CHAPTER 3 - RESULTS

3.1 DISTRIBUTION AND SOCIAL STRUCTURE

3.1.1 Annual variation in distribution throughout Islay

Introduction

A coordinated international census of Greenland White-fronted Geese in Britain and Ireland has been made each winter since the 1982-83 season, and the counts collated by the Greenland White-fronted Goose Study (Stroud 1983, 1992). Attempts were made to count the geese at least twice each season, usually in November or early December ("autumn") and in late March ("spring"). The results of these censuses are illustrated earlier in Table 1.1 (and Stroud 1992).

During the 1980s, specific counting routes were devised to improve the accuracy and efficiency of goose counts on Islay (Easterbee et al 1990). The island was divided into eight main count areas: Rhinns, Gorm, Gruinart, Kilmeny, Laggan, Glen, Oa and Ardtalla (Figure 3.1.1a), which were covered by different observers. Before 1991-92, observers recorded the number of geese present in each 1 km square within each of the eight main count areas. In the 1991-92 and 1992-93 winters, however, the numbers of geese were recorded on a farm or field basis. Attempts are made to obtain counts of the island on two consecutive days in order to verify the results. The higher of these two figures are used in the present analyses, unless it was thought at the time that the higher figure was due to counting the same birds twice. The 1991-92 and 1992-93 field by field data were converted to the 1 km square grid for an analysis of changes in the distribution of Greenland White-fronted Geese throughout Islay over several winters. Scottish Natural Heritage provided count data for the 1988-89 to 1992-93 winters (inclusive) for this analysis.

Results

The number of Greenland White-fronted Geese counted in each of the eight count areas on Islay for the 1988-89 to 1992-93 winters is given in Table 3.1.1a. The total counts differ slightly from the figures given in Stroud 1992 (see Table 1.1), possibly due to some late additions or amendments to the SNH database, from which both estimates are derived. Results indicate that the highest proportion of the Islay-wintering population were consistently found in the Kilmeny count area in both autumn and spring, but that there was some annual variation in the dispersal of birds to the other count areas (Table 3.1.1a). The Rhinns,

Ardtalla and Glen count areas tended to support only a small proportion of the Islay population in autumn, however, with the numbers using Gorm, Gruinart, Laggan and Oa upon arrival fluctuating from year to year. In spring, the proportion of birds recorded at Ardtalla and Glen was again low, but a higher proportion were recorded at Rhinns (mean value of 11.0%) than in the autumn (mean value of 8.4%). The comparatively low usage of the Ardtalla and Glen count areas may be attributed to the extensive areas of high ground (unsuitable for geese) in Ardtalla, and the comparatively small size of the Glen region. The effects of different farming practices on the distribution of the geese on Islay is considered in further detail below. The birds tended to use farms within the Gruinart count area in autumn (10.9% of the population), but only small numbers were recorded in spring (4.1% of the population), indicating that the birds use Gruinart as a safe feeding and roosting area upon arrival, before dispersing to other parts of Islay or elsewhere.

Analysis of the number of 1 km squares used by the birds in the eight main count areas again indicated that the geese were recorded at only a small number of 1 km squares in Glen and Ardtalla, and that they made most extensive use of the Kilmeny region (Table 3.1.1b). Although the total number of birds recorded within the different count areas varied from year to year (Chi-squared > 56.89, df=28, $P<0.001$ for both autumn and spring, Table 3.1.1a), there was no significant difference between seasons in the number of 1 km squares recorded with geese (Chi-squared = 10.78, df=24, n.s. in autumn and Chi-squared = 14.97, df=24, n.s. in spring, Table 3.1.1b). It seems, therefore that the birds tended to use the same parts of the island from year to year, although the proportion of the population recorded in these regions might vary. An analysis of seasonal variation in the number of 1 km squares used by the birds from 1988-89 to 1992-93 inclusive found no overall difference in distribution between the count areas in autumn, compared with spring (Chi-squared=10.55, df=7, not significant). Further consideration of the birds' use of the Gruinart count area, in comparison with other parts of Islay, found that in most regions the birds were more widely dispersed in spring than in autumn, perhaps due to the depletion of the food supply as the winter progressed, but at Gruinart geese were recorded at more 1 km squares in autumn than in spring (Chi-squared=8.22, df=1, $P<0.01$). This reinforced the view that the geese concentrate in the Gruinart region in autumn, but not in spring.

Kendall's Coefficient of Concordance was used to compare the distribution of geese across 1 km squares, between years, for the 1988-89 to 1992-93 winters inclusive. The autumn and spring count data were treated separately. Results showed that the number of birds recorded in each square was consistent in autumn for the Oa count area, that the distribution within Gorm, Kilmeny and Laggan was consistent in spring, and that the distribution of geese across the 1 km squares on Gruinart was consistent each season in both autumn and spring (Table 3.1.1c). It seems, therefore, that certain traditional sites are important for the geese from year to year. The summary of the count data presented

in Appendix 1 confirms that some 1 km squares have been used by the geese in 4 or 5 winters since 1988-89. Sightings of birds in other 1 km squares in one or two winters may, perhaps, reflect greater dispersion associated with increasing numbers wintering on Islay in recent years.

Greenland White-fronted Goose counts obtained for particular farms during the 1991-92 and 1992-93 winters similarly showed that large numbers of birds generally occurred at the same farms in both winters. Mean counts of over 400 birds were recorded in both seasons at Rockside farm (Gorm) and at Ballivicar (Oa), with over 300 birds at Sunderland (Gorm), Octovullin (Kilmeny), Leorin (Oa) and Laphroaig (Ardtalla)(Appendix 2). There were statistically significant correlations between the mean number of geese counted on farms in 1991-92, compared with 1992-93, for each of the count areas (Table 3.1.1d), and when data for the whole of Islay were combined (r_s=0.83, n=80, P<0.01, Spearman Rank Correlation, Table 3.1.1d). There were also significant correlations between the number of birds counted and mean flock size for both the 1991-92 and 1992-93 winters (Table 3.1.1d), indicating that the larger counts are attributable to the birds occurring in large flocks, rather than to them dispersing into small or medium sized flocks over several fields on one farm.

Data on habitats used by the birds, recorded routinely during the all-Islay counts, were used to identify possible reasons underlying differences in the distribution of geese between count areas. Habitat data from 1988-89 to 1991-92 inclusive, originally held by N. Easterbee, NCC Scotland, were made available by the Joint Nature Conservation Committee. The 1992-93 data, which used slightly different habitat categories, was made available by the Scottish Natural Heritage office at Bowmore, Islay. The proportion of birds recorded on different types of habitat within the eight count areas in both spring and autumn are given in Tables 3.1.1e,f. Both tables show that the birds were recorded mainly on pasture land, with over 80% recorded on the pasture categories in autumn, and over 90% in spring. Less than 3% of the birds counted were found on bog or moorland, lochs, mudflats or saltmarshes during the winter. Although the type of pasture used in 1992-93 appeared to differ from the earlier data, this was probably due to variation in land classification by observers following the change in habitat codes rather than to a real change in habitat selection by the geese.

The combined 1988-89 to 1991-92 data and the figures obtained in 1992-93 both indicate that a higher proportion of the birds used arable land in autumn, compared with spring, perhaps due to the depletion of arable crops (eg fodder beet left after the harvest) as the winter progressed. The higher proportion of birds recorded on arable land in 1992-93 (15.3% in autumn and 4.0% in spring) compared with the earlier years (9.2% in autumn and 2.2% in spring) may perhaps be attributable to changes in farming practice, with more land on Islay being put to arable cultivation. The increase in use of arable land in 1992-93 seems to be due mainly to more birds feeding in stubble fields ("arable cereal") since the proportion of the Islay-wintering population

recorded on root crops was similar to observations made in 1988-89 to 1991-92. Further information on agricultural land-use throughout Islay would be necessary for a more objective assessment of the distribution of geese in relation to habitat availability.

There was marked variation between the eight count areas in the proportion of birds recorded on different types of habitat (Tables 3.1.1e,f). A comparatively high proportion of the geese recorded at Gruinart in the autumns of 1988 to 1991 were recorded on arable crops and reseeded pasture, for instance, which may perhaps explain why the geese were more concentrated in this area in autumn than in spring. At Rhinns, conversely, the birds were mostly recorded on old improved pasture in autumn, and on recently improved pasture in spring, which may be associated with a movement of birds into the area as the winter progresses. Given the doubt over the ageing of pasture, however, further observations are necessary to verify this result. Further analysis of the distribution of geese in relation to habitat variables, based on a more detailed habitat classification used for fields in the main study area during the 1992-93 winter, is described in Section 3.1.5. Information on habitat for areas where the geese were not recorded, would also help to give further insight into the extent to which habitat availability limits the distribution of Greenland White-fronted Geese on Islay.

Conclusions

1. Analysis of the distribution of Greenland White-fronted Geese on Islay from 1988-89 to 1992-93 inclusive found that the highest proportion of the wintering population, and also the largest number of 1 km squares used by the geese, were recorded in the Kilmeny count area. A comparatively small number of geese, and of 1 km squares recorded with geese, were found in the Glen and Ardtalla regions.

2. A higher proportion of the population was recorded in spring, rather than autumn, on the Rhinns peninsula. Gruinart, conversely, held more birds in autumn than in spring.

3. Certain 1 km squares proved consistently important for the geese from year to year.

4. Certain farms also held large numbers of geese in both the 1991-92 and 1992-93 winters (eg Rockside, Ballivicar, Sunderland, Octovullin, Leorin, Laphroaig), whereas others were less intensively used by the birds (Appendix 2).

5. Analysis of the distribution of birds in relation to habitat showed that over 80% of the birds counted in autumn and over 90% counted in spring were recorded on pasture, with less than 3% on bog/moorland, lochs, mudflats and saltmarshes. Within the pasture categories, the birds appeared to be evenly distributed over permanent and recently improved pasture in autumn, but concentrated on recently improved pasture in spring.

6. Arable land was used more intensively in autumn than in spring, perhaps reflecting food availability upon arrival on Islay.

7. The habitat classification should be used to describe fields not used by the geese for a more comprehensive analysis of the extent to which habitat and food availability influences the distribution of geese on the island.

Table 3.1.1a Total number of Greenland White-fronted Geese counted during the autumn and spring counts, 1988-89 to 1992-93 winters inclusive.

AUTUMN

Count area	6/12/88 (%)	2/12/89 (%)	1/12/90 (%)	1/12/91 (%)	12/12/92 (%)	Mean (%)
RHINNS	512 (6.7)	910 (9.6)	627 (7.2)	894 (8.9)	871 (9.2)	763 (8.4)
GORM	1086 (14.2)	781 (8.3)	814 (9.3)	1665 (16.6)	1499 (15.8)	1169 (12.9)
GRUINART	1073 (14.1)	982 (10.4)	1259 (14.5)	843 (8.4)	758 (8.0)	783 (10.9)
KILMENY	1795 (23.5)	3704 (39.2)	1881 (21.6)	2297 (23.0)	2521 (26.6)	2320 (25.6)
LAGGAN	1106 (14.5)	1094 (11.6)	1471 (16.9)	1189 (11.9)	1138 (12.0)	1200 (13.2)
OA	1180 (15.5)	1136 (12.0)	1741 (20.0)	2243 (22.4)	1930 (20.4)	1646 (18.2)
ARDTALLA	240 (3.1)	311 (3.3)	291 (3.3)	385 (3.8)	248 (2.6)	295 (3.3)
GLEN	641 (8.4)	534 (5.6)	628 (7.2)	487 (4.9)	512 (5.4)	560 (6.2)
TOTAL	7633	9452	8712	10,003	9477	9055

SPRING

Count area	30/3/89 (%)	10/2/90 (%)	24/3/91 (%)	10/2/92 (%)	09/3/93 (%)	Mean (%)
RHINNS	744 (10.9)	881 (11.5)	965 (10.8)	1269 (12.9)	966 (9.0)	965 (11.0)
GORM	906 (13.2)	1236 (16.2)	1132 (12.7)	1664 (16.9)	1943 (18.2)	1376 (15.7)
GRUINART	193 (2.8)	340 (4.4)	268 (3.0)	527 (5.4)	467 (4.4)	359 (4.1)
KILMENY	2264 (33.0)	1695 (22.2)	3241 (36.4)	2774 (28.2)	2713 (25.4)	2537 (28.9)
LAGGAN	982 (14.3)	1645 (21.5)	811 (9.1)	1143 (11.6)	1261 (11.8)	1168 (13.3)
OA	1413 (20.6)	873 (11.4)	1511 (16.9)	1752 (17.8)	2543 (23.8)	1618 (18.4)
ARDTALLA	0 (0)	465 (6.1)	580 (6.5)	237 (2.4)	422 (4.0)	341 (3.9)
GLEN	351 (5.1)	506 (6.6)	407 (4.6)	473 (4.8)	363 (3.4)	420 (4.8)
TOTAL	6853	7641	8915	9839	10678	8785

Table 3.1.1b Number of 1 km squares in each count area that held Greenland White-fronted Geese, 1988-89 to 1992-93 winters inclusive.

AUTUMN

Count area	06/12/88 (%)	02/12/89 (%)	01/12/90 (%)	1/12/91 (%)	12/12/92 (%)	Mean (%)
RHINNS	5 (7.9)	7 (9.0)	3 (4.3)	7 (10.3)	7 (10.0)	6 (8.6)
GORM	3 (4.8)	7 (9.0)	5 (7.1)	6 (8.8)	8 (11.4)	6 (8.6)
GRUINART	11 (17.5)	16 (20.5)	12 (17.1)	13 (19.1)	10 (14.3)	12 (17.1)
KILMENY	15 (23.8)	18 (23.1)	18 (25.7)	13 (19.1)	19 (27.1)	17 (24.3)
LAGGAN	16 (25.4)	16 (20.5)	12 (17.1)	14 (20.6)	10 (14.3)	14 (20.0)
OA	9 (14.3)	9 (11.5)	13 (18.6)	11 (16.2)	10 (14.3)	10 (14.3)
ARDTALLA	1 (1.6)	1 (1.3)	2 (2.9)	1 (1.5)	1 (1.4)	1 (1.4)
GLEN	3 (4.8)	4 (5.1)	5 (7.1)	3 (4.4)	5 (7.1)	4 (5.7)
TOTAL	63	78	70	68	70	70

SPRING

Count area	30/3/89 (%)	10/2/90 (%)	24/3/91 (%)	10/2/92 (%)	09/3/93 (%)	Mean (%)
RHINNS	5 (7.4)	9 (10.3)	6 (10.0)	12 (12.5)	9 (10.1)	8 (10.3)
GORM	7 (10.3)	6 (6.9)	5 (8.3)	14 (14.6)	14 (15.7)	9 (11.5)
GRUINART	5 (7.4)	9 (10.3)	6 (10.0)	14 (14.6)	8 (9.0)	8 (10.3)
KILMENY	24 (35.3)	25 (28.7)	16 (26.7)	21 (21.9)	21 (23.6)	21 (26.9)
LAGGAN	12 (17.6)	19 (21.8)	14 (23.3)	14 (14.6)	17 (19.1)	15 (19.2)
OA	11 (16.2)	12 (13.8)	8 (13.3)	14 (14.6)	16 (18.0)	12 (15.4)
ARDTALLA	0 (0)	2 (2.3)	1 (1.7)	2 (2.1)	1 (1.1)	1 (1.3)
GLEN	4 (5.9)	5 (5.7)	4 (6.7)	5 (5.2)	3 (3.4)	4 (5.1)
TOTAL	68	87	60	96	89	78

Table 3.1.1c. Kendall's Coefficient of Concordance (W), used to determine whether the number of birds recorded in each 1 km square within the eight main count areas on Islay is consistent from year to year (for the 1988-89 to 1992-93 winters). Autumn and spring data are treated separately.

Count Area	Season	W	d.f.	P	Sig.
Ardtalla	Autumn	0.130	2	0.52	n.s.
	Spring	0.040	3	0.90	n.s.
Glen	Autumn	0.346	6	0.11	n.s
	Spring	0.101	6	0.81	n.s.
Gorm	Autumn	0.202	12	0.44	n.s.
	Spring	0.382	20	0.01	**
Kilmeny	Autumn	0.231	38	0.23	n.s.
	Spring	0.385	41	0.001	***
Laggan	Autumn	0.290	24	0.71	n.s.
	Spring	0.364	28	0.01	**
Rhinns	Autumn	0.076	15	0.98	n.s.
	Spring	0.228	18	0.30	n.s.
Gruinart	Autumn	0.365	21	0.01	**
	Spring	0.335	17	0.04	*
Oa	Autumn	0.340	23	0.02	*
	Spring	0.241	26	0.21	n.s.

Table 3.1.1d. Results of Spearman Rank Correlations used to compare (a) the mean number of birds counted on farm areas during the 1991-92 and 1992-93 winters (b) the association between the total number of birds and flock size in 1991-92 and (c) the association between the total number of birds and flock size in 1992-93. Raw data presented in Appendix 2.

	(a) Mean counts 91/92 vs 92/93			(b) Mean tot. count vs mean flock size 1991-92			(c) Mean tot. count vs mean flock size 1992-93		
Count area	r	n	P	r	n	P	r	n	P
Rhinns	0.62	13	0.05	0.65	13	0.01	0.51	13	0.05
Gorm	0.89	9	0.01	0.91	8	0.01	0.93	9	0.01
Gruinart	0.74	8	0.05	0.78	7	0.05	0.40	8	n.s.
Kilmeny	0.87	15	0.01	0.69	15	0.01	0.07	15	n.s.
Laggan	0.72	15	0.01	0.55	15	0.05	0.77	15	0.01
Oa	0.85	11	0.01	0.11	11	n.s.	0.48	11	n.s.
Glen and Ardtalla	0.95	9	0.01	0.66	9	0.05	0.56	9	0.05
All Islay	0.83	80	0.01	0.52	78	0.01	0.41	80	0.05

n.s. = not statistically significant

Table 3.1.1e. Distribution of geese recorded during the all-Islay counts across the different habitat categories, 1988-89 to 1991-92 winters inclusive. Data from all counts made were included, as opposed to the maximum counts given in Tables 3.1.1a,b.

AUTUMN

	PERCENTAGE OF BIRDS ON EACH HABITAT CATEGORY									
COUNT AREA	Arable Root	Arable Cereal	Re-seed	RIP	OIP	PP/ RP(+J)	Bog/ Moor	Loch	Mud/ S-M	TOTAL
Rhinns	2.5	2.8	2.6	25.1	53.5	13.6	0.0	0.0	0.0	5948
Gorm	0.5	1.5	6.7	42.1	25.2	19.7	0.1	4.2	0.0	9050
Gruinart	16.8	8.5	18.8	18.9	18.4	16.9	0.9	0.0	0.8	8179
Kilmeny	8.0	2.4	6.5	46.2	21.3	15.3	0.3	0.0	0.0	22814
Laggan	5.6	5.0	2.3	57.6	0.2	12.8	0.8	0.3	0.0	8958
Glen	6.1	1.5	1.7	66.5	22.4	1.7	0.0	0.0	0.0	4885
Oa	3.4	0.0	6.0	10.4	58.3	18.6	0.7	2.7	0.0	13222
Ardtalla	9.4	0.0	1.5	0.0	55.5	33.5	0.0	0.0	0.0	2254
All-Islay	6.4	2.8	6.5	36.1	30.9	15.8	0.4	1.0	0.04	75310

SPRING

	PERCENTAGE OF BIRDS ON EACH HABITAT CATEGORY									
COUNT AREA	Arable Root	Arable Cereal	Re-seed	RIP	OIP	PP/ RP(+J)	Bog/ Moor	Loch	Mud/ S-M	TOTAL
Rhinns	0.6	0.0	4.2	56.9	21.1	16.7	0.7	0.0	0.0	10694
Gorm	0.3	2.2	5.0	50.7	28.0	9.2	2.0	2.6	0.0	14739
Gruinart	2.5	0.5	16.4	25.8	14.5	33.2	6.7	0.0	0.4	3966
Kilmeny	1.5	0.3	10.2	58.8	18.9	8.9	0.3	1.0	0.1	28372
Laggan	4.0	0.8	8.4	61.3	11.5	13.0	1.0	0.0	0.0	10445
Glen	2.1	0.4	10.8	72.5	6.4	7.7	0.0	0.0	0.0	4972
Oa	1.4	0.0	8.4	28.5	44.5	16.8	0.0	0.4	0.0	16093
Ardtalla	3.9	0.0	0.0	54.6	41.3	0.2	0.0	0.0	0.0	3935
All-Islay	1.6	0.6	8.0	51.5	24.3	12.3	0.9	0.8	0.1	93216

Note: RIP = Recently improved pasture (< 5years)
OIP = Old improved pasture (> 5 years)
PP/RP(+J) = Permanent pasture (possibly improved), Rough/Rank pasture, possibly with Juncus
Mud/S-M = Mudflat and Saltmarsh

Table 3.1.1f. Distribution of geese recorded during the all-Islay counts across the different habitat categories in the 1992-93 winter. Data from all counts made were included, as opposed to the maximum counts given in Tables 3.1.1a,b.

AUTUMN

PERCENTAGE OF BIRDS ON EACH HABITAT CATEGORY

COUNT AREA	Arable Root	Arb. Cer.	Re-seed	RIP	RIP/ OIP	OIP	PP/ RP(+J)	Bog/ Moor	Loch	Mud/ S-M	TOTAL
Rhinns	0.0	4.6	0.0	31.7	56.7	6.5	0.3	0.0	0.2	0.0	7198
Gorm	0.0	28.2	0.0	6.0	36.1	8.1	17.3	0.8	2.5	1.0	11673
Gruinart	9.1	7.8	0.0	5.1	47.2	17.1	7.0	3.2	3.0	0.5	6640
Kilmeny	10.7	3.1	0.0	3.2	68.5	2.8	7.6	3.9	0.0	0.0	15179
Laggan	3.8	24.5	0.0	29.3	33.3	9.9	1.3	2.8	0.0	0.5	8086
Glen	6.9	7.9	0.0	14.3	62.4	8.5	0.0	0.0	0.0	0.0	5191
Oa	3.8	0.0	0.0	45.9	30.6	15.5	4.1	0.0	0.0	0.0	12796
Ardtalla	6.5	0.0	0.0	42.9	50.6	0.0	0.0	0.0	0.0	0.0	2218
All-Islay	5.1	10.2	0.0	19.3	47.6	9.0	6.2	1.6	0.7	0.3	68981

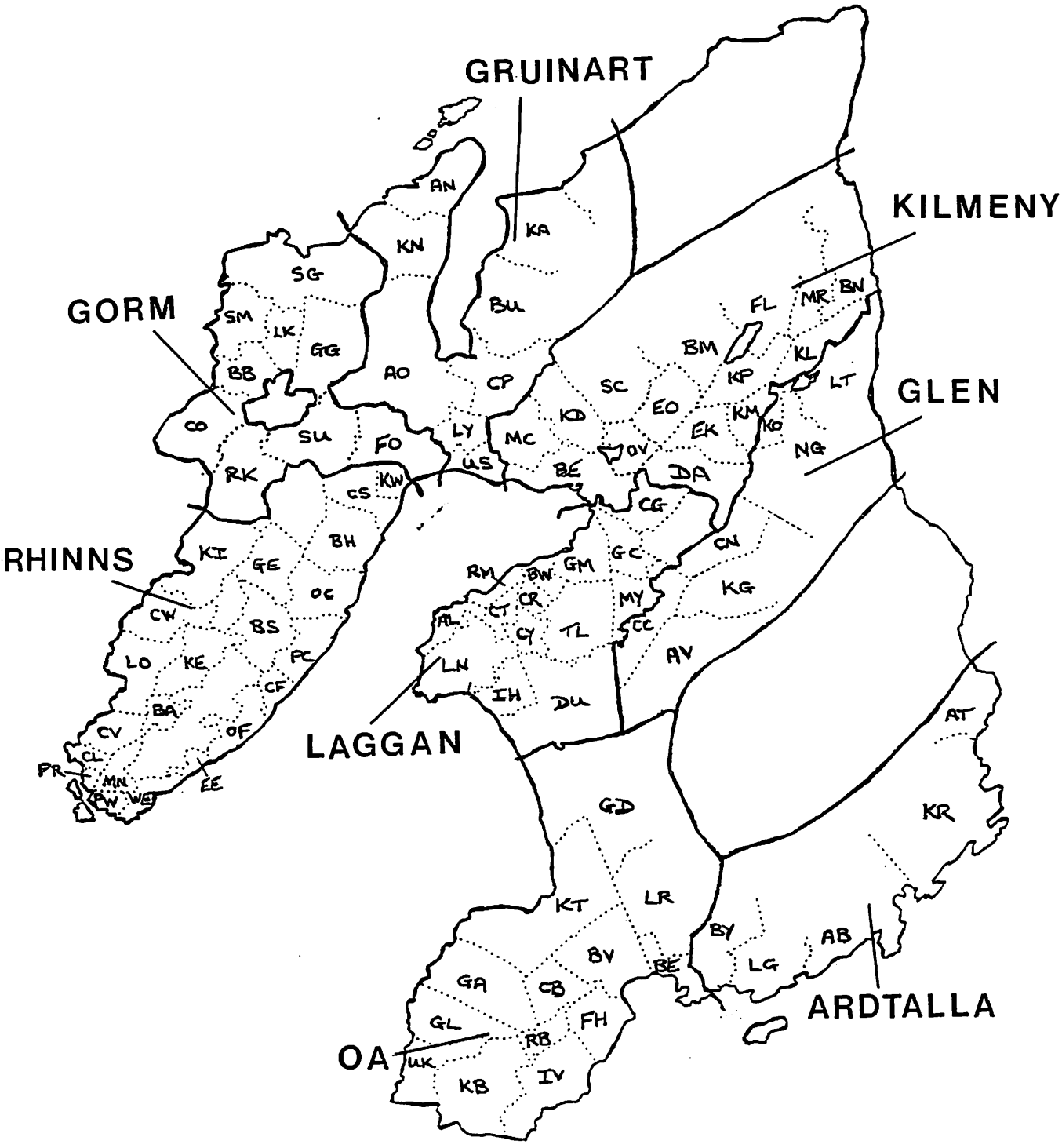
SPRING

PERCENTAGE OF BIRDS ON EACH HABITAT CATEGORY

COUNT AREA	Arable Root	Arb. Cer.	Re-seed	RIP	RIP/ OIP	OIP	PP/ RP(+J)	Bog/ Moor	Loch	Mud/ S-M	TOTAL
Rhinns	0.2	7.4	0.0	24.2	55.6	4.5	7.6	0.5	0.0	0.0	10678
Gorm	0.0	1.2	0.0	37.9	51.5	2.4	2.9	2.3	1.6	0.0	12944
Gruinart	4.9	4.4	0.0	24.0	38.4	8.8	3.3	15.1	0.4	0.6	3618
Kilmeny	2.3	1.5	0.0	14.2	70.8	3.7	5.8	1.2	0.3	0.1	23528
Laggan	4.4	2.0	0.3	13.0	66.2	9.4	4.5	0.1	0.0	0.2	9587
Glen	2.3	3.2	0.0	18.4	66.3	5.2	3.6	0.9	0.0	0.0	5101
Oa	0.0	0.0	0.0	34.9	40.2	15.9	7.1	0.9	1.1	0.0	20497
Ardtalla	14.1	0.0	0.0	27.4	55.2	0.0	3.3	0.0	0.0	0.0	3727
All-Islay	2.0	2.0	0.02	24.6	56.5	7.2	5.4	1.6	0.6	0.04	89680

Note: RIP = Recently improved pasture (< 5years)
OIP = Old improved pasture (> 5 years)
PP/RP(+J) = Permanent pasture (possibly improved), Rough/Rank pasture, possibly with Juncus
Mud/S-M = Mudflat and Saltmarsh

Figure 3.1.1a The eight main count areas covered during all-island counts of Greenland White-fronted Geese on Islay.



Farms within the different count areas on Islay illustrated in Figure 3.1.1a:

Count Area	Farm
RHINNS	Kentraw (KW), Conisby (CS), Bruichladdich (BH), Octomore (OC), Port Charlotte (PC), Bolsay (BS), Gearach (GE), Kilchiaran (KI), Carn West (CW), Kelsay (KE), Lossit Farm (LO) Ballimony (BA), Cladville (CV), Balymeanach (MN), Claddach (CL), Portnahaven(PR), Port Wemyss(PW), West Ellister (WE), East Ellister (EE) Octofad (OF), Craigfad (CF).
GORM	Foreland (FO), Sunderland (SU), Rockside (RK), Coul (CO), Smaull (SM), Ballinaby (BB), Leek (LK), Sanaig (SG), Grulinbeg (GG).
GRUINART	Uisge an t-Suidhe (US), Lyrabus (LY), Corsapol (CP), Bun an Uillt (BU), Killinallan (KA), Aoradh (AO), Kilnave (KN), Ardnave (AN).
KILMENY	Mid Carrabus (MC), Bridgend (BE), Knockdon (KD), Octovullin (OV), Scarrabus (SC), Eorrabus (EO), Daill (DA), Esknish (EK), Ballimartin (BM), Kepolls (KP), Kilmeny (KM), Kiells (KL), Finlaggan (FL), Mulreesh (MR), Bunnahabhain (BN).
LAGGAN	Duich (DU), Island House (IH), Laggan (LN), Corrary (CY), Clanchantree (CT), Ronnachmore (RM), Ardlarach (AL), Bowmore (BW), Gartmain (GM), Cruach (CR), Tallant (TL), Gartachossan (GC), Claggan (CG), Neriby (NB), Mulindry (MY).
GLEN	Knocklearoch (KO), Lossit (estate) (LT), North Glen (NG), Cluanach (CN), Kynagarry (KG), Ceannacroic (CC), Avenvogie (AV).
ARDTALLA	Brahunisary (BY), Laphroaig (LG), Ardbeg (AB), Kintour (KR), Ardtalla (AT).
OA	Upper Killeyan (UK), Kinnabus (KB), Giol (GL), Risabus (RB), Inveraval (IV), Glen Astaile (GA), Cragabus (CB), Ballivicar (BV), Kintra (KT), Port Ellen (PE), Leorin (LR), Glenegedale (GD), Carraig Fhada (FH)

3.1.2 Variation in reproductive success: annually, between regions and between habitats

Introduction

The number of birds that had their ages checked, and the number of juveniles counted in each flock, were recorded at intervals throughout the 1991-92 and 1992-93 winters. Additional data for the 1987-88 to 1990-91 winters, kindly made available by Malcolm Ogilvie, were also included in the analyses. Variation in the distribution of family parties was considered both at a farm level and between count areas. Any such variation might be attributable to differences in food supply affecting the condition of the birds in winter, which might in turn influence their reproductive success the following summer, or to sub-populations on Islay remaining in discrete groups and nesting under differing conditions in the breeding range, or to both of these factors.

Results

The proportion of juveniles recorded at 87 farms during the 1991-92 and 1992-93 winters is given in Table 3.1.2a, and at up to 38 farms from 1987-88 to 1992-93 inclusive in Table 3.1.2b. There appeared to be marked annual variation in reproductive success, with the percentage of goslings recorded in the Islay-wintering population ranging from 8.4% during the 1992-93 winter to 24.3% in the 1988-89 winter (Table 3.1.2b). Estimates of the number of juveniles in the population may be influenced, however, by some flocks being counted more frequently than others, which would bias the results in the event of there being an uneven distribution of family groups across Islay. The more extensive juvenile count data obtained in 1991-92 and 1992-93 was therefore weighted to control for variation in coverage of the different farms, and comparisons of the breeding success of flocks recorded at the different farms were made for these two years. The three ways used to estimate the percentage of juveniles recorded between count areas when comparing the more extensive 1991-92 and 1992-93 data were:

(a) to calculate the mean percentage of juveniles recorded on each farm within the count area during the winter

(b) to estimate the number of juveniles that would be present at each farm, given the observed percentage of juveniles recorded, for the mean count of that farm during the winter (derived from Table 3.1.1e). These figures were then used, together with the sum of the mean counts for farms in each count area, to calculate the percentage of juveniles in each count area.

(c) to calculate the total number of juveniles recorded on farms within each count area as a percentage of the total number of birds age-checked within the count area, irrespective of the number of counts made of the different farms.

Results of the Pearson correlations used to determine whether differences between the count areas in the reproductive success of the birds are consistent from year to year (based on observations made in the 1991-92 and 1992-93 winters) are given in Table 3.1.2c. There was a significant inverse relationship between the 1991-92 and 1992-93 data when an average of the percentage juveniles recorded on farms within each study area (method (a) above) was used for the analysis ($r=-0.801$, $P=0.03$, Table 3.1.2c, Figure 3.1.2a). Count areas with a low proportion of juveniles in one year, in comparison with flocks seen in other parts of Islay, had a comparatively high proportion in the next, and vice versa. This result should be treated with caution, since the availability of stubble fields varied between these two seasons (R. Macdonald pers. comm.), although further analysis found that the distribution of juveniles was not affected by habitat variables (see pages 32-33 below and Section 3.1.5). There was no evidence for consistent variation between years in the breeding success of birds seen in each of the count areas when the other two methods of estimating percentage of juveniles were used, however (Table 3.1.2c). A comparison of the percentage of juveniles recorded for individual farms within each of the study areas in the two winters similarly found little evidence for consistent variation between years; a positive correlation was obtained for farms in the Rhinns region ($r=0.741$, $P<0.05$) but results for the other count areas were not statistically significant (Table 3.1.2d).

Although the comparison of the 1991-92 and 1992-93 data
Consistency in the reproductive success of geese observed on individual farms and within the eight count areas from 1987-88 to 1992-93 inclusive was assessed by an ad hoc Randomisation test, since Kendall's Coefficient of Concordance was unable to control for the absence of data in some years. The Randomisation test statistic was the sum of the products of the ranked farm counts for the 6 winters. Missing data was ranked as 1, so made no contribution to the sum of the products obtained for that farm. The observed test statistic was compared with 5000 randomised values (where the farm rank was changed at random). Results showed that the test statistic was significantly large in comparison with the randomised values at the 4.98% level when the ranked farm counts were considered, and that the level of significance improved to the 1.20% level when the un-ranked count data was used. Further analysis comparing the percentage of juveniles recorded within count areas, rather than on individual farms, also found some consistency between years, but the results did not reach statistical significance ($P=0.079$ for the ranked data and $P=0.15$ for the original count data). It seems, therefore, that there is a broad tendency for geese wintering on different parts of Islay to show consistent variation in their reproductive success over several years, particularly when the birds are considered on a farm-by-farm basis.

The distribution of juveniles in relation to habitat and other variables throughout Islay was analysed for the 1991-92 season, since this provided the most comprehensive information habitat

data for the island. Habitat selection by families in the main study area during the 1992-93 season, using more detailed habitat classifications, is described in Section 3.1.5. A general linear model (GLM) was used to assess the effects of count area, time of year (ie the month of the all-Islay count), type of habitat and flock size (ie number of geese in the field) upon the percentage of juveniles recorded in each field (arcsin transformed). Results confirmed that count area had a significant effect on the percentage of juveniles recorded, and found that the time of year was also a significant factor (Table 3.1.2e, Fig.3.1.2b). Variation in the percentage of juveniles recorded during the winter season may perhaps reflect differences in the timing of migration of the family parties, with non-breeders tending to arrive earlier than breeding birds, and for juveniles to be amongst the last to leave. The percentage of juveniles did not appear to be associated with habitat, or with the number of geese in the field (Tables 3.1.2e,f). There appeared to be marked variation in the percentage of juveniles recorded for fields allocated the same habitat code (as indicated by the high standard deviation values in Table 3.1.2f), which may account for the non-significant result.

Conclusions

1. The results indicate that there is an uneven distribution of family parties on Islay, with certain sites tending to have a higher percentage of juveniles over several winters than other areas.

2. The consistency in reproductive success was more apparent at the farm level than between count areas. It seems, therefore, that within each count area there are certain sites or farms that receive a higher percentage of juveniles than others over several years.

3. There was little evidence to suggest that the percentage of juveniles recorded on particular farms within each of the count areas was consistent from year to year for two seasons with more extensive data (1991-92 and 1992-93). Data obtained over longer periods therefore appear to be necessary for analysis of consistency in the distribution of family parties on Islay.

4. Further analysis of factors affecting the distribution of juveniles during the 1991-92 winter confirmed that count area was a relevant factor and showed that the percentage of juveniles varies during the winter. Variation between fields in the percentage of juveniles recorded was not found to be attributable to habitat (based on the habitat codes used during the 1991-92 winter) or to the number of geese in the flock. There was no evidence to suggest, therefore, that the families selected one type of habitat over another.

5. The question of whether consistency in the percentage of juveniles recorded at individual farms is due to the same birds breeding well in successive years, and to them returning to the same part of Islay, requires data on the number of goslings accompanying ringed individuals over several winters. The high level of site fidelity and limited home range of individual birds, however (see Sections 3.1.3 and 3.1.4 below), indicates that this may be the case.

6. Further research, including a more detailed behavioural study, would help to identify the biological reasons underlying the consistency in reproductive success. Relevant variables may include differences in the food supply, feeding efficiency, social behaviour and condition of the birds in winter, site fidelity at the spring staging areas and differences in distribution in the breeding range.

Table 3.1.2a Age counts by farm; 1991-92 and 1992-93 winters.

FARM	Name	1991-92 Mean Count	1991-92 Mean % Juv	1992-93 Mean Count	1992-93 Mean % Juv
RHINNS:					
BH	Bruichladdich	210.7	15.5	141.0	2.8
BS	Bolsay	34.3	39.3		
CL	Claddach	1.7	0.0	0.9	1.0
CS	Conisby	50.6	16.2	147.9	4.4
CV	Cladville	105.7	11.6	115.6	2.3
EE	Easter Ellister	1.8	0.0	4.3	-
KI	Kilchiaran	196.0	10.2	50.2	-
KW	Kentraw	103.4	17.4	66.2	6.4
LO	Lossit farm (Rhinns)	27.3	12.8	8.6	-
MN	Balymeanach	142.2	16.0	28.1	-
OF	Octofad	135.5	15.6	73.2	6.3
OM	Octomore	219.7	7.4	145.0	4.1
PC	Port Charlotte	170.7	11.3	218.7	4.0
PW	Port Wemyss	1.4	46.2	16.0	12.5
WE	Wester Ellister	29.2	10.2	16.3	10.3
GORM:					
BB	Ballinaby	157.5	25.7	105.0	4.8
CO	Coul	212.1	14.0	323.9	10.6
FO	Foreland	150.5	13.0	50.7	5.5
GG	Grulinbeg	81.6	31.4	53.5	2.5
LK	Leek	112.0	12.6	189.8	3.1
RK	Rockside	448.7	12.4	403.3	14.5
SG	Sanaig	76.2	19.8	31.1	1.9
SM	Smaull	0.0	-	8.1	-
SU	Sunderland	384.4	13.3	305.6	4.8
GRUINART:					
AN	Ardnave	1.7	7.5	23.1	-
AO	Aoradh	148.5	15.5	210.3	4.9
BU	Bun an Uillt	7.9	0.0	2.3	-
CP	Corsapol	61.2	15.8	235.2	8.9
KA	Killinallan	0.0	-	1.1	-
KN	Kilnave	9.7	6.0	1.2	11.8
LY	Lyrabus	104.7	18.5	108.8	8.4
US	Uisge an t-Suidhe	105.6	9.2	71.2	12.8
KILMENY:					
BE	Bridgend	279.4	17.8	249.4	6.1
BM	Ballimartin	161.9	20.1	140.0	4.6
BN	Bunnahabhain	34.2	28.7	64.8	80.0
DA	Daill	52.2	16.0	44.7	-
EK	Esknish	226.3	10.8	273.1	8.9
EO	Eorrabus	325.4	13.5	288.3	8.7
FL	Finlaggan	158.5	13.8	120.8	3.6
KD	Knockdon	48.6	18.2	31.4	0.0
KL	Kiells	252.7	17.1	185.1	4.9
KM	Kilmeny	170.9	16.8	102.8	-
KP	Kepolls	305.0	12.2	144.3	2.4
MC	Mid Carrabus	196.1	16.9	109.9	4.3
MR	Mulreesh	88.5	9.8	120.2	0.0
OV	Octovullin	649.8	12.0	362.8	7.8
SC	Scarrabus	105.2	-	29.0	8.3

Table 3.1.2a (cont.) Age counts by farm; 1991-92 and 1992-93 winters.

		MEAN FARM TOTALS			
		1991-92		1992-93	
FARM	Name	MEAN TOTAL	N	MEAN TOTAL	No. FLKS
LAGGAN:					
AL	Ardlarach	24.4	15.4	28.3	16.7
BW	Bowmore	24.1	38.5	3.5	-
CG	Claggan	32.9	10.6	80.7	-
CR	Cruach	43.3	6.1	7.9	-
CT	Clachantree	57.6	7.9	81.4	5.3
CY	Corrary	128.6	26.6	109.4	7.4
DU	Duich	2.1	0.0	.6	0.0
GC	Gartachossan	272.4	14.4	113.8	6.6
GM	Gartmain	65.9	39.4	48.1	6.5
IH	Island House	24.3	23.9	100.0	7.7
LN	Laggan	49.3	22.8	61.4	0.0
MY	Mulindry	151.0	14.5	88.4	17.5
NB	Neriby	124.3	7.3	98.4	15.7
RM	Ronnachmore	61.7	7.0	34.9	1.8
TL	Tallant	203.9	14.3	124.8	0.0
GLEN:					
AV	Avenvogie	177.1	8.9	155.3	4.7
CC	Ceannacroic	81.1	13.9	72.4	7.1
CN	Cluanach	251.4	16.5	134.6	5.6
KG	Kynagarry	128.3	-	85.7	-
KO	Knocklearoch	95.3	-	73.7	-
LO	Lossit (estate)	11.4	-		-
NG	North Glen	94.9	10.9	50.2	16.7
OA:					
BV	Ballivicar	428.6	13.6	600.9	11.0
CB	Cragabus	16.4	40.4	7.0	-
FH	Carraig Fhada				
GA	Glen Astaile	0.0	-		
GD	Glenegedale	56.8	27.8	70.1	4.3
GL	Giol	239.6	10.7	119.7	6.9
IV	Inveraval	55.0	-	28.5	-
KB	Kinnabus	278.5	14.5	311.4	0.8
KT	Kintra	148.7	18.9	241.8	11.7
LR	Leorin	553.9	9.1	357.9	3.7
PE	Port Ellen	30.7	-	8.6	-
RB	Risabus	180.3	24.2	115.2	0.5
UK	Upper Killeyan	105.3	20.0	51.5	3.7
ARDTALLA:					
AB	Ardbeg	7.3	-	6.2	-
AT	Ardtalla	0.0	-		
BY	Brahunisary	19.0	-	3.0	-
KR	Kintour	0.0	-		
LG	Laphroaig	341.1	11.4	321.1	3.7

Table 3.1.2b Percentage of juveniles counted on farms within the different count areas between 1987-88 and 1992-93 inclusive. 1987-88 to 1990-91 data collected by Malcolm Ogilvie.

	1987-88			1988-89			1989-90			1990-91			1991-92			1992-93		
	No. Juv	No. Aged	% Juv	No. Juv	No. Aged	% Juv	No. Juv	No. Aged	% Juv	No. Juv	No. Aged	% Juv	No. Juv	No. Aged	% Juv	No. Juv	No. Aged	% Juv
Glen																		
AV				83	336	24.7	22	172	12.7				26	291	8.9	11	235	4.7
CC							162	14	8.6	48	300	16.0	26	187	13.9	7	98	7.1
CN				24	193	12.4	200	37	18.5	25	55	45.5	211	1278	16.5	10	177	5.6
KG							17	10	58.8	13	54	24.1						
KO	35	262	13.4	24	100	24.0				156	513	30.4						
Gorm																		
BB	46	162	39.7										235	914	25.7	16	330	4.8
CO	47	322	14.6	75	341	23.0				34	176	19.3	181	1289	14.0	169	1601	10.6
RK	85	384	22.1	137	663	20.7	83	669	12.4	47	226	20.8	451	3630	12.4	988	6801	14.5
SU	46	195	23.6	169	632	26.7	101	535	18.9	38	239	15.9	1056	7969	13.3	344	7147	4.8
S/R/C	54	265	20.4															
Gruinart																		
AN				5	50	10.0							12	160	7.5			
AO	60	385	15.6	165	557	29.6	253	804	31.5	38	89	42.7	38	89	42.7	66	1345	4.9
CP										8	85	9.4	38	240	15.8	66	744	8.9
LY							9	66	13.6				34	184	18.5	52	616	8.4
US	28	158	17.7	78	243	32.1	29	68	38.2	49	232	21.1	28	305	9.2	65	507	12.8
Kilmeny																		
BE				68	230	29.6	54	213	25.3	30	135	22.2	274	1537	17.8	66	1081	6.1
BM										12	110	10.9	131	653	20.1	7	153	4.6
EK				63	251	25.1	35	259	13.5				68	632	10.8	128	1434	8.9
EO				84	447	18.8				49	251	19.5	191	1411	13.5	375	4296	8.7
FL				85	292	29.1							12	87	13.8	7	193	3.6
KL				56	265	21.1	71	197	36.0				125	732	17.1	17	350	4.9
KM				39	153	25.5				30	135	22.2	63	376	16.8			
KP							20	77	26.0	30	192	15.6	189	1554	12.2	31	1306	2.4
MC										15	33	45.5	111	657	16.9	6	139	4.3
MR	28	156	17.9										29	297	9.8	0	132	0
OV	89	489	18.2	54	200	27.0	48	268	17.9	67	318	21.1	244	2028	12.0	413	5276	7.8
Laggan																		
AL										53	226	23.5	39	254	15.4,	41	246	16.7
CY	16	83	19.3	50	217	23.0							87	327	26.6	6	81	7.4
MY										26	147	17.7	62	429	14.5	10	57	17.5
NB	37	234	15.8	99	407	24.3				54	195	27.7	13	178	7.3	20	127	15.7
TL	7	35	20.0										98	684	14.3	0	17	0
Oa																		
BV	43	311	13.8	87	396	22.0	195	657	29.7				198	1460	13.6	55	501	11.0
GL				32	145	22.1							112	1050	10.7	16	232	6.9
KB							199	841	23.7				92	636	14.5	3	366	0.8
KT	13	72	18.1															
LR				107	413	25.9							182	1992	9.1	17	461	3.7
Rhinns																		
CW	23	122	21.3															
OM							26	248	10.5				73	991	7.4	22	531	4.1

All Islay

	1987-88			1988-89			1989-90			1990-91			1991-92			1992-93		
GLEN	35	267	13.4	131	629	20.8	83	551	15.1	242	922	26.2	263	1756	15.0	28	510	5.5
GORM	278	1328	20.9	381	1636	23.3	184	1204	15.3	119	641	18.6	1923	13802	13.9	1517	15879	9.6
GRUI	88	543	16.2	248	850	29.1	288	938	30.7	95	406	23.4	150	978	15.3	249	3212	7.8
KILM	117	645	18.1	449	1838	24.4	228	1014	22.5	233	1174	19.8	1437	9964	14.4	1050	14360	7.3
LAGG	60	352	17.0	149	624	23.9	-	-	-	133	568	23.4	299	1872	16.0	77	528	14.6
OA	56	383	14.6	226	954	23.7	394	1498	26.3	-	-	-	584	5138	11.4	91	1560	5.6
RHIN	23	122	18.9	-	-	-	26	248	10.5	-	-	-	73	991	7.4	22	531	4.1
TOT	657	3635	18.1	1584	6531	24.3	1203	5453	22.1	822	3711	22.2	4729	34501	13.7	3034	36580	8.3

Table 3.1.2c. Comparison of percentage juveniles recorded between different count areas during the 1991-92 and 1992-93 winters.

	Original % juvs (method a)		% juvs weighted by mean farm count (method b)		% juvs weighted by no. birds aged (method c)	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
RHINNS	15.3%	5.4%	14.4%	4.1%	12.8%	4.0%
GORM	17.8%	6.0%	15.5%	8.4%	14.7%	8.5%
GRUINART	10.4%	9.4%	14.2%	7.9%	13.8%	7.8%
KILMENY	16.0%	5.0%	14.0%	5.8%	15.7%	7.3%
LAGGAN	16.6%	7.1%	16.2%	7.5%	14.6%	8.6%
OA	19.9%	5.3%	14.4%	6.6%	13.4%	6.1%
GLEN and ARDTALLA	12.3%	7.6%	12.5%	5.5%	13.7%	8.1%
OVERALL	15.5%	6.5%	14.5%	6.6%	14.4%	7.6%
r	-0.801		0.541		0.632	
p	0.03		n.s.		n.s.	

Table 3.1.2d. Results of Pearson correlations used to compare the percentage of juveniles recorded within the different count areas in 1991-92 and 1992-93. Analyses were made using the original count data, given in Table 3.1.2a above.

	n	r	p
RHINNS	10	0.741	<0.05
GORM	8	-0.478	n.s.
GRUINART	5	-0.740	n.s.
KILMENY	12	-0.121	n.s.
LAGGAN	12	0.050	n.s.
OA	8	-0.225	n.s.
GLEN and ARDTALLA	5	-0.130	n.s.

Note: The count of 10 birds, of which 8 were goslings, at Bunnahabhain (BN) in Kilmeny were excluded from the analyses presented in Tables 3.1.2c,d since an estimate of 80% juveniles for only a small number of birds counted was considered likely to bias the results.

n.s. = not statistically significant.

Table 3.1.2e. Factors affecting the percentage of juveniles (arcsin transformed) on Islay during the 1991-92 winter, as determined by GLM analysis.

Variable	F-value	df	P	Significance level
Half month	4.27	12	0.000	***
Count area	3.43	7	0.001	***
Flock size	1.62	1	0.203	ns
Habitat code	1.21	7	0.293	ns

Note: *** = Statistically significant at the P<0.001 level
ns = Not significant

Table 3.1.2f. Distribution of juveniles in relation to habitat variables during the 1991-92 winter, based on observations made during the all-Islay counts.

Habitat	No.fields counted (n)	Mean % Juvs	SD	SE
Arable cereal	40	16.9	18.6	2.9
Arable root crop	14	15.0	17.7	4.7
Bog/Moor	36	20.7	24.5	4.1
Permanent Pasture	267	17.3	22.0	1.4
Old improved pasture	32	27.1	23.1	4.1
Recently improved pasture	286	18.3	19.3	1.1
Improved pasture (date uncertain)	47	19.6	22.1	3.2
Re-seeded field	46	19.0	18.2	2.7
Overall	768	18.4	20.8	-

Figure 3.1.2a Correlation between the percentage of juveniles recorded in the 1991-92 and 1992-93 winters for each of the count areas. Count areas: RH=Rhinns, GM=Gorm, GR=Gruinart, KM=Kilmeny, GL=Glen, LN=Laggan, OA=Oa and AT=Ardtalla.

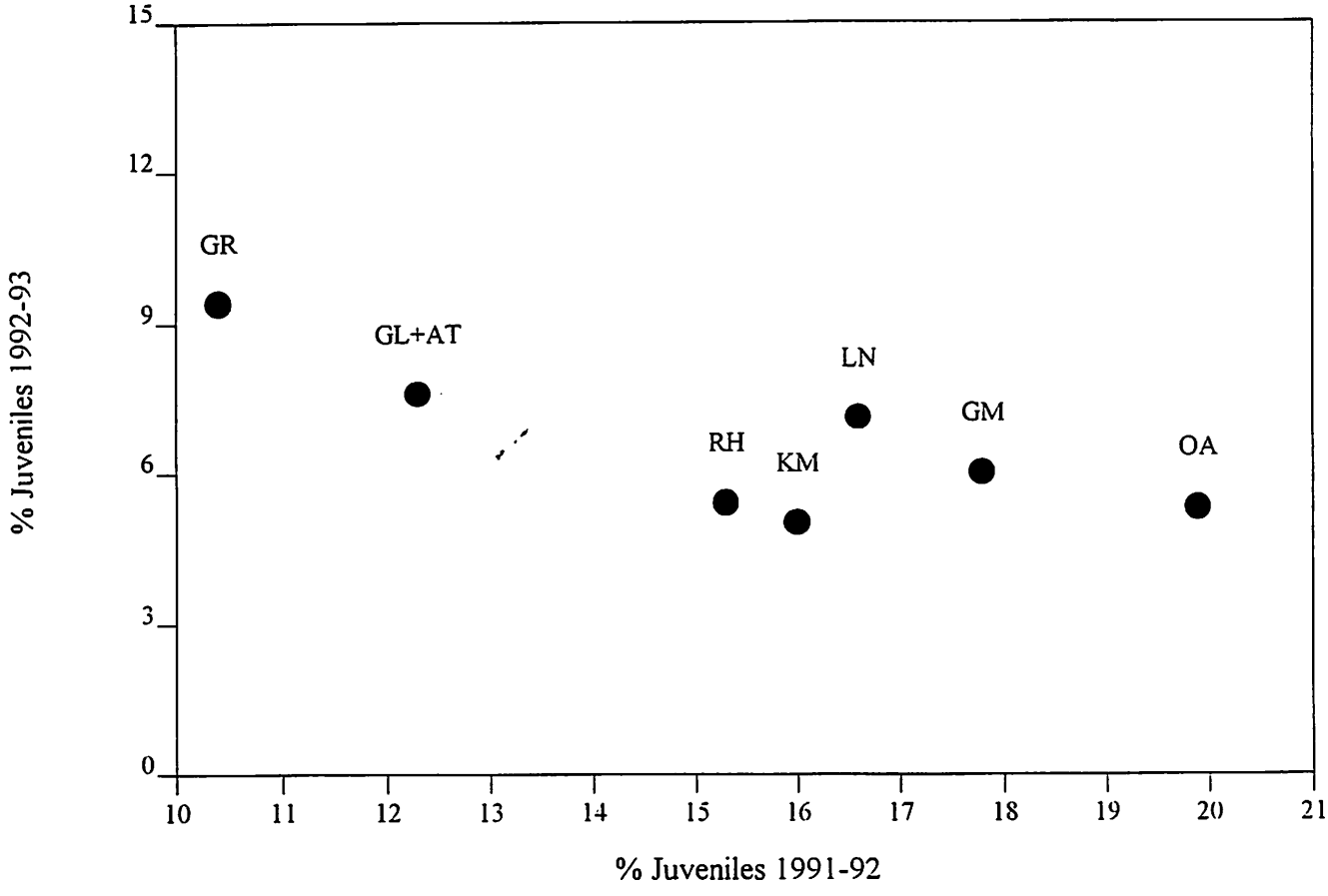
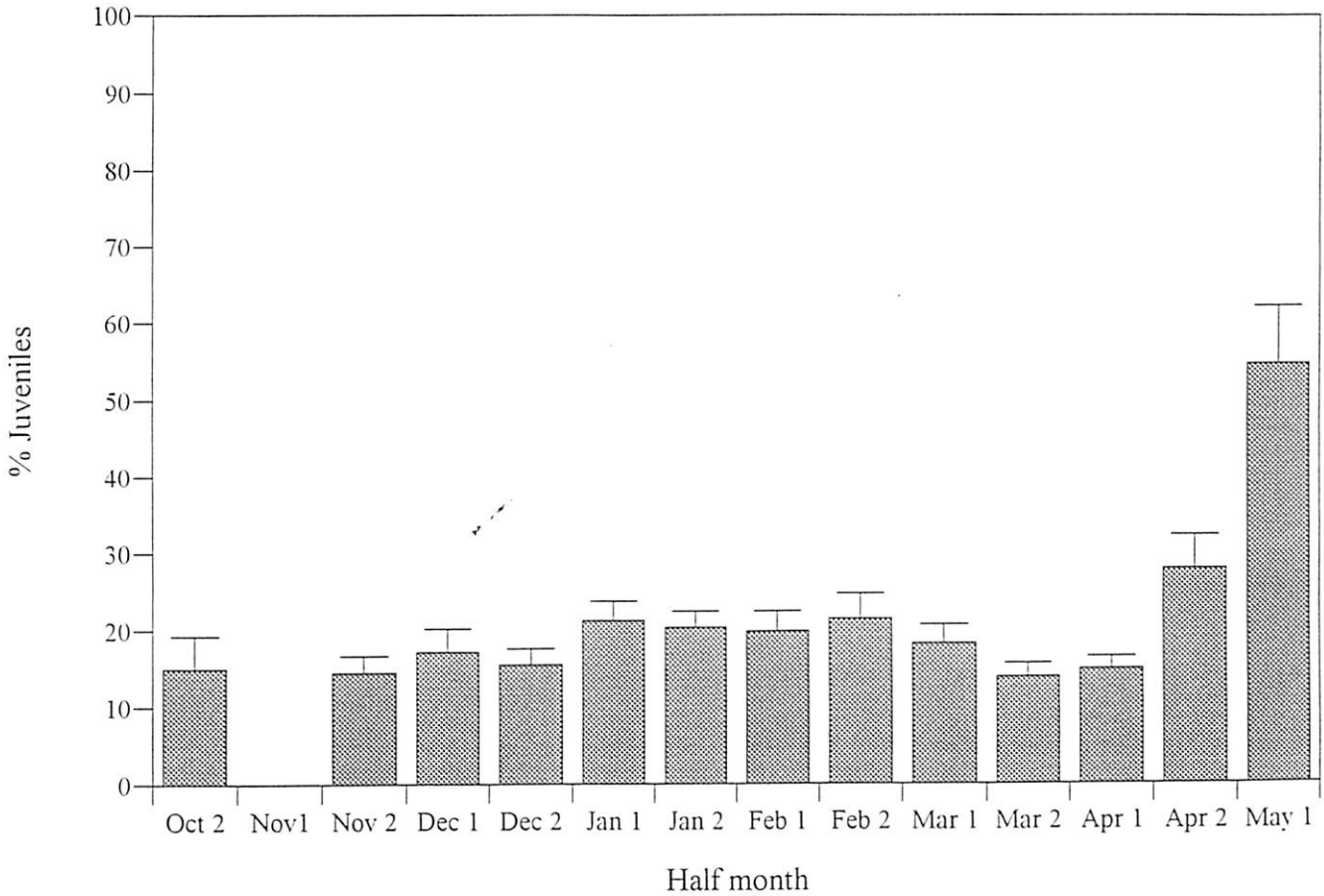


Figure 3.1.2 b Percentage of juveniles recorded during all Islay counts in 1991-1992 winter



3.1.3 Site fidelity of marked individuals wintering on Islay

Introduction

The ringing of Greenland White-fronted Geese was initiated during the Greenland White-fronted Goose Study Group expeditions to the Eqalungmiut Nunaat area of West Greenland in 1979 (Fox & Stroud 1981). During both the 1979 and 1984 expeditions to Greenland the birds were marked with leg-rings only, but some 34 birds (including two recaptured birds) were marked with neck-collars during a GWGS expedition to Sondre Stromfjord in 1989. A total of 305 individual geese have been caught and ringed for the first time in Greenland (Table 3.1.3a). Over 1,000 geese have also been ringed at Wexford Slobs in the Irish Republic, and 61 birds in other parts of Ireland (Table 3.1.3a), as part of the Irish Wildlife Service's study of the ecology of the species.

Greenland White-fronted Geese were first caught on Islay (by cannon-net) during the 1990/91 winter, when 16 birds were marked at Sunderland farm on 10.12.90 and 6 birds at Coultorsay farm on 19.12.90. A further 2 birds were caught in 1991/92 (at Rockside farm on 20th February 1992), and one more individual during the 1992/93 season (at the RSPB Loch Gruinart reserve on 3rd November 1992) (Table 3.1.3a). The birds caught on Islay were marked with an orange plastic ("darvic") neck-collar and white plastic leg-ring, each engraved with a unique alpha-numeric code in the series 0HA to 9HA, 0HC to 9HC and 0HH to 4HH. A smaller metal ring, issued by the British Trust for Ornithology, was fitted to the other leg as part of the BTO's national wild bird ringing scheme. The sex of each bird caught was determined by cloacal examination. Biometric data were also recorded.

Early studies of the movements of individual geese and swans identified by both artificial and natural markings, established that these birds show a high degree of site loyalty in both the winter and breeding ranges (Boyd 1955; Scott 1966; Owen 1976). Not only do birds use the same areas, and even the same fields, each year but the same individuals may be recorded at a particular site over several seasons. Advantages of a high degree of site fidelity in migratory waterfowl include prior knowledge of the location of suitable habitats, particularly for species with a circumscribed distribution and heavy constraints on the timing of the migratory and reproductive cycles. Moreover, in monogamous species, birds returning to traditional sites are more likely to rediscover a lost mate on occasions when members of a pair have become separated during migration. It has been suggested that the level of site loyalty is exceptionally high in Greenland White-fronted Geese, to the extent that the birds continue to frequent their traditional wintering sites rather than move to another wintering area even under adverse conditions (see Section 1.1.6 for a short review of the literature). The movements of particular birds (identified by ring code) wintering on Islay, both within and between seasons, are therefore considered in terms of the level of site loyalty

and size of the home range for individual geese.

Efforts were made to monitor the movements of marked birds wintering on Islay. In 1991-92 attempts were made to cover the whole island and relocate the ringed birds twice a month, although in practice this was not always possible. In 1992-93 observations were concentrated on the main study area, but sightings of ringed birds from other parts of the island (particularly during the all Islay counts) were also recorded. Historical data concerning the location of ringed birds identified on Islay from 1979 onwards were made available by the Greenland White-fronted Goose Study for an analysis of site fidelity shown by individual birds within and between winter seasons.

Results

Since the 1979-80 winter a total of 269 ringed geese have been re-sighted and identified by their ring or collar code on Islay. Of these 124 were ringed in Greenland, 111 at Wexford, 10 elsewhere in Ireland and 24 on Islay, representing 40.7%, 10.7%, 16.4% and 96.0% of birds ringed at these sites respectively. The high proportion (40.7%) of birds ringed in Greenland that were re-sighted on Islay reinforced the results of other studies (eg Wilson et al 1991) which indicated that birds breeding in Eqalummiut Nunaat, East Greenland, winter mainly on the western coast of Scotland, including the island of Islay. Similarly, the low proportion (10.7%) of birds ringed at Wexford that were re-sighted on Islay indicates a low level of emigration from Wexford to Islay. There have been no sightings at Wexford of Greenland White-fronted Geese ringed on Islay (A. Walsh pers. comm.); 13 (59.1%) of the 22 birds ringed on Islay in 1990-91 returned in both the 1991-92 and 1992-93 winters. The high proportion of birds ringed in Greenland that were re-sighted on Islay, in comparison with the proportion of birds ringed at Wexford and other parts of Ireland re-sighted on the island, was statistically significant (chi-squared = 189.38, df=1, $P<0.001$).

Further consideration of the re-sightings data found that 147 birds were seen on Islay in one winter only (including birds that alighted during migration), 45 birds in 2 winters, 38 in 3 winters, 14 in 4 winters, 5 in 5 winters, 8 in 6 winters, 7 in 7-9 winters and 5 birds in 10+ winters. One bird (A19) was seen on Islay in 14 consecutive winter seasons, ever since it was first ringed in Greenland in summer 1979 (Table 3.1.3b). Well over half (65.8%) of the Wexford-ringed birds sighted on Islay were recorded in one winter only, compared with 51.6% of the Greenland-ringed birds. The tendency for birds ringed at Wexford or elsewhere in Ireland to visit Islay (or call in on passage) for one winter only, compared with birds ringed in Greenland or on Islay itself, was also statistically significant (chi-squared=11.1, df=1, $P<0.001$).

In considering levels of site fidelity shown by the individual birds wintering on Islay between seasons, the "wintering sites"

used by the birds were divided into the eight main count areas (illustrated earlier in Fig. 3.1.1a), each covering several farms. The tendency for individuals to return to a particular count area was considered to be a reasonable measure of its site fiedelity, since the home range of an individual may cover several farms within a count area; a more detailed evaluation of the distribution of birds within their home range is presented in Section 3.1.4. The number of birds recorded in each count area each winter, and also the number that occurred at more than one of the Islay count areas, is listed in Table 3.1.3c. Occasions where birds were seen in one count area in October and/or November (autumn) and moved to another area thereafter, or where they moved from one count area used in mid-winter to an alternative area in March and/or April (spring) were considered separately, however, and are listed in Table 3.1.3d, since the count areas used in autumn and spring may perhaps be considered as temporary "migratory sites" rather than the birds' main destination in winter.

Results indicated that on the vast majority of occasions individual birds frequented one particular count area on Islay throughout the winter; there were only 28 (4.7%) instances of birds regularly using two count areas within a season (Table 3.1.3c). Moreover, on all but four occasions these were adjacent to each other (eg Gorm and Gruinart, Gorm and Rhinns, Kilmeny and Gruinart, Kilmeny and Glen, Laggan and Glen), so occurrance in two count areas did not necessarily reflect long-range movements by the birds (Figures 3.1.1a, 3.1.3a). Only 6 (7.7%) of the 78 geese recorded on Islay in 1991-92, and 7 (7.1%) of the 98 geese recorded in 1992-93, were seen in two count areas in mid-winter, despite the more intensive observations made during these winters (Table 3.1.3c), indicating that the tendency for birds to use one wintering area only within a season is not attributable simply to variation in effort in relocating the birds.

Geese were recorded at "migratory sites" on Islay (in autumn, in spring, or in both autumn and spring) and at another count area on the island in mid-winter on 36 occasions, with the majority (26) of reports coming from the 1991-92 and 1992-93 study period (Table 3.1.3d). In most (30) cases the birds used the migratory site on arrival in autumn, then moved to another site on Islay in late November or December. On only 3 (8.3%) occasions were geese recorded moving to a "migratory site" in spring, just before leaving Islay for the breeding grounds. On a further 3 (8.3%) occasions geese were seen at "migratory sites" in both autumn and spring. Of the five different count areas used as migratory sites in autumn, Gruinart was used on 20 (66.7%) occasions, Gorm on 7 (23.3%) occasions, and Kilmeny, Glen and Laggan each on one (3.3%) occasions (Table 3.1.3e). The high incidence of movement recorded from Gruinart in autumn to Gorm in mid-winter, and from Gorm in autumn to Rhinns in mid-winter, in recent years probably reflects the increase in observations made of birds wintering in western Islay during the 1990s. That there was little recorded movement in the reverse direction (ie from Rhinns to Gorm and from Gorm to Gruinart), however, may indicate variations in food supply and subsequent site selection

by the geese in autumn.

The location of the 122 geese sighted on Islay for at least two seasons was considered in further detail to determine the level of site fidelity shown by individuals over several winters. If a bird was reported at a different count area in one winter only, it was still considered to have changed its wintering site. Overall, 98 (80.3%) of the geese were recorded in the same count area each year, irrespective of the number of years that each individual wintered on Islay (Table 3.1.3e). Moreover, 60% of the geese that spent at least 5 winters on Islay appeared to use the same count area each season. Of the 60 birds ringed in Greenland and 21 ringed on Islay that were sighted on Islay in two or more winters, 49 (81.7%) and 21 (100%) used the same count area each year (Table 3.1.3f). By comparison, of the 38 birds ringed in Wexford and 3 birds ringed elsewhere in Ireland which wintered on Islay for two or more years, slightly lower figures of 26 (68.4%) and 2 (66.7%) respectively were seen at the same count area each season. The higher level of winter-site fidelity on Islay shown by birds ringed in Greenland, or on Islay itself, compared with birds marked in Ireland, was statistically significant (chi-squared = 6.47, df=1, $P<0.05$).

Conclusions

(1) A high proportion (40.7%) of birds ringed in East Greenland were re-sighted on Islay, reinforcing the view that birds breeding at Eqalungmiut Nunaat tend to winter in Western Scotland rather than Ireland. This may be attributed either to a sub-population from Eqalungmiut Nunaat remaining together through the winter months, or to the birds migrating on a broad front.

(2) The low proportion (10.7%) of birds ringed at Wexford subsequently recorded on Islay, and the apparent lack of movement of Islay-ringed birds to Wexford, indicates a low level of movement between the two sites.

(3) Of the Irish-ringed birds sighted on Islay, most were recorded on Islay for one winter only, whereas birds ringed in Greenland or on Islay itself were more likely to return over several winters. Islay therefore appears to be the traditional wintering area for the birds ringed in Greenland or Islay, but may also be used by birds that normally winter in Ireland, perhaps on migration in autumn or spring, or as an alternative short-term wintering site.

(4) The vast majority of marked geese were sighted in just one part of Islay throughout the winter season, although there was some evidence for a shift from one count area used in autumn to an adjacent count area in mid-winter.

(5) Of 122 geese sighted on Islay for at least 2 seasons, 98 (80.3%) were recorded at the same site each year, confirming that these birds show an exceptionally high level of winter-site fidelity.

Table 3.1.3a: Number of Greenland White-fronted Geese caught and marked throughout the migratory range from 1979-80 to 1992-93 inclusive. (Irish ringing data from Warren 1990; A Walsh pers. comm.)

		Ring Site			
Season	Year	Greenland	Wexford	Ireland	Islay
Summer	1979	95	-	-	-
Summer	1984	88	-	-	-
Summer	1989	32	-	-	-
Summer	1992	90	-	-	-
Winter	1983-84	-	39	-	-
Winter	1984-85	-	162	-	-
Winter	1985-86	-	134	-	-
Winter	1986-87	-	109	14	-
Winter	1987-88	-	107	14	-
Winter	1988-89	-	124	14	-
Winter	1989-90	-	70	12	-
Winter	1990-91	-	83	-	22
Winter	1991-92	-	98	-	2
Winter	1992-93	-	116	7	1
TOTAL		305	1042	61	25

Table 3.1.3b: Number of years in which individual birds were sighted on Islay.

Ring Site	Season ringing started	No.of birds	No. of winters seen on Islay									
			1	2	3	4	5	6	7	8	9	10+
Greenland	1979	124	64	18	12	8	2	8	4	2	1	5
Wexford	1983	111	73	18	12	5	3	-	-	-	-	-
Ireland	1986	10	7	1	1	1	-	-	-	-	-	-
Islay	1990	24	3	8	13	-	-	-	-	-	-	-
TOTAL		269	147	45	38	14	5	8	4	2	1	5

Note 1: Birds ringed on Islay could be identified for a maximum of three winters only, since the Islay ringing programme did not commence until the 1990-91 winter.

Note 2: Individuals seen for at least 5 years are as follows:

Ringed at Wexford: 6JK, 6KP, 6TC (all seen for 5 years)

Ringed in Greenland: A60, K77 (seen for 5 years)
A18, A32, A56, K03, K15, K34, K51, T01 (6yrs)
K02, K16, K23, K36 (7 years)
A31, T17 (8 years)
A38 (9years)
A14, A66 (10 years)
A26 (11 years)
A24 (12 years)
A19 (14 years)

Table 3.1.3c Number of individual birds recorded within each area of Islay in each winter.

SITE	79/80	80/1	81/2	82/3	83/4	84/5	85/6	86/7	87/8	88/9	89/90	90/1	91/2	92/3	TOT
	Winter														
RHINNS	0	0	0	0	0	10	6	6	3	1	7	8	10	13	64
GORM	0	0	0	0	1	0	4	6	9	5	10	28	22	26	111
GRUINART	0	0	0	2	1	4	6	1	4	3	3	1	3	3	31
KILMENY	0	3	0	2	1	11	15	12	12	8	23	18	21	33	159
LAGGAN	2	1	1	0	0	5	1	4	2	0	4	3	5	6	34
GLEN	18	10	7	9	10	6	6	6	7	6	9	6	2	4	106
ARDTALLA	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
OA	2	3	0	0	0	3	7	5	3	2	9	8	8	6	56
GORM+RHINNS	0	0	0	0	0	0	2	0	0	2	1	0	0	0	5
GORM+GRUIN.	0	0	0	0	0	0	1	0	0	0	1	0	5	6	13
GRUIN.+RHINNS	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
GRUIN.+KILMENY	0	0	0	0	0	0	0	1	0	1	1	1	0	0	4
GRUIN.+LAGGAN	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
GRUIN.+GLEN	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
LAGGAN+GLEN	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
KILMENY+GLEN	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
TOTAL BIRDS	22	17	8	13	13	39	48	43	40	29	68	74	78	98	590

Table 3.1.3d. Number of occasions on which (A) birds were identified at one count area in autumn and moved to another in mid-winter; (B) where they moved from one area used in winter to another in the spring; and (C) where at one count area in both autumn and spring and at another in mid-winter.

Note: **BOLD** type indicates the "migratory site" in each case.

Sites	85/86	86/87	87/88	88/90	89/90	90/91	91/92	92/93	**Tot**
A. AUTUMN									
Gruin-Gorm	-	-	-	-	-	-	9	6	**16**
Gorm-Rhinns	-	1	-	-	1	-	-	4	**6**
Gorm-Gruinart	1	-	-	-	-	-	-	-	**1**
Gruin-Rhinns	1	-	-	-	-	-	-	2	**3**
Gruin-Gorm+Rh.	1	-	-	-	-	-	-	-	**1**
Gruin-Kilmeny	-	-	-	-	-	-	-	1	**1**
Kilmeny-Gruin	-	-	-	1	-	-	-	-	**1**
Glen-Laggan	-	-	-	-	1	-	-	-	**1**
Laggan-Rhinns	-	-	-	-	-	1	-	-	**1**
AUTUMN TOTAL	**3**	**1**	**0**	**1**	**2**	**1**	**9**	**13**	**30**
B. SPRING									
Gorm/Gruin-**Kilmeny**	-	-	-	-	1	-	-	-	**1**
Rhinns-**Gorm**	-	-	-	-	-	-	1	1	**2**
SPRING TOTAL	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**3**
C. BOTH									
Kilmeny-Gruin/Lag-**Kilmeny**	1	-	-	-	-	-	-	-	**1**
Laggan-Gorm-**Laggan**	-	-	-	-	-	-	1	1	**2**
BOTH TOTAL	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**3**

Table 3.1.3e. Site fidelity shown by individual geese seen on Islay in at least two winters. () indicates the number of individuals from different ringing sites: (G)= geese ringed in Greenland, (W)= geese ringed at Wexford, Eire, (Ir)= geese ringed elsewhere in Ireland and (Is)= geese ringed on Islay.

No. Winters Seen on Islay	Same site each winter						Diff. site each winter					
	(G)	(W)	(Ir)	(Is)	TOT-AL	%	(G)	(W)	(Ir)	(Is)	TOT-AL	**TOTAL**
2	(16)	(12)	(0)	(8)	36	**80.0**	(2)	(6)	(1)	(0)	9	**45**
3	(11)	(10)	(1)	(13)	35	**92.1**	(1)	(2)	(0)	(0)	3	**38**
4	(8)	(3)	(1)	(0)	12	**85.7**	(0)	(2)	(0)	(0)	2	**14**
5	(2)	(1)	(0)	(0)	3		(0)	(2)	(0)	(0)	2	**5**
6	(5)	(0)	(0)	(0)	5		(3)	(0)	(0)	(0)	3	**8**
7	(3)	(0)	(0)	(0)	3	**60.0**	(1)	(0)	(0)	(0)	1	**4**
8	(1)	(0)	(0)	(0)	1		(1)	(0)	(0)	(0)	1	**2**
9	(0)	(0)	(0)	(0)	0		(1)	(0)	(0)	(0)	1	**1**
10	(1)	(0)	(0)	(0)	1)		(1)	(0)	(0)	(0)	1	**2**
11	(0)	(0)	(0)	(0)	0)		(1)	(0)	(0)	(0)	1	**1**
12	(1)	(0)	(0)	(0)	1)	**60.0**	(0)	(0)	(0)	(0)	0	**1**
13	(0)	(0)	(0)	(0)	0)		(0)	(0)	(0)	(0)	0	**0**
14	(1)	(0)	(0)	(0)	1)		(0)	(0)	(0)	(0)	0	**1**
TOTAL	49	26	2	21	98		11	12	1	0	24	122

Table 3.1.3f. Levels of winter site fidelity for birds ringed in different parts of the migratory range.

Ring location	Total on Islay for >1 winter	Number in same count area each winter	% in same count area each winter
Greenland	60	49	81.7%
Wexford	38	26	68.4%
Ireland	3	2	66.7%
Islay	21	21	100.0%