A census of the Icelandic Whooper Swan population

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The Whooper Swan *Cygnus cygnus* is generally distributed as a breeding bird in Iceland, being found in most wetlands from sea-level to an altitude of about 700 m. Moulting and staging flocks are conspicuous in some localities and easy to count. Much new information on such flocks has been accumulated in recent surveys.

During a short period in late September to early October most of the Icelandic Whooper Swan population regularly concentrates in relatively few staging areas (Fig. 1), prior to the emigration of the majority of the birds to Ireland and northern Britain.

This paper is primarily based on a survey of the staging areas in Iceland in early October 1982. Certain information on breeding success, moulting flocks, movements and habitat selection is also presented here in summary insofar as it helps to interpret the results of the census. Our aim is to produce a more accurate estimate of the size and structure of this population than hitherto available.

Methods

Almost all staging areas, known from previous surveys and local information, were covered from low-flying aircraft or from the ground, or both.

Aerial surveys on 5 and 6 October 1982 covered the southern and western lowlands and the coast, from Nupsvötn in the southeast to Sauratjörn on Snaefellsnes in the west. The south coast of Breidafjördur, from Bjarnarhöfn to Budardalur, was also surveyed from the air on 5 October, as were the lowlands of Hunavatnssysla and the Arnarvatnsheidi plateau. Some southern and western areas (Laugardaelavatn, the Reykjavik area, most of Borgarfjördur) were censused both from the air and on the

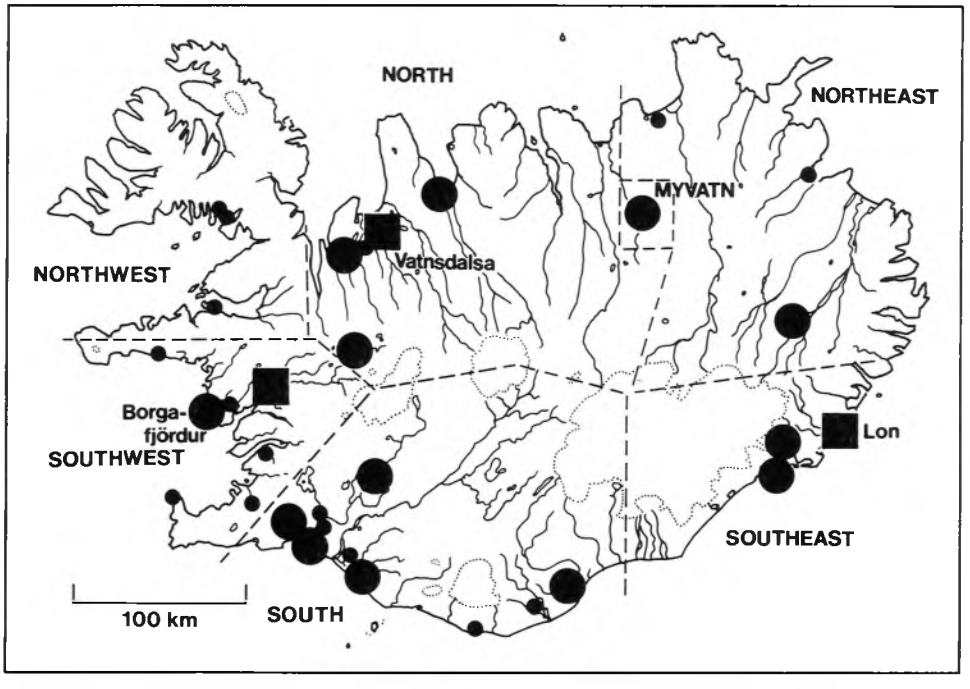

Figure 1. The distribution of main staging sites of Whooper Swans in Iceland in October 1982. Small circles indicate 11–100, large circles 101–1000 and squares over 1000 birds. Regional boundaries employed here are also shown.

ground. Other areas were censused only from the ground: the Kjos valley, Reykjanes and southern Snaefellsnes peninsulas in the southwest on 2–4 October; Djupifjördur in the northwest on 15 October, Skagafjördur in the north on 7 October, Myvatn on 9 October, Kelduhverfi (northeast) about 17 October, eastern interior areas on 8 to 16 October, and the southeast on 12 and 13 October. About 96% of the birds were censused during 9 days, 5 to 13 October.

We assume that there was little movement between adjacent areas during the census as well as between the western regions, censused mostly on 5 and 6 October, and the eastern regions, censused largely on 9, 12 and 13 October.

Some areas in Iceland which may have held Whooper Swans were not surveyed in October 1982. For these areas we have used what collateral evidence we had available. Also, some swans had left Iceland before the census. We tried to account for them by making enquiries amongst observers in the northwestern parts of the British Isles.

Age ratios and brood sizes were recorded in most of the areas censused and records were kept of the types of habitat used by swans. Relevant information from our field notes of previous surveys is used freely here, especially as regards the composition of the population and the numbers and distribution of moulting flocks. Brood sizes and age ratios in the British Isles were obtained directly from the observers, from National Wildfowl Counts, and from published reports.

Results

Numbers in Iceland in October 1982

A total of 9057 Whooper Swans were censused in early October 1982 (Table 1). Their regional distribution (Fig. 1) is outlined in some detail below.

South

The lowlands of the counties Vestur-Skaftafellssysla, Rangarvallasysla and Arnessysla are largely covered by partly drained meadows and flood plains. There are some shallow lakes and many ponds and meres, often with abundant vegetation. Whooper Swans breed widely and occur in this region at all times of the year, though concentrations are usually small.

On 6 October a total of 1646 Whooper Swans were found in the southern lowlands, mostly in loose aggregations in a few areas. Most of the swans (1372) were in the Arnes- and Rangarvallasysla, the largest concentrations were on lakes near Stokkseyri (about 380), in Pollengi (330), on Lake Skumsstadavatn (170), in the Ölfusa estuary (140), on Lake Alftavatn (100) and Lake Laugardaelavatn (90). A total of 274 swans were in Vestur-Skaftafellssysla, mainly in the eastern part of Medalland (170).

We probably covered all important staging areas in the south, but must have missed some birds because of incomplete coverage in the lowlands and almost none in the highlands. The number missed was probably low, perhaps 100–200 birds.

Table 1. Numbers and distribution of Icelandic Whooper Swans in October 1982.

Region	Date (October)	Method	Total seen	Estimated no. missed	% young (95% C.L.)	no. aged
South	6	air	1646	100–200	23.0 (21.1–24.9)	1007
Southwest	2–9	air/ground	1934	50–100	18.9 (17.1–20.7)	1804
Northwest	5, 15	air/ground	234	100–200	4.1 (1.3–6.9)	194
North	5,7	air/ground	2227	200–300	25.0 (22.5–27.5)	1137
Myvatn	9	ground	716	0	17.3 (14.4–20.2)	636
Northeast	8–17	ground	296	400–600	—	0
Southeast	12, 13	ground	2004	0	7.9 (6.7–9.1)	1884
Total Iceland			9057	850–1400	18.2[1]	6662
In British Isles				200–500		
Total missed				1050–1900		
Corrected total				10,107–10,957		

[1] Weighted for regions.

Southwest

The southern half of this region, comprising the barren Reykjanes Peninsula and hilly country between Reykjavik and the Borgarfjördur lowlands, is little used by swans except in winter when it is relatively important. We found 30 in small coastal lakes on the outer peninsula on 9 October, 49 in and around Reykjavik on 6 October, 46 in Kjos on 2 October and 14 scattered in the southern Borgarfjördur on the same date.

The flood plains of the Borgarfjördur lowlands, especially along the rivers Grimsa, Nordura and Gljufura, are a major staging site of Whooper Swans in autumn as well as in spring. Numbers begin to build up in early September (e.g. 96 on 8 September 1977, 171 on 12 September 1981) and appear to reach a maximum in the last days of September or in early October, when up to 1800 swans were seen in 1974 (Gardarsson 1975). This important area was covered both from the ground and the air on 5 October 1982. The aerial census yielded 973 swans of which an estimated 800 were on the Nordura-Gljufura. The ground census came to 1057 (851 on the Nordura-Gljufura). The latter figure is used in Table 1 as it was presumably more accurate because of the difficulty of counting large flocks from the air. The Borgarfjördur lowlands were covered thoroughly again on 23 October. No ice had formed on the rivers or other wetlands, yet only 9 swans (two pairs with young) were found. According to the local inhabitants most of the swans had disappeared a week earlier.

Shallow sea bays, with a good growth of eelgrass *Zostera marina,* and coastal lakes of the Myrar district hold important numbers of swans, especially during the moult but also at other seasons. A total of 587 swans were censused on 5 October in and around the estuary Alftaros, a further 80 were on a lake near Leirulaekur and 31 were scattered, mainly in family parties on inland lakes. A total of 40 swans were found on 4 October on lakes in Stadarsveit on the Snaefellsnes peninsula.

All known concentrations of Whooper Swans in the southwest were covered. However, not all interior lakes were visited and these may have held perhaps 10 to 20 families, i.e. about 50 to 100 individuals if the average brood was 2.7 (see Table 2).

Northwest

This region only holds small numbers of breeding Whoopers, but several moulting flocks occur in shallow bays and in some of these small flocks are found in spring and autumn. Before the decrease of *Zostera* in the 1930s very large numbers of swans moulted in Gilsfjördur (Theodorsson 1936), which in recent years has only held a few dozen, as well as in Hvammsfjördur and Alftafjördur (Thorsteinsson 1947).

On 5 October a total of 93 Whoopers were found on the sea in Alftafjördur and Hvammsfjördur, where 5 were seen on a river. On 15 October 96 were counted in Djupifjördur and 40 on a lake in Gufudalur.

Coverage was incomplete in the northwest, in particular a few bays known to hold moulting birds were not included. Clearly a small number, perhaps 100 to 200, were missed in the census.

North

This region comprises the three lowland valleys of Hunavatnssysla, Skagafjördur and Eyjafjördur, as well as the adjoining western highlands, a lake-studded boggy plateau with many nesting swans.

The lowlands of Hunavatnssysla were surveyed on 5 October. Most of the 1645 swans seen there were concentrated on the lower Vatnsdalsa (1464), a further 164 were on Midfjardarvatn and the remaining 17 on a lake in Vididalur. Vatnsdalsa was surveyed also on 17 September 1982 when we found 1075 swans there of which there were 974 adult and 101 (9.4%) young. On 5 October there were 22.7% young in a sample of 696 on Vatnsdalsa, corresponding to 332 young and 1132 adult in the total. Hence the increase at Vatnsdalsa can be attributed entirely to families moving into this staging locality. In the only previous census of Vatnsdalsa, on 14 October 1978, 454 swans (16.5% young) were found.

Three moulting localities in Hunavatnssysla were omitted on 5 October but surveyed on 17 September: Lake Svinavatn (40 swans), Lake Hop (12) and the estuary Sigridarstadavatn (57). Some of these swans may have been still on their moulting grounds in October. Some may also have been missed on lakes on the Skagi peninsula.

In Skagafjördur only the major concentration of Lake Miklavatn was censused. This held 310 Whooper Swans on 7 October and 320 on 17 September. Other wetlands in Skagafjördur were not investigated; some may still have held breeding pairs. Nor were any swans counted in Eyjafjördur where

only a few pairs breed and autumn flocks do not occur.

The high ground between Vatnsdalur and Hvitarsida in Borgarfjördur was surveyed from the air on 5 October. No swans were on the numerous small lakes and ponds, but a total of 272 were seen in flocks on a few large lakes from Arnarvatn southwest to Ulfsvatn.

Further east in the highlands there may have been a staging flock on Lake Vestara Fridmundarvatn, where a pilot reported that perhaps a hundred swans were present on 29 September.

Our survey in this part of north Iceland was fairly complete, we feel that perhaps 200 to 300 swans may have been missed.

Myvatn

The shallow and highly productive Lake Myvatn is an important haunt of the Whooper Swan throughout the year (Gardarsson 1979). It is surrounded by extensive dry uplands and therefore relatively isolated and best treated separately.

Myvatn and surrounding wetlands were counted on 9 October. A total of 716 Whoopers were found, mostly on the very shallow Ytrifloi (363) and Graenavatn (117). The 1982 total is lower than the only previous comparable count on Myvatn, on 7 October 1978 when 926 swans were found.

On 30 July 1982 there were 674 moulting Whooper Swans on Myvatn, on 15 September the total was 590, including 10 young of the year (1.7%). In October the proportion of young was 17.3% (n 636). Thus some emigration or dispersal of moulters took place, and broods moved into the area in autumn.

Northeast

This region includes the counties Nordur-Thingeyjarsysla and the Mulasyslas south to Djupivogur. There are extensive areas of Whooper Swan breeding habitat and some minor moulting and staging localities. We had few direct observations from the northeast in October 1982 and rely largely on previous surveys.

Most of the Kelduhverfi-Öxarfjördur delta wetlands were censused on 17 October. Of the total of 106 swans found, 65 were on the river Arnarneslon.

Coastal wetlands of the far northeast were not covered, but were likely to have held some swans, especially the brackish inlets and lakes of Melrakkasletta and Langanes. An aerial survey of this coastline on 10 September 1977 yielded a total of 120 Whoopers, mainly non-breeders.

The brackish lagoon Skogalon in Vopnafjördur held about 30 swans on 18 October 1982. This is somewhat less than the numbers moulting there in recent years which have varied between 40 and 70.

The lowland lakes of Herad were incompletely covered, but very few swans are likely to have been missed. On 14 and 16 October about 50 Whooper Swans were found there.

The highland bogs and numerous lakes of the eastern interior are a major nesting area of Whooper Swans. Near Lake Anavatn on the Jökuldalsheidi 16 Whoopers were found in family parties on 11 October. On the Gilsarvötn and Bessastadavötn lakes about 120 were seen on 7 and 8 October. We were unable to reach an important moulting and staging locality on Tunguheidi where about 300–400 swans were present on 28 September 1981 and 'large numbers' on 7 and 8 October 1982.

Clearly some hundreds were missed in the northeast, especially in flocks on Tunguheidi and on the coast, but also an unknown number of dispersed birds. In view of the incomplete coverage we estimate that about 400–600 swans were missed in this region.

Southeast

This region comprises Sudur-Mulasysla south of Djupavogur and the county Austur-Skaftafellssysla. Whooper Swans in this part of Iceland are concentrated in a few well-defined coastal wetlands. The brackish lagoons Lon and Alftafjördur are important staging and moulting sites. Spring totals in the southeast sometimes exceed 4000, mostly on Lon (e.g. 3300 on 19 May 1979, a late spring, and 2600 on 6 April 1980). About 1200 swans moult on Lon and 200–400 on Alftafjördur. Freshwaters around Hornafjördur are used by many staging swans and several breed there.

On 12 and 13 October a total of 2,004 Whooper Swans were censused in the southeast. Most were on Lon, 1,060, and near Hornafjördur, 939 of which 603 were on a lake near Vidbord and 260 near Flatey. We feel confident that practically all swans present in the southeast were accounted for.

Observations at Lon in autumn 1982 showed that the main exodus of the swans took place between 14 and 23 October and suggested that families moved later than

adults without young. The totals and proportion of young were as follows: 12 October 1060 (3.8%), 14 October 1178 (4.3%), 23 October 416 (18.5%) and 1 November 243 (13.6%).

Swans missed by emigration

The census was timed to coincide with maximum numbers of swans being present on their staging grounds in Iceland. No doubt some swans were missed in Iceland because they were dispersed or were in flocks that were not covered in the census. Their number was probably between 850 and 1,400 (Table 1). It remains to account for birds that had already left Iceland for the winter. In Scotland arrival takes place chiefly from mid-September to November (Bannerman 1957), with peak arrival in late October (Hewson 1973). In Ireland the first Whooper Swans arrive early in October or sometimes in September (Hutchinson 1979). A few Whoopers spend the summer in the northwestern British Isles (e.g. Ruttledge 1974, Bannerman 1957).

Enquiries in northwest Scotland and Ireland suggest that few Whooper Swans had arrived there at the time of the 1982 census. In Shetland the first two were seen on 2 October, with good numbers on 9–10 October and widespread arrival in mid-October (J. D. Okill, *in litt.*). At Loch Spiggie in Shetland (Fig. 2) 8 Whooper Swans were seen on 8 October and up to 24 before 20 October. Numbers then began to increase, reaching a maximum of 344 on 3 November. There was some suggestion that arrival was late in Shetland (Okill 1982).

On Fair Isle 5 Whoopers were seen on 15 September and again on 21 September. Then none were seen until 21 October. From that date to 12 November up to 30 Whooper Swans were sighted each day except 7 and 9 November (Riddiford 1983).

In Orkney arrival time was probably a few days later than usual and the main influx was during 21–23 October (C. Booth, *in litt.*). In

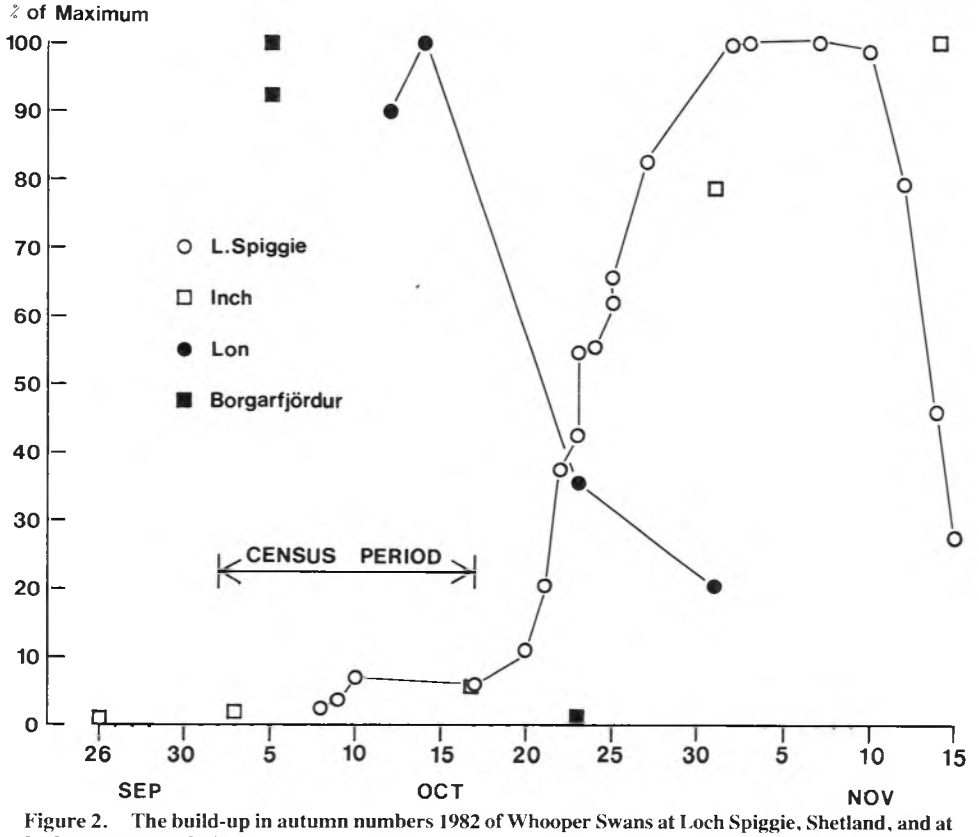

Figure 2. The build-up in autumn numbers 1982 of Whooper Swans at Loch Spiggie, Shetland, and at Inch near Lough Swilly, Ireland, compared with observations at Lon and Borgarfjördur, Iceland, and the census period.

Lewis in the Outer Hebrides one Whooper was seen on 23 September, 15 on 23 October and 90 on 24 October, the largest number recorded since 1977 (W. A. J. Cunningham, *in litt.*).

At Inch Lough, near Lough Swilly in northwest Ireland, 13 Whooper Swans were seen on 25 September, some of these had probably summered there; 38 on 3 October, 110 on 17 October, 1500 on 31 October and 1900 on 14 November. At Lough Foyle 14 were seen on 10 October, 19 on 22 October and numbers reached 300 on 25 October. Arriving swans were noted at Malin Head on 20 and L. Foyle on 22 October. These dates were probably a little later than usual and numbers were unusually high at Inch (J. R. Sheppard, *in litt.*).

The total numbers of Whooper Swans in the British wildfowl counts were 25 in mid-September, 710 in mid-October and 3,150 in November (Salmon 1983). At both Loch Spiggie in Shetland and Inch in Ireland about 2–7% of the maximum number recorded had arrived before the end of our census period (Fig. 2). This proportion can be regarded as a rough indication of the numbers likely to have been missed abroad which we estimate as lying between 200 and 500.

The proportion of young

About 74% of all swans seen in the census were aged and a total of 356 broods were counted. The proportion of young in the total, weighted by regions, was 18.2% (Table 1). The proportion of young within a region was obviously influenced by its relative importance as a breeding or moulting area. Thus the north and the south both had high percentages of young (25 and 23% respectively) and had small numbers of moulters (cf. Table 6) and extensive breeding areas. Conversely, the southeast (about 8% young) was dominated by large concentrations of moulters and only about 30 pairs breed in the area, though immigration of families from the northeast probably takes place in the autumn.

The mean brood size (Table 2) in the total was 2.60, it was smallest in the east (2.34) and largest in the southwest (2.74). Regional differences in brood size were not statistically significant in October, but this apparent uniformity may be caused by the mixing of swans from wide areas in the autumn.

It is interesting to compare the proportion of young in the population in October, immediately before emigration, with estimates made earlier in Iceland, and during the winter, mainly in Britain. In early August broods (Table 3) were significantly larger than in either September ($t = 2.25$, $p > 0.05$) or October ($t = 2.87$, $p < 0.01$). Other differences in brood sizes were not significant, suggesting that little mortality of young took place in Iceland after fledging and that migration over the sea to the British Isles was not a particular hazard.

Age ratios in winter 1982–3 did not

Table 2. Brood sizes of Whooper Swans in Iceland in early October 1982.

Region	Mean ± S.E. (n)	Brood size						
		1	2	3	4	5	6	7
South	2.63 ± 0.13 (87)	19	23	25	11	9	–	–
Southwest	2.74 ± 0.12 (115)	20	33	32	23	3	2	2
North	2.55 ± 0.10 (110)	18	38	31	22	1	–	–
East	2.34 ± 0.16 (44)	11	14	14	3	2	–	–
Total	2.60 ± 0.06 (356)	68	108	102	59	15	2	2

Table 3. Brood sizes in Iceland in August and September 1982 and in Scotland, including Shetland and Orkney, in mainly November 1982. (cf. Table 2 for October).

	Mean ± S.E. (n)	Brood size							
		1	2	3	4	5	6	7	8
4 and 6 August	3.16 ± 0.21 (43)	4	9	16	7	6	–	–	1
14–18 September	2.64 ± 0.12 (56)	6	19	20	11	–	–	–	–
November, Scotland	2.56 ± 0.09 (118)	21	34	40	22	1	–	–	–

depart significantly from the estimated ratio in the census (Table 4). There was considerable regional variation in the winter ratios which is outside the scope of this paper but clearly local samples of age ratios need to be treated with care. It should also be noted that age ratios did not change through the winter. This is in agreement with previous findings (Boyd & Eltringham 1962) and suggests that the juveniles did not have a substantially lower survival rate than adult swans.

Table 4. The proportion of young in winter 1982–3.

	% (95% C.L.)	n
British Isles:		
October	19.4 (14.7–24.1)	278
November	17.8 (16.0–19.6)	1827
December	15.4 (13.2–17.6)	1027
January	18.0 (14.0–22.0)	355
Iceland:		
mostly March	22.4 (17.9–26.9)	326

The proportion of pairs that raise broods is an important variable in the estimation of the production of young. In aerial surveys on 3 and 6 August 1982, covering a wide area of breeding habitat in southwest, north and south Iceland, 48 (61%) of 79 scattered pairs were parents and 31 were without young. However, this proportion is dependent on the definition of what constitutes a dispersed pair and if single adults and groups of 5 or less are included the 96 parent swans correspond to 53% of 180 dispersed adults. Again parents were about 55% of dispersed pairs in August in two highland areas where breeding success was followed in 1976 and 1981 (Table 5) and 56% (14 of 25 pairs) in highland areas studied by Bulstrode *et al.* (1973). Since the proportion of parents among dispersed swans was similar in 1982 as in the previous surveys, the data in Table 5 can be used to approximate breeding success of birds dispersing in spring 1982, though regional and annual variation is likely to be considerable.

Numbers in moulting flocks

Moulting flocks varying in size from a few to 1300 swans occur in many parts of Iceland, especially on the coast (sea bays and lagoons) and on large inland lakes. The flocks usually begin to form in June and a rapid build-up occurs during the first 3 weeks of July. Numbers are stable during about 25 July to about 20 August after which they often decrease.

A complete survey of these flocks in one year has yet to be made. They seem to vary little in numbers over large areas though numbers can be quite variable in any one locality between years. At 9 moulting localities numbers totalled 1753 in 1976 and 1755 in 1982. Moulting numbers at Myvatn have been monitored for ten years, 1973–83. They averaged 588 ± SE 21 with extreme values of 484 in 1980, after a year of exceptionally poor breeding, and 698 in 1983. The very large flock at Lon seems to have remained at about 1200 over 20 years (occasional counts). On the west coast we have noted a big decrease at Alftaros after 1973 and an increase in Hvammsfjördur.

The best available estimate of the numbers of Whooper Swans in moulting flocks is about 6200 (Table 6). This estimate has relevance to the examination of the structure of the population attempted here.

Habitat distribution in late summer and autumn

Breeding Whoopers are found almost entirely on fresh waters, at altitudes from sea level to about 700 m. Moulting flocks, consisting of non-breeders and presumably failed breeders, are primarily found on marine and brackish waters (Table 7).

Table 5. Estimates of breeding success of Whooper Swans in two highland areas, Arnarvatnsheidi (western highlands) in 1976, wetlands east of Snaefell (eastern highlands) in 1981.

	June		August		
	Total pairs	With nests	With broods	Without broods	Disappeared
Arnarvatnsheidi	28	14	6	11	11
Snaefell	36	26	10	2	24
Total (%)	64	40(62)	16(25)	13(20)	35(55)

Table 6. A summary of the numbers and distribution of moulting flocks of Whooper Swans in Iceland. Counts used here were made in the period 25 July–20 August in the year(s) when the largest contiguous areas were covered.

	Freshwaters above 300 m	Freshwaters below 300 m	Brackish lagoons	Sea bays	Year(s)
South					
Stokkseyri	–	–	–	285	1975
6 other sites	47	66	–	–	1972–82
Southwest					
Alftaros	–	–	–	1300	1973
4 other sites	–	–	–	136	1973(76)
Northwest					
Hvammsfjördur	–	–	–	402	1973
11 other sites	–	–	–	295	1973(–82)
North					
Miklavatn	–	242	–	–	1976
Ulfsvatn	184	–	–	–	1976
Arnarvatn	102	–	–	–	1976
Sigridarstadavatn	–	–	–	145	1976
Fridmundarvötn	84	–	–	–	1976
12 other sites	54	162	–	45	1976(71)
Myvatn	–	626	–	–	1976
Northeast					
Tunguheidi	130	–	–	–	1981
Skogalon	–	–	68	–	1980
Anavatn	66	–	–	–	1981
9 other sites	0	104	99	–	1976–81
Southeast					
Lon	–	–	1265	–	1975
Alftafjördur	–	–	215	–	1975
Hamarsfjördur	–	–	–	60	1975
3 other sites	–	0	9	0	1975
Total	667	1200	1656	2668	
					6191

Table 7. Habitat distribution of Whooper Swans in Iceland in August and October.

	Freshwaters above 300 m	Freshwaters below 300 m	Sum	Per cent Brackish lagoons	Sea bays	Number
August						
Flocks	20	11	31	28	41	6191
Dispersed	?	?	99	–	1	5000
Total estimated	–	–	61	15	24	11000
Early October						
Total seen	75	4	79	12	9	9057

Notes. August data on flocks in 1971–83 from Table 6. 'Flocks' include presumed non-breeders and failed breeders. 'Dispersed' are successful parents and their young, plus failed breeders; their number is approximated from the total population and the number of birds in moulting flocks.

About 41% of swans in moulting flocks occur on sea bays and estuaries with close to full salinity and feed largely on eelgrass *Zostera marina,* about 28% occur on brackish lagoons and take mainly *Ruppia maritima* (Lon). The remaining 30% of the moulting flocks stay on fresh waters with about two-thirds in the lowlands (below about 300 m a.s.l.), presumably feeding largely on *Potamogeton filiformis,* and one-third in the highlands.

After the moult, from late August through September, a shift of breeders from highlands to lowlands and of non-breeders from saline to freshwater habitats takes place (Table 7). It is not known whether this shift is related to the phenology of the main food species or whether perhaps the more open marine habitats are preferred by flightless non-breeders for safety reasons. The shift from moulting to staging grounds is most pronounced in the western parts of Iceland, for instance no swans moult in the very important staging localities Vatnsdalsa, the Borgarfjördur and numerous wetlands in the south. By early October about three-quarters of the birds are found on lowland freshwaters and only about a fifth in marine habitats. As a result pondweeds (mainly *Potamogeton filiformis* in the west and north and *P. natans* in the south) become a much more important food in October than in the summer.

Discussion

The census in perspective

Somewhere between 850 and 1400 swans were probably missed in Iceland and perhaps 200 to 500 in the British Isles (cf. Table 1). Since the census took place almost entirely within a period of only 9 days we assume that the number counted twice was negligible, but we are unable to quantify this. In round figures the estimated population of the Icelandic Whooper Swan in October 1982 was about 10,000 to 11,000 individuals. This estimate is considerably higher than previous ones.

There have been no prior censuses of the Icelandic Whooper Swan population approaching complete coverage. Previous totals (Boyd 1963; Ogilvie 1972; Gardarsson 1975; Atkinson-Willes 1981; Brazil 1981) are all based to a large extent on indirect evidence. We believe that the present estimate 10,000 to 11,000, instead of 5000 to 7000 as generally supposed earlier, is a consequence of better coverage and should not be taken as an indication of population increase. The first estimate was made by Boyd (1963) who stated that 'since Icelandic birds probably make up almost the entire number of Whoopers visiting Great Britain (3000–4000) and Ireland (perhaps 2000) while some remain in Iceland throughout the year, the total population of Whoopers in Iceland is probably 5000–7000 . . .'. It is worth noting that Boyd must be referring to the adult population in Iceland and this considerably lessens the gap between his and our estimates.

A total of 500 to 800 Whooper Swans winter in Iceland according to our recent surveys. This is considerably less than the 'thousands' previously suggested without supporting evidence by Finnur Gudmundsson (in Bannermann 1957) and the widely quoted '1000 to 1500' of Ogilvie (1972) from information supplied by Gudmundsson (M. A. Ogilvie, pers. com.).

Boyd and Eltringham (1962) considered that the total number of Whooper Swans wintering in Scotland, England and Wales did not exceed 4000. This estimate was based on a census of 2200 in the winter of 1960–1 and 3100 in November 1961. Brazil (1981), referring to a census in November 1979, estimated the size of the Whooper Swan population wintering in Britain and Ireland to be about 6700, of which 4100 were in Scotland.

Ireland is likely to be the main winter region of Icelandic Whooper Swans but a complete census has not been conducted there. Hutchinson (1979) states that the size of the population wintering in Ireland is difficult to estimate, but is probably between 4000 and 6000 birds. The lower figure is supported by detailed regional data. The upper part of Hutchinson's range for Ireland is indicated by our population estimate and known wintering numbers in Britain and Iceland.

Finally, ringing recoveries show that Icelandic Whooper Swans reach the Continent (2 out of 41 recoveries) and the possibility of some numbers wintering regularly in, e.g., western Norway should not be ignored.

A population model

The information now available on the numbers and distribution of Whooper

Swans in late summer and autumn can be used to examine in more detail the structure and dynamics of the population. This analysis extends the pioneering report of Boyd and Eltringham (1962).

As a basis we use 10,500 as the total population in October 1982. The error of this estimate is at most ±5%. Error in estimating the various components of the population is of course much larger. In view of the crudeness of the data and for the sake of simplicity we choose to present them without indication of error or range (Table 8).

The proportion of young was 18.2% and the number of adult birds in October therefore about 8600 (cf. Table 1). Assuming that this replacement rate equals the annual mortality rate of adult swans and that losses occur at a constant rate throughout the year, the number of adults about 1 August becomes about 8900. Moulting numbers seem to have remained fairly stable at about 6200 in recent years. Hence dispersed adults in August were about 2700. Of these about 1500, i.e. 17% of all adults, were successful parents, using brood data from October 1982. This is in good agreement with observations in August 1982 and in earlier years (Table 5).

The large number of swans moulting in flocks bears closer examination. In particular it is of interest to know the age distribution in these flocks and to what extent birds that disperse on the breeding grounds in spring later join moulting flocks. Using the assumption of constant survival rates of full-grown birds, yearlings in early August are about 1600 and the dispersed adults require about 490 recruits (2700 × 0.18) to balance their annual losses. Hence the total of 6200 swans in moulting flocks equals the number of birds aged 1–6 years (Table 8). A number of swans disperse on the breeding grounds in spring and later join the moulting flocks, perhaps most often without nesting. This category is estimated from data in Table 5 as 55%, corresponding to 3300 birds in the total population which is the same as the figure for birds aged 3–6 years. This suggests that birds may remain in flocks in the first two years and that 3–6 year old Whoopers are generally unsuccessful as breeders. While the foregoing speculation fits the data, it ignores much detail, such as variation in the age of first breeding and the presence in moulting flocks of injured or otherwise handicapped individuals.

While more intensive studies are clearly needed, we can tentatively conclude that the moulting flocks may consist largely of pre-breeders 1–6 years old.

Table 8. A model of the structure of the Icelandic Whooper Swan population about 1 August.

Category	Number (%) in category	Number in year class	Age years
Dispersed			
Without young	1200 (13)		
With young	1500 (17)	2000	0
Total dispersed	2700 (30)		
Moulting flocks			
Always in flocks	2900 (33)	1600	1
		1300	2
Dispersed in spring	3300 (37)	1100	3
		900	4
		700	5
		600	6
Total in flocks	6200 (70)		

Notes.

1. Total number of adults is based on estimated total in October, corrected for calculated losses in August–October. Survival was assumed to equal proportion of old birds in October. The proportions of the main categories of adult birds are calculated from data in Tables 5 and 6.
2. The model assumes that the population does not change between years, that annual survival is 0.82 and does not change with age after the first September of life, that survival is independent of time of year and that the sexes are equal in numbers and survival.

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Summary

A total of 9057 Whooper Swans *Cygnus cygnus* were found in a census covering most staging areas in Iceland in October 1982. About 850–1400 may have been missed in Iceland and 200–500 in the British Isles. Thus the total Icelandic population was between 10,000 and 11,000.

About 18% of the number were young of the year. The percentage of young in October varied between parts of Iceland, largely as a result of the distribution of flocks of moulting non-breeders. The mean brood size was 2.60. Significant brood reduction occurred in August–September but after that there was good survival. Migration did not appear to increase juvenile mortality and the proportion of young did not change during winter 1982–3, suggesting that survival of juveniles was similar to that of older birds.

Surveys in 1971–83 indicate that about 6200 full grown Whoopers moult in flocks, mainly on saline waters. A shift to freshwaters and ot breeders from high ground to the lowlands takes place in autumn.

An outline model of the population which fits available census data is presented (Table 8).

References

Atkinson-Willes, G. L. 1981. The numerical distribution and conservation requirements of swans in northwest Europe. Pp. 40–48 in G. V. T. Matthews and M. Smart (ed.). *Proceedings 2nd International Swan Symposium, Sapporo.* IWRB, Slimbridge.

Bannerman, D. A. 1957. *The birds of the British Isles.* Vol. 6. Oliver and Boyd, London.

Boyd, H. 1963. *Whooper Swans seen in aerial surveys of parts of Iceland in early July 1963.* Wildfowl Trust (mimeogr.).

Boyd, H. & Eltringham, S. K. 1962. The Whooper Swan in Great Britain. *Bird Study* 9: 217–41.

Brazil, M. 1981. The behavioural ecology of the Whooper Swan *(Cygnus cygnus cygnus).* Unpubl. Ph.D. thesis. University of Stirling, Scotland.

Bulstrode, C. J., Corbett, E. S. & Putman, R. J. 1973. Breeding of Whooper Swans in Iceland. *Bird Study* 20: 37–40.

Gardarsson, A. (ed.) 1975. Votlendi. *Rit Landverndar* 4. Reykjavik.

Gardarsson, A. 1979. Waterfowl populations of Lake Myvatn and recent changes in numbers and food habits. *Oikos* 32: 250–70.

Hewson, R. 1973. Changes in a winter herd of Whooper Swans at a Banff loch. *Bird Study* 20: 41–49.

Hutchinson, C. 1979. *Ireland's wetlands and their birds.* Irish Wildbird Conservancy, Dublin.

Ogilvie, M. A. 1972. Distribution, numbers and migration. Pp. 29–55 *in* P. Scott and the Wildfowl Trust. *The Swans.* Michael Joseph, London.

Okill, J. D. 1982. The 1982 Whooper Swan count. *Shetland Bird Club Newsletter* No. 45: 9–10.

Riddiford, N. (ed.) 1983. *Fair Isle Bird Observatory Report* No. 35, 1982. Edinburgh.

Ruttledge, R. F. 1974. Winter distribution of Whooper and Bewick's Swans in Ireland. *Bird Study* 21: 141–5.

Salmon, D. G. (ed.) 1983. *Wildfowl and wader counts 1982–1983.* The Wildfowl Trust, Slimbridge.

Theodorsson, J. 1936. Alftir og alftafjadrir. *Eimreidin* 42: 236–8. Reykjavik.

Thorsteinsson, Th. 1947. Dalasysla. *Arbok Ferdafelags Islands 1947.* Reykjavik.

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