use of fields about the same as usual.
	Alastair Martin had noted recent use of fields at Nether Locharwoods but thought key use was likely to be in the upcoming period - he had noted very little use of fields north of the road but some use of Mid-Locharwood fields. Alastair was not against the use of a trail camera to monitor the fields.
	Jack Graham agreed that there had been use of the fields to east of road where Juncus rushes had been cut but felt that there had been recent high use of field S65 where no geese had been recorded yet during the SNH counts.
	Roger Guy said he was no longer in the Scheme but felt that it was unfair in terms of other very low use fields remaining within the Scheme in that Locharwoods area and he wondered if assessment was "independent" enough and all interests had been declared. He was not against trail cameras being used to monitor his fields.
	Jim Kirkland said there had been high use of fields by the road of late and all those south of the farm. Very little use north of the road and not very many lately on the stubbles below the nursery; things were fairly normal.
15/02/18	James Worthington asked about all aspects of the Scheme and felt that goose use and structure of zones might benefit from some adjustment of which fields were Buffer and which Feeding and to raise this at summer meeting; he was content that trail cameras might be used to monitor fields near Lantonside
06/03/18	Stephen Brown felt that field S56/57 should be feeding zone as surrounded by feeding zone fields and has the goose usage in his opinion; he thought he would like to attend a meeting to make this point and to suggest that there should be "enhanced" feeding zone fields like the enhanced buffer zone ones.
14/03/18	Stephen Murray feels that scaring and licensed shooting on golf course fields may have saved some grass in previous years as there is virtually no grass this year after heavy use by geese so felt it proved a point now that the fields are "buffer". Otherwise business-as-usual and last weekend some geese using fields to north of road but very little grass about and so birds only in for a day and then disperse again. Felt that not many big flocks about but still time for that to happen.
	Andrew Marshall says he hasn't seen many about except for some use of field in front of Willow Cottages (SC15) and some use of field near reeds (probably SC09), other than that and merse it has been quiet.
	John Jamieson seemed to suggest that there was good use of the two fields that are in the Scheme but other than that nothing much different to usual, some earlier use of reseeds up at Woodlands but not later on. Some use of big fields north of road by small flocks occasionally.
08/05/18	Doug Freeman had geese using the field between Stanhope and Brow Well which been in grass for a couple of years; when fertilising in early May he said the grass had yet to get away as had been thick with geese. Whooper swans had also eaten grass on field behind Geoff Beazley's cottage on north side of road at Brow Well and on meadow field closer to Doug's steading at Clarencefield, probably 80-90 birds and had earlier used the stubble and unharvested crop between Stanhope and Shore Cottages. Late use of field near Willow Burn by geese into end of April/start of May.
	Ben Oliphant felt there had been a bit more use of the fields just south of road at Mid-Locharwoods where he has tried to add new drainage and plans to reseed due to the wet. He agreed that was possibly due to bags on sticks in fields opposite on north side of road. Fields very wet and so difficult to reseed at present.

3.10 Coordinated Svalbard Barnacle Goose population count totals

Table 12. Coordinated Svalbard Barnacle Goose population count totals for the Solway.

Count section	04-Oct	13-Oct	25-Oct	15-Nov	13-Dec	21-Feb	14-Mar	18-Apr	25-Apr	02-May	09-May	16-May	23-May	30-May	4-June
Annan to Gretna	0	0	0	800	280	0	480	220	116	60	550	0	0	0	0
Ruthwell to Cummertrees	0	0	0	2050	11008	700	40	4600	0	0	0	0	0	0	0
Longbridgemuir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caerlaverock	140	14670	7000	6530	4790	7987	3397	12020	5460	5345	0	0	0	0	0
Kirkconnell & Ward Law	0	1500	5400	4750	4495	3225	3340	683	4270	0	0	0	0	0	0
Mersehead to Airds Pt	0	8221	10597	6748	10387	6144	5395	7003	5168	1805	0	0	0	0	0
Caulkerbush to Rascarrel	0	0	60	0	n.c.	0	0	0	0	0	0	0	0	0	0
Dundrennan to Wigtown	0	0	0	0	35	4000	2850	674	380	0	0	0	0	0	0
Rockcliffe Marsh	0	6400	3450	10000	140	14160	10410	10850	14600	22500	16200	8350	500	250	30
Burgh Marsh	0	3200	13100	375	0	0	0	6100	250	8500	0	0	0	0	0
Bowness to Grune	0	320	1889	3440	2600	800	3630	1395	1130	950	0	0	0	0	0
Solway total	140	34311	41496	34693	33735	37016	29542	**43545**	31374	39160	16750	8350	500	250	30

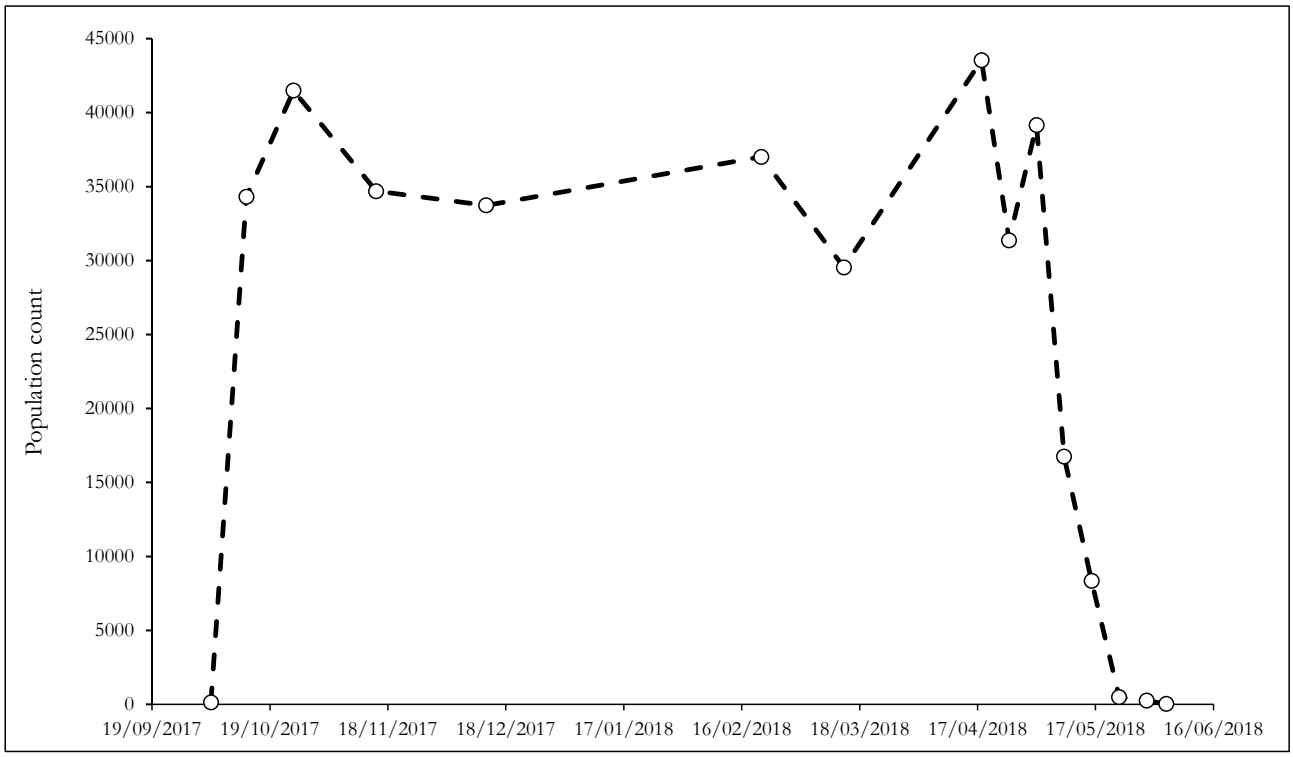

Figure 8. Total population of the Svalbard Barnacle Goose on the Inner Solway from October 2017 to June 2018.

The first arrival of Svalbard Barnacle Geese thought to be genuine migrants was a flock of 121 recorded on pasture at WWT Caerlaverock on 17 September 2017. Total population counts of Barnacle Geese built up incredibly slowly on the Solway as a whole with only 140 present by the morning of 4 October 2017 (**Table 12**; **Figure 8**). By 8 October further flocks were starting to arrive and there were almost 9,000 in the Caerlaverock area by the afternoon, with over 10,000 the following day. By 13 October there were over 34,000 on the Solway as a whole and nearly 41,500 by 25 October, the second highest census count of the 2017-2018 season. It was not until 18 April that the peak count of 43,545 was recorded on the Solway, probably due to significant numbers of birds staging/wintering on the east coast at Budle Bay until mid-March 2018. Over 37,000 geese were recorded on four out of eight census counts between the end of October 2017 and the start of May 2018 – it is not clear why there was more variability in census totals this winter compared to last winter. There were some periods of freezing conditions and laying snow this winter so it is possible the more limited food resources pushed birds into different areas not covered by the usual survey routes. The first evidence of significant spring migration was seen by 2 May with at least 31,000 geese gathered at the east end of the Solway on Rockcliffe Marsh, Cumbria (including Burgh Marsh and Redkirk Marsh) with only 8,000 elsewhere on the Inner Solway. By 9 May all birds remaining on the Solway were on Rockcliffe Marsh (including Redkirk Marsh) and numbers had more than halved to 16,750. This number had halved again by 16 May and by 23 May only 500 birds were present. Unusually, at least 250 remained on Rockcliffe Marsh until 30 May – finally dropping to 30 by 4 June - possibly held back by a period of north easterly winds.

Due to count variation, with possible inaccuracies and the chance of double-counting, an adopted count total for the Solway population is usually derived by averaging those counts within 10% of the maximum recorded during the winter (prior to spring migration). In 2017-2018 the counts of 41,496 on 25 October 2017 and 43,545 on 18 April 2018 fulfilled this criterion and were thus averaged to produce **an adopted Solway population total of 42,600 Svalbard Barnacle Geese** (rounded up to the nearest 100; compared to 41,700 in 2016-2017).

3.11 Brood size and juvenile productivity of the Svalbard Barnacle Goose

The juvenile productivity of the Svalbard Barnacle Goose observed in flocks sampled on the Inner Solway from October 2017 to December 2017 in the Caerlaverock, Kirkconnell, Carsethorn and Southerness areas varied between 0.5% to 15.9% (**Table 13**; 0.0% to 42.5% in 2016-2017) with a mean of 4.8% young from 14 flocks with 13,862 geese sampled (16.0%; n = 15 flocks; 7,352 geese sampled in 2016-2017). Across the same area, the total number of broods sampled was 151, with a mean family size of 1.8 young, range 1-4 young (1.9 young; n = 67 broods; range 1-4 young in 2016-2017).

Table 13. Brood size and juvenile (juv) productivity for Svalbard Barnacle Geese on the Solway in winter 2017/18.

Date	Flock Size	Sample Size	Total Juvs	Field	Crop	Brood of 1	Brood of 2	Brood of 3	Brood of 4	Brood of 5	Brood of 6	Single Juvs	% juvs	Obs
12/10/2017	4500	3535	107	O11	pasture	23	25	10	1				3.0	LRG
27/10/2017	1040	1030	31	A8	reseed								3.0	LRG
09/11/2017	970	940	33	E10	stubble	7	4	1					3.5	LRG
09/11/2017	3000	2300	11	A9/10	pasture								0.5	LRG
09/11/2017	180	166	5	OM7	merse	1	2						3.0	LRG
09/11/2017	160	155	9	OM1	merse	3		2					5.8	LRG
10/11/2017	1900	850	80	KM13	stubble	3	4	1					9.4	LRG
10/11/2017	5200	1530	90	T6	pasture	7	1	2	2				5.9	LRG
14/11/2017	1300	600	83	E1	pasture	11	14	8					13.8	LRG
28/11/2017	580	580	32	C7	pasture	7	11	1					5.5	LRG
04/12/2017	1170	580	92	X28	pasture								15.9	LRG
04/12/2017	780	540	15	V4	pasture								2.8	LRG
04/12/2017	166	166	14	V8	stubble								8.4	LRG
04/12/2017	1500	890	62	T10/11	pasture								7.0	LRG
Total		13862	664											
Overall juv%			**4.79**			Brood size totals:								
						62	61	25	3	0	0	Total broods	151	
						Number of juveniles per brood size category:						Max %juvs	15.9	
						62	122	75	12	0	0	Total juvs	271	
												Mean brood	**1.79**	

3.12 Leucistic Barnacle Geese

A minimum of seven leucistic Barnacle Geese was recorded on 18 April 2018 (with six recorded on 14 March), including two on Rockcliffe Marsh, two in the Newton Marsh area, two at Southwick and one at Caerlaverock. Until at least 21 February 2018, two leucistic birds had been closely associating at Budle Bay, these were not seen on 14 March at that site but there were two birds closely associating on Rockcliffe Marsh that day.

3.13 Other geese

On 17 January 2018 a pair of Greenland White-fronted Geese *Anser albifrons flavirostris* alighted briefly at Eastpark and then eight were seen on most days between 22 January and 4 February 2018 at Eastpark.

3.14 Trial of trail cameras to monitor goose use of fields

In February 2018, six Acorn LTL 6310MC trail cameras plus 32GB SD cards and rechargeable batteries were purchased from Pakatak Ltd. These were deployed on trees or fence posts, with landowner permissions, at six locations within the Goose Management Scheme and other surveillance areas (**Table 14**). The cameras were used in time lapse mode to take images every 15 minutes from 06:00-21:00. During late March and early April some evening images were redundant but by mid-April to mid-May the first hour of daylight from about 05:00 was not covered but in the evening it was light until 21:00. In general, the images were unaffected by periods of poor weather except for some early morning mists. In most circumstances it was possible to discern goose flocks at distances up to 700m, though this no doubt depended on flock size to an extent and the terrain between the

geese and the camera. The approximate surveillance polygons depicted in **Figures 9-12**, within which goose flocks could readily be detected, do not show their patchy nature, with the typically oblique angle of the camera to the field resulting in extensive areas of "dead ground" and intervening tree lines or thicker hedges also creating "blind spots". These additional factors have been taken into account with regard to the subjective assessment made of approximate percentage field visibility (**Table 14**).

Table 14. Trail camera deployment locations, field areas surveyed and the survey periods covered.

Location	Fields in line of sight and approximate % visible[1]	Deployment time and date	Retrieval time and date
Redkirk Point, east (**Figure 9**)	RK36 ~40%; RK37 ~75%; RK38 <5%	14:30 26/03/18	08:30 16/05/18
Redkirk Point, west (**Figure 9**)	RK29 ~40%; RK30 ~80%	14:30 26/03/18	08:30 16/05/18
Mid-Locharwoods (**Figure 10**)	L30 ~10%; L31 ~20%; L36 ~60%; L37 ~75%	13:00 26/03/18	10:30 09/05/18
Eastpark Farmhouse Tower, north (**Figure 11**)	C19a ~40%; C19b ~30%; C21/22 ~30%; C23a ~80%	16:00 16/03/18	12:00 15/05/18
Eastpark Farmhouse Tower, west (**Figure 11**)	C01 ~75%; C02 ~95%; C03 ~40%; C04/04 ~20%; S66 ~10%; S67 <5%; S68 5%.	10:00 20/03/18	12:00 15/05/18
Lantonside (**Figure 12**)	S17/18a ~40%; S18b/24 ~70%	09:00 22/03/18	11:15 09/05/18

[1] Assessments of % visibility of each field take account of "dead ground" and "blind spots" as discerned from the point of view of the camera at the site.

Figure 9. Two trail camera positions (star symbols) at Redkirk Point and their approximate surveillance polygons. One deployed 2m high in a tree faced northwest mainly covering pasture RK30 but also parts of RK29, and one at 1m high on a fence post on the sea wall faced northeast mainly covering pasture RK37 but also parts of pasture RK36 and saltmarsh section RK38. Each view within which goose flocks could be readily detected extends to ~500m.

Figure 10. Trail camera position (star symbol) at Mid-Locharwoods and its approximate surveillance polygon. The camera deployed 1m high in a hedge faced northeast covering most of pastures L36 and L37 with some limited parts of pastures L30 and L31 also being visible. The view within which goose flocks could be readily detected extends to ~500m.

Figure 11. Two trail camera positions (star symbols) outside the upper floor windows of the Eastpark Farmhouse Tower and their approximate surveillance polygons. One faced north mainly covering pastures C19a and C23a but with aspects of pastures C19b and C21/22 also being visible (trees in C17 and C18 obscured much of the foreground view into the Newfield farm fields) and one faced west covering most of pastures C01 and C02 and parts of pastures C05 (much of which obscured by barn in foreground) and a very limited part of pasture C04/05. Flock detection in fields S66, S67 and S68 was probably very limited due to distance and intervening hedgerows. Each view within which goose flocks could be detected extends to ~600m.

Figure 12. Trail camera position (star symbol) at Lantonside and its approximate surveillance polygon. The camera deployed 2.5m high in a tree faced northwest covering most of pastures S18b/24 and S17/18a with views onto the hillside fields being limited by trees. The view within which goose flocks could be readily detected extends to ~700m.

The pictures from the cameras were viewed on Windows PhotoViewer on a 27 inch desktop screen at the rate of about one picture per 2-3 seconds, each picture being scanned from side to side by the viewer (LG) for signs of goose flocks. It is quite likely that small flocks of less than 10-20 birds will be missed on occasion at increasing distance from the camera, and also that larger flocks will be missed on more distant fields under poorer lighting conditions. A subjective assessment of the flock size was made along with the approximate arrival and departure times to and from the field. These are probably minimum assessments of feeding times spent by the geese on the fields as often a flock was seen to move into or out of view of the camera's vantage point and so it was not known if the flock had just arrived or just left the field. In some cases where a flock disappeared with a direction of travel into a known area out of view and then reappeared within the next hour from that direction an extrapolated decision was made that the flock had remained within the field during that whole time period. Some examples of the images from each of the cameras and of the goose flocks "captured" are given in **Figures 15-20**.

Feeding flocks of geese were recorded at all trail camera locations except that deployed at Lantonside. At Mid-Locharwoods, feeding flocks were recorded on three dates in mid to late April. Flocks were recorded at Newfield and Midtown on most days during March, with much reduced use during April. Surprisingly heavy use of the fields at Redkirk was witnessed especially during April and, unlike the other locations, into mid-May. The cameras provided useful evidence of the Redkirk fields being used at first light with flocks often dispersing by 09:00 or earlier, probably in response to dog walker disturbance as recorded by the cameras (**Table 15**).

The cameras at all locations recorded other sources of disturbance such as farming operations by tractors or stock introduction to fields and even helicopters. In general, due to the nature of the cameras' limited field of view and oblique angle to the fields and other restrictions to the field of view caused by field boundary features and the landscape structure, it is only possible in most cases to monitor goose use in one or two fields at most in a thorough way. Some indications of use for adjacent fields seems unlikely to be consistent and a record of the absence of geese in non-focal fields should not be taken as a true zero count as flocks might be present but not obvious due to the effects outlined above and/or poor lighting giving rise to observer error during the rapid analysis of each image, i.e. false negatives are more likely than false positives (**Table 15**).

The cameras can provide useful evidence of use or non-use of fringe fields, though a key limiting factor in the future, if boosting the number of trail cameras used, will be the amount of time needed by a human subject to interpret the pictures. In future, if covering e.g. 05:00-21:00 daily at 15 minute intervals from October to May, which would probably require one battery change mid-winter, *each* camera's images would take at least 11 hours to analyse simply in terms of visual inspection; therefore it might be prudent to cover only certain key months.

Although the cameras were only run from late March to mid May 2018 in the current study (exact dates given in **Table 14**), an attempt was made to compare the data derived from the images with the flock count data collected during the SNH/JNCC surveys of the Goose Management Scheme area.

Each flock count recorded on the trail camera images was converted to "goose hours (goosehrs)" by multiplying the maximum count recorded in a series of contiguous images by the period of time over which those images extended, for example 100 geese on a field for at least 30 minutes (two consecutive images) equates to 100*0.5 = 50 goosehrs which is deemed equivalent to 200 geese being present for 15 minutes or 50 geese for an hour. If a flock was only present on one 15 minute image this was classed as being present for 0.25 hours. All 'goosehrs' estimates made for each field probably represent a minimum as the time period considered in the calculation was not extended beyond the first or last images on which geese were recorded. Also on some occasions it was noted that geese were present in a field (predominantly in the Redkirk area) in April/May before the first picture of the day, the birds presumably having arrived there at first light and on a few occasions birds may have roosted on fields as birds were present on images at dark before camera shutdown. Each separate period of goose use of a field throughout a day was summed to produce a 'goosehrs/day' metric.

For the SNH/JNCC counts, only two April counts (on 1st and 18th and highlighted grey in **Table 4**) were available within the period that the trail cameras were deployed, though data from three JNCC census counts made in late April and May were also made available for calculations. The counts were transformed into 'goosehrs' by multiplying any flock counts by 1.8 hours, the average time a flock remained on a field as recorded by trail camera surveillance (total of 407 'goosehrs' recorded across 15 fields used by geese during 229 separate goose use events within the trail camera survey period). This metric was then divided by the number of SNH/JNCC counts carried out over the period (five) to derive 'goosehrs/day' (note that unlike the trail camera derived metric, fields were not revisited during a day on the SNH/JNCC surveys). The same method was employed to convert goose count totals collected across the whole winter (17 counts; 14 under the SNH/JNCC contract + 3 extra JNCC counts for late April and May not reported here) to derive 'goosehrs/day'.

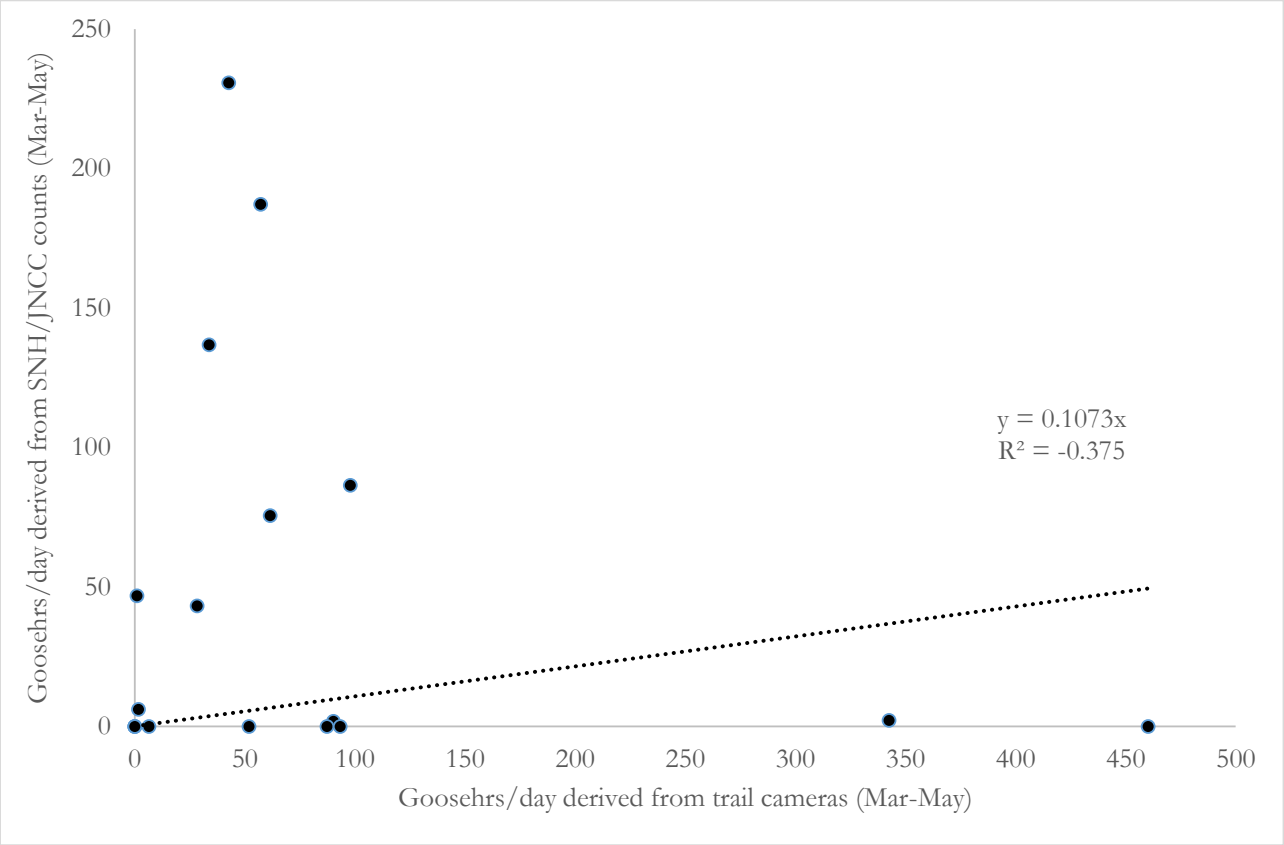

Figure 13. Goose use (goosehrs/day) as derived from daily, 15 minute frequency, trail camera images from late April to mid-May (for exact dates see Table 14) from six cameras monitoring 18 fields to varying degrees compared to the goose use recorded by an observer conducting ground counts over the same period on five occasions (where field survey "events" generally last from ~1-15 minutes).

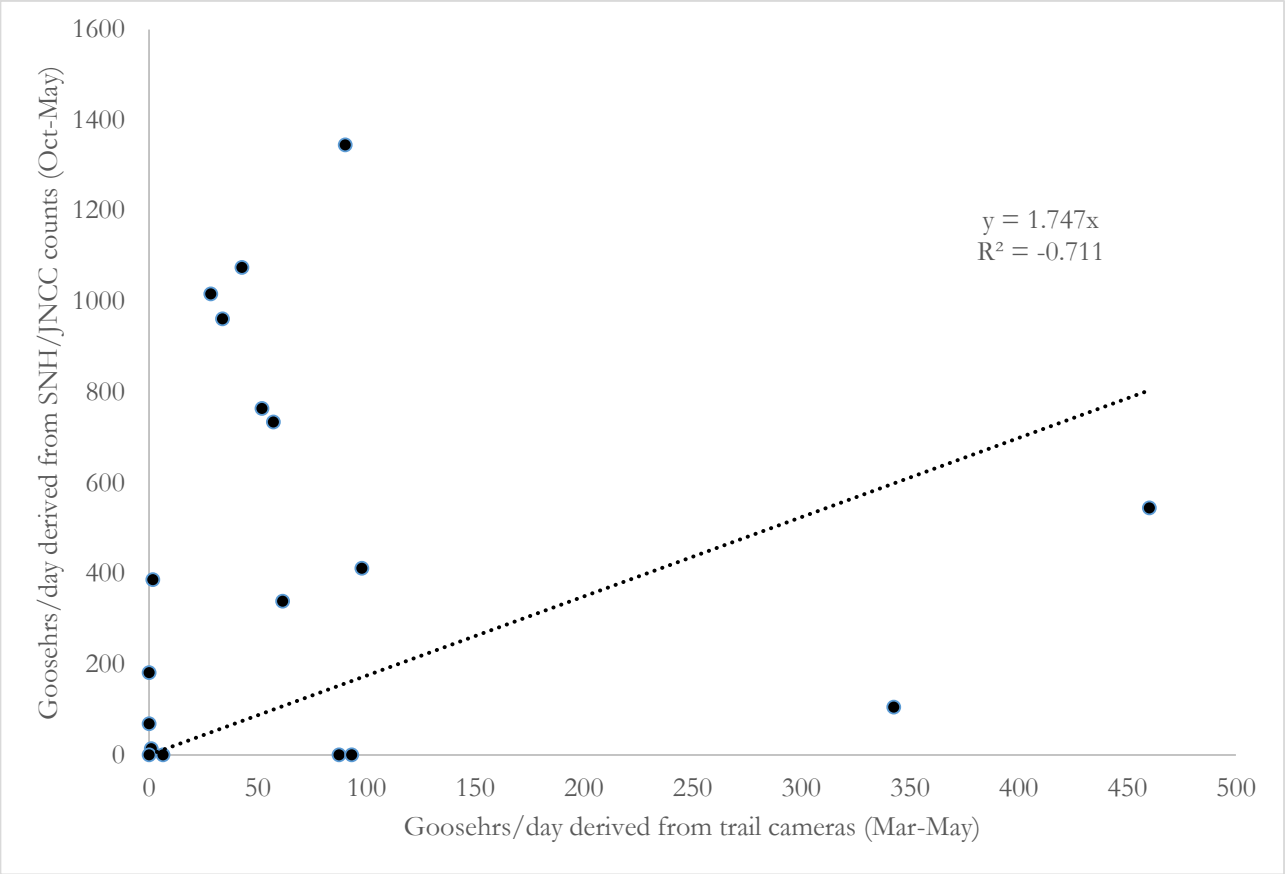

Figure 14. Goose use (goosehrs/day) as derived from daily, 15 minute frequency, trail camera images from late April to mid-May (for exact dates see Table 14) from six cameras monitoring 18 fields to varying degrees compared to the goose use recorded by an observer conducting ground counts over the winter period from October 2017 to May 2018 on 17 occasions (where field survey "events" generally last from ~5-15 minutes).

The reason for the differences between the metrics shown in the graphs above is the very different sampling regimes and periods employed under the two methods for assessing goose use (**Figure 13**). It would be more meaningful to compare full winter periods as certain parts of the Solway have traditional periods of use and e.g. somewhere like Redkirk tends to be used more late in the season due to the whole population gathering on Rockcliffe Marsh prior to spring departure and then spilling onto the Redkirk fields early each morning before those areas are disturbed. Also the SNH Goose Scheme allows for disturbance of the geese by land managers after 1st April and the SNH field counts end after 23rd April. As the trail camera surveillance was mostly concentrated in the April and May period we did not get a close correlation between the two survey methods though there does tend to be a better correlation when more of the winter's counts were included (**Figure 14**).

Figure 15. Trail camera deployed 1m high on a fence post on top of sea wall on east side of track to Redkirk Point. This flock was estimated to contain ~1,000 geese (including two leucistic individuals) based on prior and subsequent images. The time, date, temperature and moon phase are stamped at the bottom of the image.

Figure 16. Trail camera deployed 2m high on a tree on west side of track to Redkirk Point. This flock was estimated to contain ~800 geese (including a yellow ringed individual in the foreground) based on prior and subsequent images. The time, date, temperature and moon phase are stamped at the bottom of the image.

Figure 17. Trail camera deployed at 1m high on a hedge overlooking fields at Mid-Locharwoods. This flock was estimated to contain at least 150 geese which must be seen as a minimum considering those heading out of shot. The time, date, temperature and moon phase are stamped at the bottom of the image.

Figure 18. Trail camera deployed on top floor window ledge of Eastpark Farmhouse Tower. The foreground view of Scheme fields was obscured by tree leaf-up during May.

Figure 19. Trail camera deployed on top floor window ledge of Eastpark Farmhouse Tower. The foreground view of Scheme fields is obscured by the barn roof but at least 600 geese can be seen in the western half of the field.

Figure 20. Trail camera deployed at 2.5m on a tree at Lantonside. No goose flocks were seen on the ground but some flying geese – see left hand side on this image for example – were recorded.

Table 15. Flock count estimates per field as derived from the imagery from five trail cameras deployed in late March to May 2018 (no feeding goose flocks were recorded by the sixth camera overlooking two Lantonside fields).

	Flock count estimates and inclusive time periods that flocks were present														
	Redkirk east			Redkirk west		Mid-Locharwoods		Eastpark north				Eastpark west			
Date	RK37	RK36	RK38	RK30	RK29	L37	L30	C19a	C23a	C19b	C21/22	C03	C01	C02	C04/05
16/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a					n/a	n/a	n/a	n/a
17/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a		200 @07:15-08:15	200 @11:30-12:15	100 @12:45-13:45	n/a	n/a	n/a	n/a
18/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a	80 @10:45-12:45	250 @13:00-15:00	150 @11:15-12:45		n/a	n/a	n/a	n/a
19/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a	300 @06:45-08:45; 50 @15:30-16:15	150 @15:30-16:15	300 @13:15-16:15		n/a	n/a	n/a	n/a
20/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a	50 @06:30-12:15				600 @09:30-12:30; 200 @16:30-18:00		100 @16:30-18:00	
21/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a					100 @06:45-11:30; 30 @12:30-12:45; 500 @17:00-18:15	500 @06:45-11:15; 250 @18:15	180 @13:30-15:15; 500 @18:00-18:15	1000 @17:00-17:45
22/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a	50 @13:00-16:45				450 @06:15-08:00		450@11:30-12:45	450 @07:30-12:30
23/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a								
24/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a								
25/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a								
26/03	n/a	n/a	n/a	n/a	n/a	n/a	n/a								
27/03															
28/03												180 @07:15-08:00		180 @07:45-10:30	
29/03	1 @09:15-09:45									200 @18:15-18:45		100 @06:00-06:45			
30/03								80 @06:30-09:30	250 @09:45-11:30	150 @07:15-09:15		250 @18:30-19:15	70 @08:15-08:45	70 @06:00-08:00; 120 09:00-09:30; 500 @17:45-19:15	

Date	RK37	RK36	RK38	RK30	RK29	L37	L30	C19a	C23a	C19b	C21/22	C03	C01	C02	C04/05
31/03				650 @08:30-09:00; 60 @13:00-13:45	300 @08:30-09:00			50 @07:15-08:15				400 @06:00-06:45; 90 @17:30	120 @11:30-12:00; 500 @17:15-18:15	120 @09:45-11:15	
01/04					300 @06:15-09:00			100 @06:15-09:30				100 @09:00			
02/04				50 @08:00-09:15; 350 @09:45-10:15	300 @06:00-09:15										
03/04				50 @08:30-09:00; 90 @09:30-13:15	300 @06:00-09:00										
04/04	300 @06:00-08:00; 70 @15:15-18:00			300 @06:00-08:45; 350 @14:15-18:00	100 @17:45-18:00										
05/04	850 @06:00-07:23			800 @08:00-08:45; 20 @17:30						20 @15:30-16:15					
06/04	1000 @06:00-08:15			800 @07:00-09:15; 1 @15:15					600 @09:15-09:45						
07/04	230 @06:00-08:15			450 @07:00-09:45; 10 @ 13:00											
08/04															
09/04				30 @08:00-09:30	200 @09:00-09:30										
10/04	300 @06:00-07:15; 5 @08:00-08:15		3 @06:00-07:15	450 @06:00-07:45; 300 @08:15-08:45; 10 @15:30-18:45						30 @11:00-11:15				150 @14:15-16:45	
11/04	1000 @06:00-07:00; 10@14:30-15:30	200 @06:00-07:00	30 @14:30-15:30	15 @06:00-06:15										100 @07:15-08:00	
12/04	200 @13:00-13:45; 300 @16:30-17:30			250 @06:00-08:15; 250 @11:45-13:00; 275 @14:30-19:45											
13/04	500 @06:00-08:30	500 @06:00-08:30		500 @06:00-08:30	100 @06:00-08:30										
14/04				60 @06:00-08:45											
15/04				20 @06:00-08:00										20 @17:30-19:45	

Date	RK37	RK36	RK38	RK30	RK29	L37	L30	C19a	C23a	C19b	C21/22	C03	C01	C02	C04/05
16/04	20 @06:00-07:45			15 @06:00-07:45								40 @11:00-16:45		5 @07:45	20 @07:45
17/04	100 @06:00-07:15; 100 @12:30-13:30; 300 @17:15-18:15	700 @13:45-16:00; 300 @17:00-17:15	700 @13:45-16:00	4 @06:00-06:15; 6 @08:00-08:30; 50 @10:00-14:15; 900 @14:30-15:45	500 @14:15-15:45		60 @12:00-12:45					70 @06:00; 20 @08:15-10:45		130 @08:15-10:45	
18/04	50 @06:00-07:00; 600 @08:15-09:15; 70 @11:15-14:15	500 @06:00-07:00; 500 @07:45-09:15		500 @06:00-09:15					150 @13:30-14:15						
19/04	400 @06:00-06:15; 10 @08:00-08:15; 35 @17:45-18:30	300 @06:00-06:15		60 @06:00-08:30		150 @15:15-16:00			300 @06:00-12:45						
20/04	1000 @06:00-06:45			500 @06:00-08:30											
21/04	100 @06:00-06:45			80 @06:00-08:30											
22/04	200 @06:00-06:30	100 @06:00-06:30		4 @06:00-08:30		100 @08:00-10:00								60 @13:00-14:30	
23/04	50 @06:00-07:00; 20 @15:00-20:00	?? @06:00-07:00	10 @08:00-08:15; 100 11:45-12:30; 50 @14:45-20:00									10 @10:00-11:00			50 @06:00-07:30
24/04	10 @07:30-08:15 and 4 @14:30			2 @06:00-08:00; 10 @16:15-17:15	30 @06:00-08:00							20 @06:00-06:45; 60 @15:45-16:45		60 @06:00-06:45; 40 @15:45-16:45	50 @06:00-06:45
25/04	100 @06:15			10 @07:00-08:00	100 @06:00-08:00							10 @07:30; 20 @08:15-09:00		10 @06:00-07:15	
26/04	380 @06:00-07:45			60 @06:00-08:15								60 @10:15-12:15		30 @13:30-19:15	
27/04	80 @06:00-06:45			180 @06:00-08:00; 7 @18:00-20:30										20 @06:00-06:45; 4 @07:00-10:15; 40 @18:00-20:00	80 @19:00-20:00
28/04	750 @06:00-06:15			200 @06:00-06:45; 25 @08:15-09:15								10 @08:00-10:30		150 @06:00-07:00; 10 @08:00-10:30; 200 @17:00-19:30	
29/04	350 @06:00-07:00			300 @06:00-08:00; 10@17:00 5 @20:15-20:45								20 @13:30-14:30		70 @07:00-07:45; 50 @17:45-20:30	

Date	RK37	RK36	RK38	RK30	RK29	L37	L30	C19a	C23a	C19b	C21/22	C03	C01	C02	C04/05
30/04	400 @06:00-06:30		3 @06:00-07:00	100 @06:15-07:45	25 @06:00-07:45			20 @06:00-12:45				10 @10:45-12:45		160 @06:00-06:30; 10 @09:00-12:45	
01/05			5 @18:15	350 @06:00-07:30; 5 @17:30-17:45											
02/05	200 @06:00-08:30			350 @06:00-08:30								15 @09:45-20:30			
03/05	50 @06:00			350 @06:00-08:15								4 @06:00			
04/05				700 @06:00-07:30											
05/05	350 @06:00-08:30			550 @06:00-08:30											
06/05	500 @06:00-08:15		10 @06:00-08:15	20 @06:00-08:15											
07/05	500 @06:00-07:45			15 @06:00-07:30											
08/05				110 @06:00-07:45; 7 @16:30											
09/05	50 @16:15-17:45														
10/05	210 @06:00-08:30		20 @10:30-13:30												
11/05	260 @06:00-08:30; 200 @13:00-16:15		30 @12:00-13:45	20 @06:30-08:30											
12/05	400 @06:00			50 @06:00											
13/05	90 @06:00-08:00			3 @06:00-06:30											
14/05	Cattle knocked camera out of line so that view of saltmarsh RK38 only – no geese			6 @06:30-07:15											
15/05	Cattle knocked camera out of line so that view of saltmarsh RK38 only – no geese														

3.15 Acknowledgements

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