

Barnacle Geese in the west of Scotland, 1957-1967

HUGH BOYD

Introduction

Twenty years ago it appeared to most of the few people with substantial knowledge that the Barnacle Goose *Branta leucopsis* had decreased considerably as a wintering bird in Scotland. That belief led to a successful attempt to have the Barnacle Goose excluded from the list of birds that might be shot under the Protection of Birds Act, 1954, effective on 1st January 1955. On 18th November 1955 the Secretary of State for Scotland issued an Order which allowed the geese to be shot in the months of December and January on 'those islands which are situated within any of the counties of Argyll, Inverness and Ross and Cromarty and which lie off the mainland of the said counties and to the west of longitude 5 degrees west'. Only those Barnacle Geese frequenting islands off the coast of Sutherland and those wintering on the Solway Firth continued to enjoy total legal protection after November 1955. This disappointing and potentially dangerous decision made it urgent to obtain detailed information on the numbers of Barnacle Geese in different parts of Scotland and to follow their changes over the years.

No attempt at a census had been made before 1955, because the geese were widely scattered through the Hebridean islands, many difficult of access and no longer permanently inhabited by man. The only estimates of population size were derived from adding together information, much of it second-hand, obtained in a haphazard way by a variety of recorders over an indeterminate period.

Such an approach was clearly useless for reliable assessment of population changes. The only practicable alternative appeared to be an inspection of the islands from the air, a somewhat costly method about which little was known in Britain.

After some preliminary exercises in the techniques of aerial observation in 1956, a first survey of the Hebrides was made in 1957 (Boyd and Radford 1958). A second aerial survey of British Barnacle Geese, including those in Ireland as well as in Scotland, was conducted in 1959 as part of an international assessment of the entire population of the species (Boyd 1960). Subsequent surveys were made in 1961, 1962, 1965 and 1966. This paper has the limited objectives of making the results of the aerial surveys generally available, using them to find how the Hebridean stock of Barnacle Geese has fared during the last decade and investigating whether the lack of total legal protection has had the serious consequences that were feared.

Boyd (1960) inferred from the recoveries of ringed geese that there were three populations of Barnacle Geese which mixed very little. Those breeding in Siberia winter in Germany and Holland; those from Spitsbergen winter on the Solway Firth; and those breeding in east Greenland winter in the Hebrides and Ireland. Later ringing, and comparisons of the proportions of first-winter birds in different flocks, have confirmed this picture, although there is a puzzling discrepancy between the numbers wintering in Germany and Holland (some 20,000 in

recent years) and the few small breeding colonies known on southern Novaya Zemlya and Vaygach Island (Uspenski 1965). Jennov (1963) reviewing the breeding distribution in east Greenland, concluded that the Barnacle Geese occurring there were more than enough to account for the numbers reported from Ireland and north-west Scotland, and supposed that the excess might be fortifying the continental stock. That seems unlikely because 1,236 Barnacle Geese had been ringed in Holland by the end of 1966 and 2,396 in Greenland between 1955 and 1964: 97 recoveries of Dutch-ringed and over 140 of Greenland-ringed geese have been reported without providing any evidence of movement between Greenland and Holland. There is a single sight record of a Barnacle Goose, colour-marked in east Greenland in July 1963, in the Groningen province of Holland on 20th March 1966. The present strength of the Hebridean-Irish group seems to be consistent with Jennov's assessment of the situation in Greenland, and other explanations must be sought for the discrepancy between the Russian and Dutch evidence.

Since it is still uncertain to what extent the Greenland stock breaks up into sub-populations with distinct wintering areas, counts from Ireland in 1959, 1961, 1962 and 1966 are included here. Only the total numbers are used. The details will be included in a report on the distribution of Barnacle Geese in Ireland being prepared by Mr. D. B. Cabot.

Inventory methods (Plate IX, facing p. 108)

Conducting an inventory of geese in their winter quarters poses two problems: finding the geese and counting them. Finding the geese requires that you know where to look and that having reached the place you can then detect the geese. The Hebridean Barnacle Geese are much easier to find from the air than, for example, grey geese in central Scotland, because they mostly live on small islands and the areas of grass on which they might be feeding are even smaller. Provided there is enough light to see the time of day when they are looked for is unimportant, because the geese roost and feed in the same place. On the few parts of the Scottish mainland used by Barnacle Geese and on the larger islands, particularly Islay, searching is more difficult because the possible sites are less restricted and the geese fly from roosts, usually on offshore islands or sandbanks, to grasslands of several types.

There are several hundred islands in the Hebrides. Before embarking on the first aerial survey it was possible, after talking to people with local knowledge and searching for published records, to prepare lists of islands where Barnacle Geese had or had not been seen. There remained a formidable number lacking records, so that all the surveys involved 'exploration' as well as journeys to known haunts. Rather reassuringly, the number of newly-discovered haunts was quite small and nearly all the islands found unsuitable on the early surveys continued to lack geese.

Though in principle all the islands in the Hebrides likely to hold Barnacle Geese can be inspected from the air, there are many practical difficulties in arranging comprehensive itineraries. Searching has to be carried out at low altitudes and slow speeds, and it was necessary to hire the cheapest light aircraft, which, inevitably, has relatively limited endurance. There are very few airfields in the west of Scotland and suitable fuel is available on demand at only Prestwick, Ayrshire, and Stornoway, Lewis. The weather in the area is often unsuitable for light aircraft and cannot be forecast accurately, since most of the relevant weather systems are arriving from the Atlantic Ocean where the recording network is thin. Winds of only moderate strength (15-25 knots) can make an appreciable difference to the performance of a light aircraft and add greatly to the difficulty of manoeuvring at low altitudes particularly in the vicinity of steep-sided islands. No two surveys were conducted in the same sequence, but care was taken to keep track of shifts of geese from one island to another close by. There is no evidence of frequent long-distance movements between winter quarters. The first aerial survey was made in February, the second in late November and early December. Those periods were chosen as being times when migratory movements were unlikely. The operational penalties of very short days, poor light and a high proportion of days when flying was not possible were so great that the later surveys were carried out in March or April. The greater risk of migratory shifts in early spring seems to have been unimportant and the increase in operating efficiency was considerable.

The most obvious gain was in the ability to take photographs of goose flocks and so obtain checks upon the counts and estimates made by the observer and pilot. One of the great merits of the highly dispersed distribution of Barnacle

Geese in the Hebrides is that few of the flocks encountered exceed five hundred birds and many are less than one hundred. Thus it is often possible to enumerate the birds individually or to estimate by groups of ten. That is important for the opportunities for counting are fleeting. A likely place for Barnacle Geese is approached at 400-600 feet above the sea, low enough to cause the geese to lift off the ground but not so low as to make them scatter in alarm or to make handling of the aircraft awkward. The pilot attempts to keep the entire group of geese clearly visible, preferably to both the observer and himself, for long enough to allow a count to be repeated two or three times. The flock is not closely pursued because that would alarm the birds unduly, which is objectionable in itself and may also defeat the end of the survey by scattering the geese. Photography, which calls for the geese to be set against a sufficiently contrasted background largely free from glare, was best done by the pilot using colour film in a hand-held 35 mm. camera. Earlier efforts with the observer using monochrome film in a K 20 aerial camera were rarely useful.

Photographic records cannot be relied upon for making a goose census, even though good photographs provide the only permanent evidence of location and numbers. On many winter days photography is scarcely possible, there is often uncertainty whether the picture will include the entire flock and there can be no assurance that technical failures in processing or the loss of a film may not destroy the evidence.

Results

Table I records the number of Barnacle Geese seen on each visit to each island or group of islands for which there were positive records from the aerial surveys. (Figure 1 shows the main island haunts). A single figure is used for each positive record, irrespective of the number of counts or estimates that could be made, and represents the value thought at the time to be the best. It is necessary to assess the reliability of these results before using them to establish whether the total population has varied appreciably in size and whether it can be divided into geographical groups. There are three sources of difficulty. First, in how many cases were geese present but not seen? Second, how accurate were the counts or estimates? Third, to what extent was the total falsified by movements of geese

from place to place in the course of a survey.

Long-distance movements of geese were unlikely to be substantial enough to vitiate the results, largely because of the brief duration of the surveys. The extensive replication of counts that would be needed was too costly for the limited budget. Indeed routes were laid out to avoid covering the same ground twice, and only seven pairs of repeated counts are available. In February 1957 repeat visits at intervals of between five and ten days were made to Islay, the Treshnish Isles, Gunna and Gasker (Lewis); and the totals for the first and second visits were 1,600 and 2,400 respectively. In 1959, visits to Loch Bee, South Uist, yielded 21 Barnacle Geese on 26th November and 110 on 3rd December. In 1966 the Shiant Islands were visited on successive days (3rd and 4th April) and the 'best' totals were 440 and 480 respectively (the latter from four photographs). In six of the seven cases more geese were seen on the second visit, the total rising from about 2,060 to 2,990. Supposing that the mean (2,525) represents the best approximation to the numbers present on the mid-point dates, this suggests that a variation of about 18% resulted from a combination of short-term movements and counting errors.

Given the general impression from Table I that there has been a substantial increase of the numbers of Barnacle Geese in the Hebrides, it is important to examine to what extent that increase may be attributable to better observing or to systematic changes in the methods of assessment. The numbers on Islay, where the Barnacle Goose flocks are frequently much larger than elsewhere in the Hebrides and where the geese are widely distributed over a large area, are discussed in a separate section. There can, however, now be little doubt that the aerial counts there in 1957 and 1959 were too small.

Both an increase in the population and an increase in searching skill might lead to apparently larger numbers in the places already occupied, and to birds being found on more islands. Table II demonstrates that such tendencies have been found. A seasonal factor may also be involved, between earlier surveys in November/December and February and the later ones in March or April. It is probable that there are changes in distribution during the winter, as food supplies on some islands become depleted, and that the increased dispersion might reflect changes within seasons rather than between them.

Table I. Numbers of Barnacle Geese seen during aerial surveys of the Hebrides, 1957-1966.

Islands grouped by county and listed from south to north and west to east. Figures in brackets show the number of islands (and headlands) in each group on which geese have been recorded during the surveys. Full records are deposited at the Wildfowl Trust.

The symbol X indicates that the island was not visited, — that it was visited but no geese were seen.

	1957 12-22 Feb	1959 24-27 Nov 2-3 Dec 3+2	1961 16-19 Mar	1962 7-10 Apr	1965 30 Mar 1 Apr	1966 1-4 Apr.
<i>Number of flying days</i>	8		3	4	2	4
ARGYLL						
Islay (consolidated)	3000	2800	5500	4800	X	8500
Sound of Jura (9)	71	150	143	168	X	262
Oronsay	16	—	—	230	X	18
Iona and islets to south	5	—	—	—	X	61
Staffa and Erisgeir	60	80	72	10	80	151
Treshnish Islands (6)	257	219	398	380	430	644
Soa, off Tiree	—	—	80	130	X	—
Gunna	420	25	230	4	X	490
Coll	—	—	70	350	X	44
INVERNESS						
<i>Outer Hebrides</i>						
Berneray	85	—	—	14	18	13
Geirum Mor	—	—	30	—	—	51
Mingulay	32	35	70	114	90	250
Outer Heisker	—	14	—	—	—	4
Pabbay	42	—	—	18	90	95
Lingay	—	—	—	—	24	—
Greanamul	—	—	18	25	—	—
Sandray	—	—	24	—	—	30
Muldoanich	—	—	—	—	19	—
Biruslam	64	—	—	—	—	—
Sound of Barra	238	86	431	395	428	360
South Uist (west of L. Bee)	200	110	250	—	23	—
Monach Islands (4)	330	470	519	863	750	1035
Sound of Harris (19)	490	304	599	498	490	578
Taransay	192	15	120	7	—	120
Gasker	41	110	10	70	190	122
Scarp	9	—	—	—	—	—
<i>Inner Hebrides</i>						
Eilean an Each, off Muck Skye and islands off its NW coast (13)	19	—	—	X	X	X
	526	190	370	646	992	888
ROSS						
Longa	38	56	15	20	5	—
Foura	21	—	—	11	—	—
Summer Isles (6) and Blarbuie, Rubha Mor	95	106	—	57	X	146
Shiant Islands (4)	303	290	214	317	450	483
Islands off Lewis (5)	37	—	—	32	52	109
SUTHERLAND (islands and headlands)						
West coast (9)	173	230	197	34	X	153
North coast (4)	X	X	359	379	X	545
TOTAL SEEN						
(to nearest hundred)	6600	5100	9700	9600	—	15200



Figure 1. Map of West Scotland showing places mentioned in text and Table I.

Table II. Numbers of Hebridean islands seen to be occupied by Barnacle Geese during aerial surveys, 1957-1966. (Islay and immediately adjacent islands excluded.)

<i>Islands</i>	1957	1959	1961	1962	1965	1966	<i>mean</i>
with geese present	42	34	53	64	38	60	49
no geese seen	61	67	54	44	41	47	52
not visited	6	8	2	1	30	2	8
Total	109	109	109	109	109	109	109
% islands occupied	41	34	50	59	48	56	48
aver. no. geese on each occupied island	85	69	79	74	108	110	88
aver. no. geese per island visited	35	23	39	44	52	62	43

In the absence of independent counts, it does not seem possible to exclude the likelihood that growing experience led to more of the geese present being seen, but that is unlikely to be the cause of the great variation between surveys on particular islands. It is far more probable that these changes reflect movements of the geese. The only direct evidence relating to possible changes in observer skill is provided by comparing estimates of flocks with subsequent counts from photographs. Few photographs were successful in earlier years and most did not correspond exactly to observed groups. Figure 2 demonstrates the relationship between 45 pairs of counts made in flight and from photographs. Some of the observations deviate rather widely from the photographic counts but in general the fit is reasonably close. The sum of the 31 aerial counts by the observer is only 2% greater than that obtained from the photographs (5,157 v. 5,039). The estimates of the pilot were less close (3,205 v. 2,553,

or 26% too large), though still remarkably accurate in view of his preoccupation with flying the aircraft and taking the pictures.

Figure 2 does not suggest any marked change in precision between the counts made in 1959 and 1962 and those made in 1965 and 1966. Furthermore, the ratio of 38 estimates made by the observer and by the pilot varied scarcely at all from 1961 to 1966, those of the pilot averaging 20% above those of the observer. In 1959, when a different pilot took part, 5 pairs of counts showed a wider difference.

The evidence of consistency in observer performances makes it unlikely that much of the apparent population increase can have been due to observational error. Little would be achieved by trying to adjust the figures in Table I to allow for counting errors, though some allowance for geese in places that could not be visited in 1957, 1959 and, particularly, in 1965 is necessary.

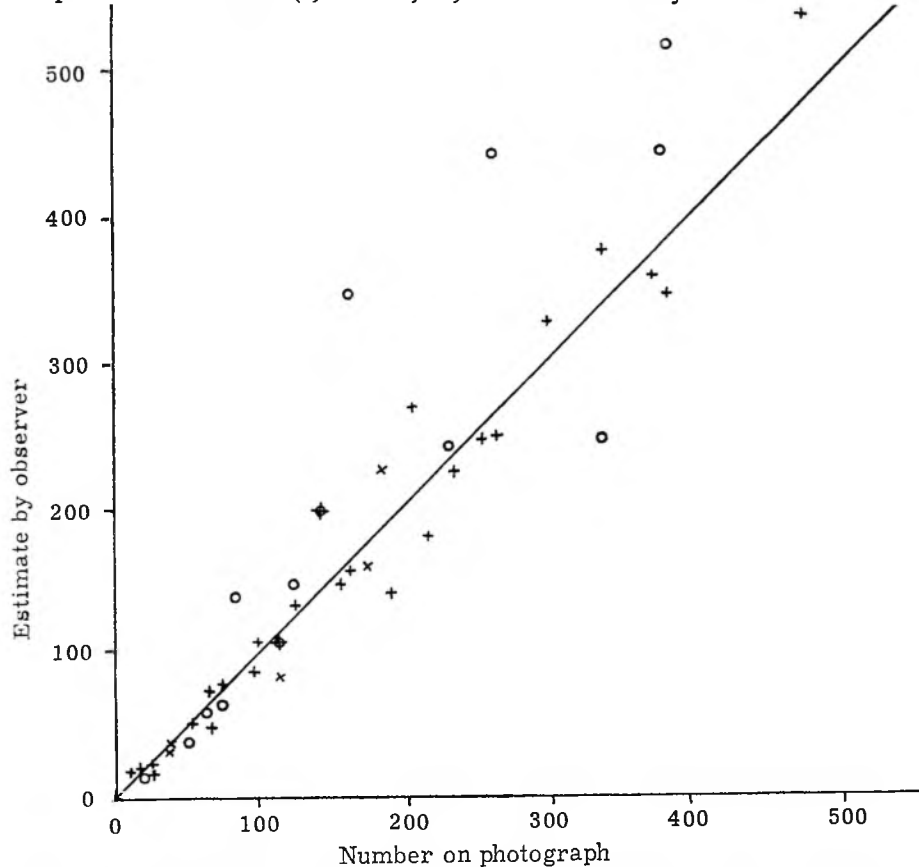


Figure 2. Comparisons between photographic records and aerial observations of Barnacle Geese flocks. O J. Radford (pilot); X H. Boyd, 1959 and 1962; + H. Boyd, 1965 and 1966.

The numbers of Barnacle Geese on Islay

The problems of counting Barnacle Geese on Islay are without parallel elsewhere in the Hebrides. Most of the geese occur in flocks of several hundreds or thousands and their roosts and feeding places are often several miles apart. They may be found on such typical Hebridean sites as Nave Island or the small islands east of Kildalton, or on the flat, wet, grasslands at the head of Loch Gruinart, or, most unexpectedly, on the rolling farmlands east of Bridgend.

Despite the scepticism of some people who know both Islay and the geese well, it is quite possible to count the geese present at any time with reasonable precision, either from the air or on the ground. The aerial surveys in February 1957 were thorough, but the numbers in

large flocks of geese were then being grossly underestimated. It took much practice, spread over several years of searching for grey geese elsewhere in Scotland, and involving verification by photographs and counts from the ground, to improve the accuracy of estimates of a thousand birds or more. The December 1959 survey also very probably suffered from under-estimation of large groups. On later visits the flying was better planned and the estimates more accurate.

Since 1952 at least eighteen people have attempted to count the Barnacle Geese of Islay. With a vehicle, this can be easily done in two days, if the observer spends considerable periods counting large flocks bird by bird and if the geese are consistent in their movements. The mobility, tenacity and good fortune of the counters

Table III. Numbers of Barnacle Geese reported from Islay, 1947-67.
All estimates here rounded to nearest hundred; aerial counts in *italic*.

<i>Winter</i>	<i>Date</i>	<i>Number</i>	<i>Seasonal mean</i>	<i>Counters</i>
1952-53	Dec.	nearly 3000		J. M. Boyd
1953-54	autumn	2500-3000		J. Turner
1954-55	late Jan.	8000-10000		A. B. Duncan, G. A. Swanson
1955-56	late Mar.	under 3000		J. M. Boyd
1956-57	12 Feb.	1200		H. Boyd
	22 Feb.	1700-3000*		H. Boyd, (*) J. D. H. Radford
1957-58	mid Nov.	over 10000	7100	M. F. M. Meiklejohn
	early Dec.	just over		
		5000		J. V. Weir
	early Dec.	7500		J. M. Boyd
	1 Apr.	5500		J. Sheppard
1958-59	16 Nov.	well over		
		10000	6300	M. F. M. Meiklejohn
	1 Dec.	4200		H. Boyd, S. K. Eltringham
	25 Jan.	5600		H. Boyd
	18 Mar.	4500		R. J. F. Taylor
1959-60	2 Dec.	2800	6000	H. Boyd
	mid Feb.	5800-8600		D. Jenkins <i>et al.</i>
	late Feb.	8000		M. F. M. Meiklejohn
1960-61	7 Nov.	4600	5700	H. Boyd
	6-8 Feb.	5600-8100		D. Jenkins <i>et al.</i>
	19 Mar.	5500		H. Boyd, J. D. H. Radford
1961-62	16 Nov.	5800	6300	H. Boyd, M. A. Ogilvie
	15-19 Feb.	6300		C. J. Cadbury
	2-3 Mar.	5800		D. Jenkins <i>et al.</i>
	4 Mar.	6800		D. Jenkins <i>et al.</i>
	12-15 Mar.	7500-8500		R. J. F. Taylor, W. H. N. Wilkinson
	10 Apr.	4800		H. Boyd, J. D. H. Radford
1962-63	31 Oct.	6100	7400	H. Boyd
	15-18 Mar.	8400-9000		R. J. F. Taylor, W. H. N. Wilkinson
1963-64	25-27 Feb.	10400		J. M. Boyd
1964-65	30 Oct.-2 Nov.	8300	8300	M. A. Ogilvie
	27 Jan.	8000-8500		R. N. Campbell, N. C. Morgan
1965-66	1 Mar.	9000		H. Boyd, J. M. Boyd
	1 Apr.	8500		H. Boyd, J. D. H. Radford
1966-67	11 Nov.	8400	8500	M. A. Ogilvie
	15-19 Dec.	6500		C. J. Cadbury
	22-23 Feb.	10500		N. C. Morgan
1967	8-9 Nov.	16500		M. A. Ogilvie

have varied in ways which do not lend themselves to precise comparisons. Their totals (Table III) are rounded to the nearest hundred, and in some cases a cautious estimate is reduced to a single figure. Correspondence relating to these observations is kept in the Wildfowl Trust files.

The range of 1,200 to 16,500 shown in Table III is very wide. The requirement is to obtain measures of any trend, and of year-to-year fluctuations, while reducing the effects of counting errors, and of movements in the course of the winter. Atkinson-Willes (1963) described the status thus: 'Taking the island as a whole the normal numbers are estimated at about 5-6,000, but by February there is usually an increase to 7,500 and in some seasons as many as 10,000 may be present for short periods.' This admirably concise summary of the position from 1955 to 1962 implies that there are usually more Barnacle Geese on the island in late winter than earlier. Figure 3, drawn from the data of Table III, does not support

the inference that numbers increase in the late winter. Given the lack of any consistent pattern of change between November and April, all the counts in any one winter can, perhaps, be treated as estimates of a constant population. In order to use as much information as possible, the trend in population size can be estimated by calculating the regression of numbers upon seasons, using all the individual values in Table III, rather than seasonal means. (That involves giving all estimates the same weight, which is undesirable but scarcely avoidable without rejecting most of the counts, for which no measure of reliability is available.) A linear regression appears to fit the data rather better than a logarithmic one; and yields an estimated mean rate of increase of 6.3% annually.

There have been fluctuations in the breeding success of Islay birds, as indicated by autumn observations on the proportion of first-winter to older geese and in the mean size of broods (Table IV). Obviously mortality may also have varied importantly from year to year. No inde-

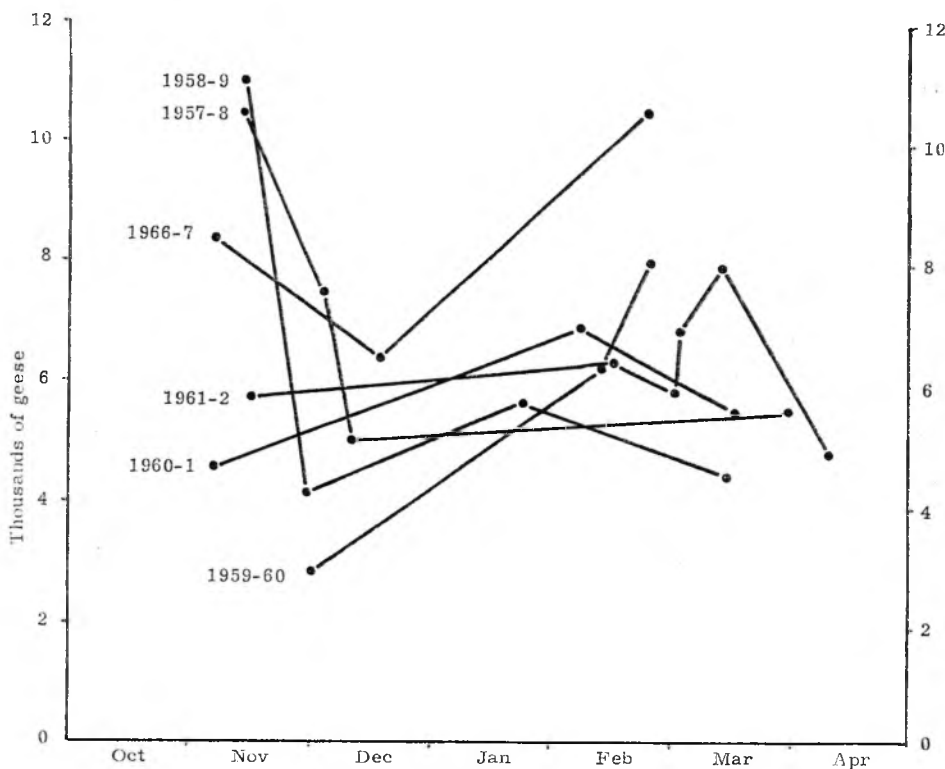


Figure 3. Changes in recorded numbers of Barnacle Geese on Islay during the winter, 1957-58 to 1966-67. Only winters in which at least three independent counts were made are included here.

pendent measure of the losses suffered by this stock is available. It is known that the kill on Islay itself is small, because the owners of most of the land used by the geese allow very few geese to be shot. A preliminary impression of mortality suffered by the population may be gained by using the first-winter ratios in conjunction with the seasonal means (Table V). These suggest that from 1959 to 1966 the losses of full-grown birds averaged scarcely 10% annually, an unusually low rate for geese. From the published recoveries of Barnacle Geese ringed in Greenland in 1955, 1961 and 1963 the average annual mortality rate of full-grown geese is calculated to have been about 20% in the years 1955-64. Several of the Greenland-ringed geese were reported shot, and many seen, on Islay. The discrepancy between the mortality rate of marked geese and the apparent rate for those visiting Islay suggests that the true rate of mortality of Islay-visitors has been masked by extensive immigration unless mortality in other places is vastly greater. Thus it is of particular interest to compare changes in the numbers on

Islay with changes in other parts of the wintering range.

Changes in numbers in other regions

Table VI and Figure 4 summarize the data given in Table I in forms which make it easier to compare the observed changes in different parts of the Hebrides and in Ireland. It appears that a decrease occurred nearly everywhere between February 1957 and November 1959 while gains were general thereafter. The geese on the islands off the Sutherland coast may not have shared in this prosperity, though the lack of aerial inspections of the islands along the north coast before 1961 makes the extent of the decline between 1959 and 1962 uncertain. That is unfortunate, because of the special interest attaching to the geese in Sutherland as the only ones nominally afforded full protection since 1955. What seems certain is that the extra protection has not led to an exceptional rate of increase. The most likely reasons are the very limited number of suitable feeding places in Sutherland, and that on the bigger islands,

Table IV. Breeding success of Barnacle Geese wintering on Islay, as shown by observed proportions of first-winter birds and average brood-sizes, 1958-67.
Data obtained by H. Boyd, 1958-63 and Mar. 1966, and M. A. Ogilvie, 1964-67.

Year	Proportion first-winter birds		Mean brood-size	
	sample	% 1st w.	sample	mean
1959	721	14.1	20	2.5
1960	1500	9.7	20	1.9
1961	1900	10.7	14	2.1
1962	1088	7.6	21	2.5
1963	320	30.6	13	2.8
1964	580	7.5		
1965	798	11.2	24	1.7
1966	660	13.0	20	1.4
1967	550	17.1	32	1.8

In 1963 observations were made on 23rd October, before majority of geese had arrived.

Table V. Estimates of recruitment to and losses from the population of Barnacle Geese wintering on Islay, 1959-66.
Data from Tables II and III.

Year	Population	1st winter	Older	Losses since previous winter
1959	6000	846	5154	—
1960	5700	555	5145	855
1961	6300	674	5626	74
1962	7400	562	6838	(538 gain)
1963	10400	3192	7208	192
1964	8300	623	7677	2723
1965	8800	1100	7700	600
1966	8500	1105	7395	1405

$$\text{mean rate of recruitment} = \frac{\Sigma (\text{1st winter})}{\Sigma (\text{older})} = 16.4\% \text{ annually}$$

$$\text{mean rate of loss} = \frac{\Sigma [\text{losses} (- \text{gains})]}{\Sigma \text{population}} = 10.1\% \text{ annually}$$

Table VI. Numbers of Barnacle Geese found in different regions of the Hebrides and in Ireland during aerial surveys, 1957 to 1966.

Region	1957	1959	1961	1962	1965	1966	mean
Islay	3000	2800	5500	4800	8300	8500	5500
other Argyll	800	500	1000	1300	1200	1700	1100
Skye and Wester Ross	700	300	400	700	1100	1000	700
Outer Hebrides	2100	1400	2300	2400	2600	3300	2400
Sutherland	800	1000	600	400	700	700	700
total Hebrides	7400	6000	9800	9600	13900	15200	10300
Ireland	4400	2800	4100	4400	—	4800	4100
total	11800	8800	13900	14000		20000	14400

Notes: Hebridean records from Table I, group totals rounded to nearest hundred, with some adjustments for incomplete searches. Irish records for 1959 by H. Boyd, for 1961, 1962 and 1966 by H. Boyd, D. B. Cabot and J. D. H. Radford; no survey in Ireland in 1957, the total given being the sum of the average numbers in each locality recorded by Rutledge and Hall Watt (1958).

Islay figure for 1965 from ground counts in November and January. Argyll and Sutherland figures for 1965 and Sutherland figures for 1957 and 1959 include estimates for unvisited sites.

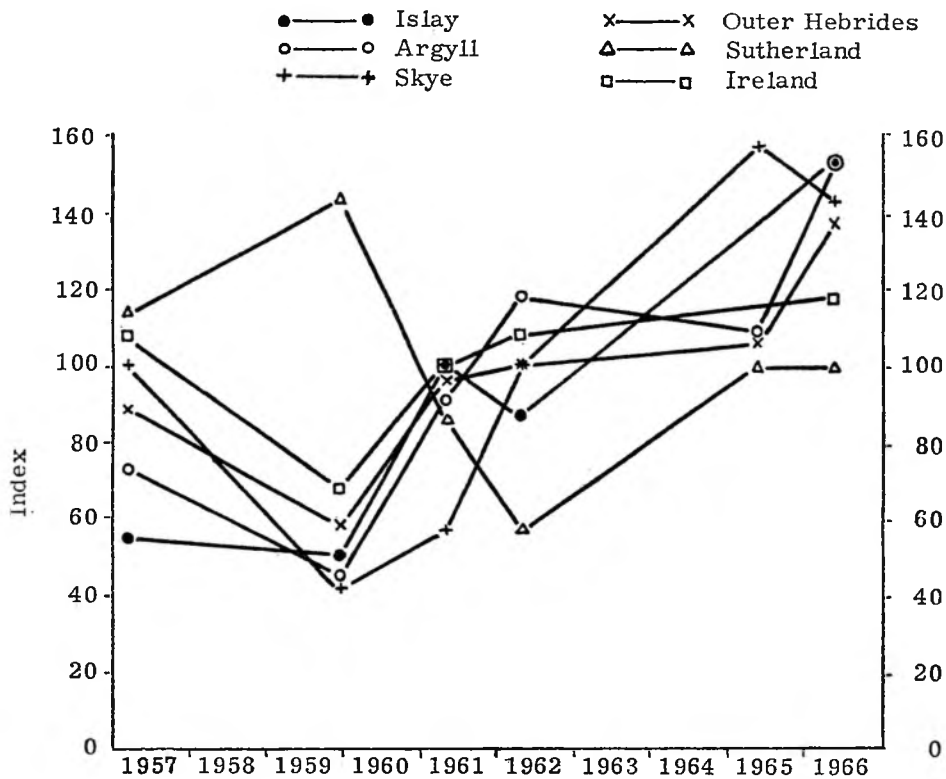


Figure 4. Changes in numbers of Barnacle Geese found during aerial surveys in different regions of the Hebrides, and in Ireland, 1957-66. Index numbers based on mean = 100 for each region.

such as Handa and Eilean nan Ron, the geese are competing with relatively large numbers of sheep and are more disturbed by shepherds and other human visitors than on most small Hebridean islands.

Despite important shifts in distribution within Ireland, the total strength there appears to have altered little in the last decade. The Irish total in November-December 1959 was probably depressed by under-estimates of the large flocks on the Inishkeas, islands off Co. Mayo, where Cabot (1963) found 2,200 \pm 100 resident during his visit from 19th March to 22nd April 1961, and 2,500 from 10th to 18th March 1962, compared with estimates from the air of 1,580 on 11th March 1959, 1,200 on 5th December 1959, 1,010 on 23rd March 1961 and 1,570 on 6th April 1962 (all by H. Boyd). The species was given full protection in Ireland in 1962.

Nearly all the 'natural groups' of geese on adjacent islands have increased in the same way as the total population. Two exceptions may be noted in the Outer Hebrides: on the islands south of Barra the numbers seen on the last four visits have fluctuated between 430 in 1961 and 360 in 1966; a reduction in numbers and frequency of occurrence of Barnacle Geese near Loch Bee on South Uist has been confirmed by many observers. The change is presumably due to the construction of a rocket-firing base in the area, but has been more than offset by increases on the Monach Isles some twelve miles to the north-west. The Monach Isles were declared a National Nature Reserve on 1st December 1966, primarily for the benefit of the geese.

Some of the outermost of the Hebridean islands—the St. Kilda group, North Rona and the Flannan Isles—have not been included in the aerial surveys, apart from a visit to the Flannans on 19th February 1957 during the first survey. Though Barnacle Geese and other geese have frequently been reported flying over these remote islands on passage in the spring and autumn and have occasionally alighted on them, they are not probably regular haunts during the winter.

Discussion

The general increase in the number of Barnacle Geese in the Hebrides and Ireland is pleasing. While the causes have not been established, there are indications that the geese wintering on Islay have benefited from very low annual mortalities. There are few records of age-ratios among the geese elsewhere in the Hebrides but such as there are, and data col-

lected in Ireland, chiefly by Mr. D. B. Cabot, suggest that the proportions of young birds in different places in the same year resemble each other. Thus it is quite likely that low mortality has characterised much of the Greenland-breeding population of Barnacle Geese during the last decade.

There are differences between the behaviour of Barnacle Geese on Islay and elsewhere. On Islay they feed inland, as well as close to the sea, and they often occur in large flocks. The rate of increase on Islay seems to have been somewhat greater than among the geese scattered on small islands. One result has been that, while in February 1957 Islay apparently held 40% of the Barnacle Geese in the Hebrides and 25% of the entire Greenland stock, by April 1966 the proportions were 56% and 43%. The increase on Islay began at least forty years ago (Berry 1939). Its long continuation is due in large part to the special protection afforded to the geese by landowners. Their success has led to growing complaints by farmers that the geese now take too large a proportion of the grazing on the island. Should a change in circumstances lead to measures against the geese there is little doubt that large numbers could be killed and the survivors find it necessary to move off the farmed land. In that event there might well be strong competition for space and food on other Barnacle Goose haunts, perhaps far removed from Islay.

This investigation was prompted by concern about the survival of the Barnacle Goose. There are perhaps twice as many Barnacle Geese now as there were ten years ago, for those wintering on the Solway Firth and in the Netherlands have also increased. Does this mean that the anxiety was ill-founded and unnecessary? Or that the additional protection afforded to the species has been effective? Could that protection safely be relaxed?

The criterion applied by the U.S. Federal Government is that any species less than 100,000 strong is so scarce that it should be protected from hunting as far as possible. The group breeding in Spitsbergen and wintering on the Solway Firth is so very small and its breeding and wintering grounds are so limited that it should always be given special care. The geese wintering in the Netherlands are threatened by the loss of large parts of their feeding grounds (Lebret 1965). The Barnacle Geese of the Hebrides and Ireland are less vulnerable. The breeding places available in east Greenland are relatively extensive. In winter, many of

their haunts are at present little disturbed, either by local residents seeking them for food or by visiting sportsmen.

There is a final question of great interest to the biologist, which is also fundamental to sound conservation. Should an attempt be made to follow up this study by finding out how many Barnacle Geese could live on the habitat available in the Hebrides, on the supposition that no further increase in their numbers on the improved grasslands of Islay can be accepted by the farmers? The recent declaration of the Monach Isles as a National Nature Reserve, though welcome as providing the first sanctuary for Barnacle Geese in the Hebrides, may deflect attention from the real problems associated with the welfare of these exciting birds. At a time when funds for research are contracting, it is especially easy to choose problems that are merely urgent, instead of others of greater long-term importance. It would be regrettable if the transitory well-being of the Barnacle Goose were to diminish the interest shown in it in Britain.

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The counts of geese on Islay would have been much less plentiful and informative without the contributions of the gentlemen listed in Table III. Many of them, like me, are indebted to the directors of Islay Estates Limited, and especially also to Mr. J. H. Cranston, O.B.E., until recently their factor, for permission to move over their land and for assistance of various kinds. Mr. M. A. Ogilvie, by continuing the annual series of observations on the numbers and age-composition of the Islay flocks, has added greatly to their value.

Summary

Five aerial surveys of the Barnacle Geese wintering on islands off the west and north-west coasts of Scotland were made between February 1957 and April 1966. The practical problems of the aerial survey of geese dispersed in small groups on islands are discussed. Supplemented by counts made from the ground on Islay, much the most important haunt, the surveys show that the Hebridean population has increased substantially from about 7,400 in February 1957 to 15,200 in April 1966. Numbers in different regions of the Hebrides have varied in rather similar ways. The gradual increase on Islay up to 1966 may have been due to low adult mortality. A massive increase there in 1967 must have involved immigration. The geese in Sutherland, and in Ireland, afforded full protection since 1955 and 1962 respectively, have increased less than in the Hebrides, where shooting is permitted in the months of December and January.

The present healthy state of the Hebridean population could be drastically altered if their competition with agriculture on Islay leads to countermeasures.

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