

Population size and breeding success of the Icelandic Whooper Swan *Cygnus cygnus*: results of the January 2005 international census

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Abstract

The fifth international census of Whooper Swans in Britain, Ireland and Iceland was undertaken in January 2005 to determine the size and winter distribution of the Icelandic-breeding Whooper Swan population. A total of 26,366 Whooper Swans was counted, of which 37% were recorded in the Republic of Ireland (9,748 birds), 25% in England (6,480), 16% in Northern Ireland (4,331), 16% in Scotland (4,142), 6% in Iceland (1,556) and < 1% in Wales and the Isle of Man (109). A comparison with results of the previous international census made in January 2000 found that the numbers of swans counted had increased in all countries except Wales. There was also an increase in the proportion of swans wintering in England and Scotland, compared with numbers elsewhere in the range. The substantial increase in numbers of birds in England was not accompanied by a significant increase in the number of flocks recorded, and distribution remains concentrated at relatively few sites. In contrast, there was a decrease in the number of flocks found in the Republic of Ireland and an increase in Scotland. As with previous censuses, birds were recorded most commonly on pasture in Britain and Ireland, although use of arable land has increased over the last three censuses from 7% to 27%. The total number of Whooper Swans counted in 2005 was the highest census total to date. This represents a 26.4% increase on numbers recorded in the January 2000 census, and a 66.4% increase in population size over the last decade.

Key words: *Cygnus cygnus*, international census, population size, population trends, winter distribution, Whooper Swan.

The Whooper Swan *Cygnus cygnus* breeds across the northern Palearctic, ranging from Iceland and northern Scandinavia in the west, to the Pacific coast of Russia in the east (Brazil 2003; Rees 2005). Five main populations have been described: the Icelandic-breeding population; the Northwest Mainland Europe population; the Black Sea/East Mediterranean population; the Caspian/Central Asian population; and an East Asia population (Wetlands International 2002). Counts and resightings of leg-rings have shown that most birds from the Icelandic population winter in Britain and Ireland (Cranswick *et al.* 2002; Rees *et al.* 2002), although a small number (up to 1,300 individuals) remain in Iceland for the winter (Gardarsson & Skaphedinsson 1985; Cranswick *et al.* 2002). Data from swans ringed in Britain or Iceland and re-sighted in Norway, Denmark, France and the Netherlands indicate that 400–600 birds from the Icelandic population may winter on continental mainland Europe (Gardarsson 1991; Cranswick *et al.* 1997). Conversely, a small number of birds ringed in Finland have been recorded in Britain, mainly in southeast England, giving rise to the suggestion that about 200 birds from the Northwest Mainland Europe population winter in Britain (Laubek *et al.* 1998).

Whooper Swan population size is most effectively monitored during the non-breeding season, when the birds congregate at traditional wintering sites. During the breeding season birds are dispersed across Iceland, often in relatively inaccessible areas. Annual monitoring of waterbirds during the non-breeding season has taken place in Britain since the 1940s and continues

through the Wetland Bird Survey (WeBS) (Collier *et al.* 2005), whereby coordinated counts are made at selected wetland sites on a specified date each month. WeBS was extended to Northern Ireland in 1986 and the establishment of the Irish Wetland Bird Survey (I-WeBS) in the Republic of Ireland followed in 1994/95, providing regular coverage of Irish wetlands (Crowe 2005). In addition, the Irish Whooper Swan Study Group (IWSSG) has collected data on this species since the early 1990s, including at sites not normally counted by WeBS and I-WeBS.

The annual indices of Whooper Swan abundance derived from the WeBS dataset suggest that numbers of Whooper Swans in Britain were relatively stable from the mid 1960s to the mid 1980s, after which a substantial increase occurred during the late 1980s. Numbers appeared to stabilise once more for most of the 1990s, but have since undergone a further major increase. The total number of Whooper Swans recorded at WeBS sites each year nearly doubled in the ten-year period between 1993/94 to 2003/04 (Cranswick *et al.* 2005; Collier *et al.* 2005).

Dispersal of small flocks of Whooper Swans over a large number of sites and the tendency to feed on temporary wetlands and non-wetland habitats means that WeBS counts may miss a substantial proportion of birds. Since many sites which are used by Whooper Swans are not covered by WeBS or I-WeBS, species-specific surveys remain important for confirming population size and trends. International censuses have been undertaken since 1986 and now occur once every five years in mid January. The first

coordinated census found a total of 16,742 individuals in 1986 and subsequent censuses in 1991, 1995 and 2000 found 18,035, 15,842 and 20,856 individuals, respectively (Salmon & Black 1986; Kirby *et al.* 1992; Cranswick *et al.* 1997; Cranswick *et al.* 2002).

In the second half of the 20th century, the Whooper Swan's traditional feeding habitats of freshwater lakes and marshes, brackish lagoons and coastal bays broadened to include farmland habitats (Robinson *et al.* 2004). Feeding in harvested potato fields was first reported in the 1940s, since when flocks have also been recorded on cereal stubbles and potato stubbles, winter cereals and occasionally oil seed rape (Anderson 1944; Kear 1963; Chisholm & Spray 2002). Although numbers counted at arable sites during the censuses in Britain and Ireland have not exceeded 15% of the Icelandic Whooper Swan population (Cranswick *et al.* 2002), it has been estimated that 60% of the Northwest Mainland Europe Whooper Swan population frequents farmland (including grass) in winter, with 41–84% of those in Denmark, the Netherlands and Germany recorded on arable crops (Laubek *et al.* 1999).

This paper describes the results of the fifth international census of Whooper Swans in Britain, Ireland and Iceland, undertaken in January 2005. It aims to provide an update on the size and distribution of the wintering population, information which is essential to enable the selection and management of sites of international and European importance designated under agreements such as the

Ramsar Convention and the Birds Directive. Variation in the proportion of juveniles recorded in flocks in different parts of the wintering range is considered in relation to age ratio data recorded in previous censuses, to determine whether any consistent bias exists in the distribution of families across the wintering range. Finally, habitat use during January 2005 is described in relation to past census data. Changes between censuses in the use of arable habitats in Britain and Ireland are assessed to determine the scope for any future conflict between the swans and agriculture.

Methods

The census of Whooper Swans wintering in Britain, Ireland and Iceland was undertaken by a network of volunteer counters in mid January, and aimed at complete coverage of known and potential Whooper Swan sites. Most counts in Britain and Ireland were made within a five-day period around the weekend of 15–16 January 2005, the dates being chosen to coincide with the national waterbird monitoring schemes in the UK (WeBS) and in the Republic of Ireland (I-WeBS), and also with a census of the Northwest European population of Whooper Swans being made in mainland Europe. In addition to WeBS and I-WeBS sites, counters visited areas less frequently monitored by such count schemes, including areas which had held swans in former census years, sites where swans had been sighted in recent winters, and those thought to be potentially suitable for swans. Sites were identified using previous census data, the WeBS and I-WeBS databases, the

IWSSG database, and information from local birdwatchers and professional conservation staff.

In order to cover areas with limited accessibility in Ireland, an aerial survey was conducted on 21 January and covered the rivers Suck, Brosna and Shannon Callows (south of Athlone), Lough Derg and the Shannon and Fergus Estuary.

In Iceland, areas known to hold swans in the southwest of the country were covered by ground counts on 9 January, coinciding with national mid-winter counts organised by the Icelandic Institute of Natural History. The southern lowlands were covered mostly by an aerial survey on the 22 January, although some areas were not surveyed until 1 March. Ground counts in northern regions were undertaken on 26–27 February and 6 March. West Iceland was not included in the census since few swans were believed to be present (only 24 birds were recorded there in the January 1995 census; Cranswick *et al.* 1997), and any that were present would have been highly dispersed over a large area.

Census forms were provided and the following information was recorded: species, number, location, date, time, method of count (daytime or dusk/dawn roost count) and count accuracy (either “OK” or deemed “Low” due to poor visibility, disturbance or restricted view). Participants were also asked to collect information on the number of young in each flock as well as brood size. Information regarding site use (*e.g.* feeding or roost site) and habitat type was also requested. A list of habitat categories were provided using ten main habitat types as used in the 2000 census: permanent standing

water, river, coastal, pasture (improved/wet, improved/dry, unimproved/wet and unimproved/dry) and arable (waste and growing), under which sub-categories were identified (see Results section for full classification). Counts were coordinated both nationally (in Ireland for cross-border sites) and locally to minimise double-counting and ensure maximum coverage.

Submitted data were assessed to identify duplicate counts, due to the same site being counted more than once or by movements of birds between adjacent sites, determined from information provided by the counters. Those counts deemed duplicates were omitted from the census total. For those sites where no data existed for the scheduled weekend, counts were included a week either side of the census weekend if movement of birds from other censused sites nearby was deemed unlikely. In exceptional circumstances, counts were included from outside this time period if the risk of double-counting was minimal.

Counts and age data were grouped by country for the purpose of analysis, namely Iceland, Northern Ireland, the Republic of Ireland, Scotland and England. Only small numbers occurred on the Isle of Man and in Wales so these were combined with the England data. For some analyses, countries were further divided into regions, definitions of which are given in Appendix 1.

Counts, distribution across habitats, frequency of brood sizes and flock size variation between years were analysed using Chi-Squared, Friedman and Wilcoxon sign rank tests in Minitab. The Kruskal-Wallis test was used to test for variations in brood sizes and differences in the proportion of

young recorded in flocks at sites between countries and regions.

Results

Coverage

In Britain, 99% of counts were conducted within one week preceding, or one week following, the census weekend and 75% were made on the census weekend itself (15–16 January). All counts conducted in Northern Ireland were during this two-week period and all but one were carried out during 14–17 January. Of those counts conducted in the Republic of Ireland, 67% were made on the census dates, rising to 96% on including counts made during the week preceding or week following the census weekend. Count data in Iceland were collected over a longer time period (9 January–6 March). Organisation of aerial and ground counts were such that double-counting was considered unlikely, particularly as it is believed that there was little movement between wintering sites in Iceland during this period.

Particularly wet conditions during the weekend of the census meant that many areas throughout Britain and Ireland were flooded and the birds were widely dispersed. Nevertheless, coverage was generally good with few omissions of sites known to be used by Whooper Swans. In Ireland, 23 sites were not visited in 2005 that had been covered in the 2000 census, when combined numbers totalled 245 individuals. In Britain, of those sites holding more than five birds during the previous census, no data were received for 17, which together held a total of 673 individuals in January 2000. The

estimated total of missed birds for Britain and Ireland combined (918) derived from the 2000 census represents approximately 3% of the total number of birds counted in 2005. Taking a cautious approach, these missing counts were not added to the census total because it was not possible to confirm whether these sites were used by Whooper Swans during 2005.

Numbers and distribution

The total number of Whooper Swans counted in January 2005 is the highest census total to date (26,366) (Table 1). This represents a 26.4% increase on the January 2000 census total (Table 2), and a 66.4% increase compared with the census total of 1995 (15,842).

Of the 26,366 swans counted, 37% were recorded in the Republic of Ireland (9,748), 25% in England (6,480), 16% in Northern Ireland (4,331), 16% in Scotland (4,142) and 6% in Iceland (1,556). Less than 1% of the wintering population was found in Wales and the Isle of Man (94 and 15 birds, respectively). In Britain, two major concentrations occurred, one in Norfolk at the Ouse Washes, and the other in Lancashire at Martin Mere. Otherwise, whilst Whooper Swans were recorded throughout England, generally flocks were small and dispersed. Larger numbers were recorded from the Borders through to central and northeast Scotland (Fig. 1). In Ireland, most large concentrations were found in central and northern regions, similar to past census years, although variations at the county level were apparent in both Ireland and Britain (see next section).

Table 1. Numbers of Whooper Swans recorded in Ireland, Britain and Iceland in January 2005, by region.

	Number of flocks	Number of swans		Number of flocks	Number of swans
Iceland			Scotland		
North	6	162	Dumfries & Galloway	23	677
South	101	783	Strathclyde	26	512
Southwest	19	611	Borders	8	138
Total	126	1,556	Lothians	6	203
Northern Ireland			Central	9	61
Down	10	411	Fife	7	178
Antrim	13	601	Tayside	19	518
Armagh	22	668	Grampian	4	286
Londonderry	18	1,538	Highland	48	829
Tyrone	11	200	Western Isles	27	298
Fermanagh	28	913	Orkney	18	297
Total	102	4,331	Shetland	24	145
Republic of Ireland			Total	219	4,142
Donegal	21	1,068	Isle of Man		
Leitrim	35	496		1	15
Sligo	12	209	England		
Mayo	35	949	Cornwall	1	1
Roscommon	23	665	Dorset	1	1
Longford	10	235	Somerset	1	4
Galway	24	803	Avon	1	2
Clare	24	561	West Sussex	1	2
Limerick	6	240	Kent	2	9
Tipperary	7	309	Surrey	1	1
Kerry	5	390	Greater London	1	1
Cork	4	320	Essex	2	2
Waterford	6	339	Northamptonshire	1	1
Wexford	5	465	Bedfordshire	1	5
Laios	1	73	Cambridgeshire	1	79
Offaly	9	734	Suffolk	3	17
Kildare	3	49	Norfolk	6	3,425
Wicklow	1	42	Lincolnshire	2	17
Meath	7	252	Nottinghamshire	2	53
Westmeath	5	356	East Yorkshire	3	17
Cavan	34	836	Staffordshire	1	2
Monaghan	12	357	Shropshire	1	17
Total	289	9,748	Cheshire	1	11
Wales			West Yorkshire	1	8
Dyfed	4	38	North Yorkshire	2	22
Powys North	1	25	Tyne & Wear	1	1
Gwynedd	5	20	Northumberland	10	454
Clwyd	1	11	Lancashire	13	2,119
Total	11	94	Cumbria North	7	209
			Total	67	6,480
			Grand total	815	26,366

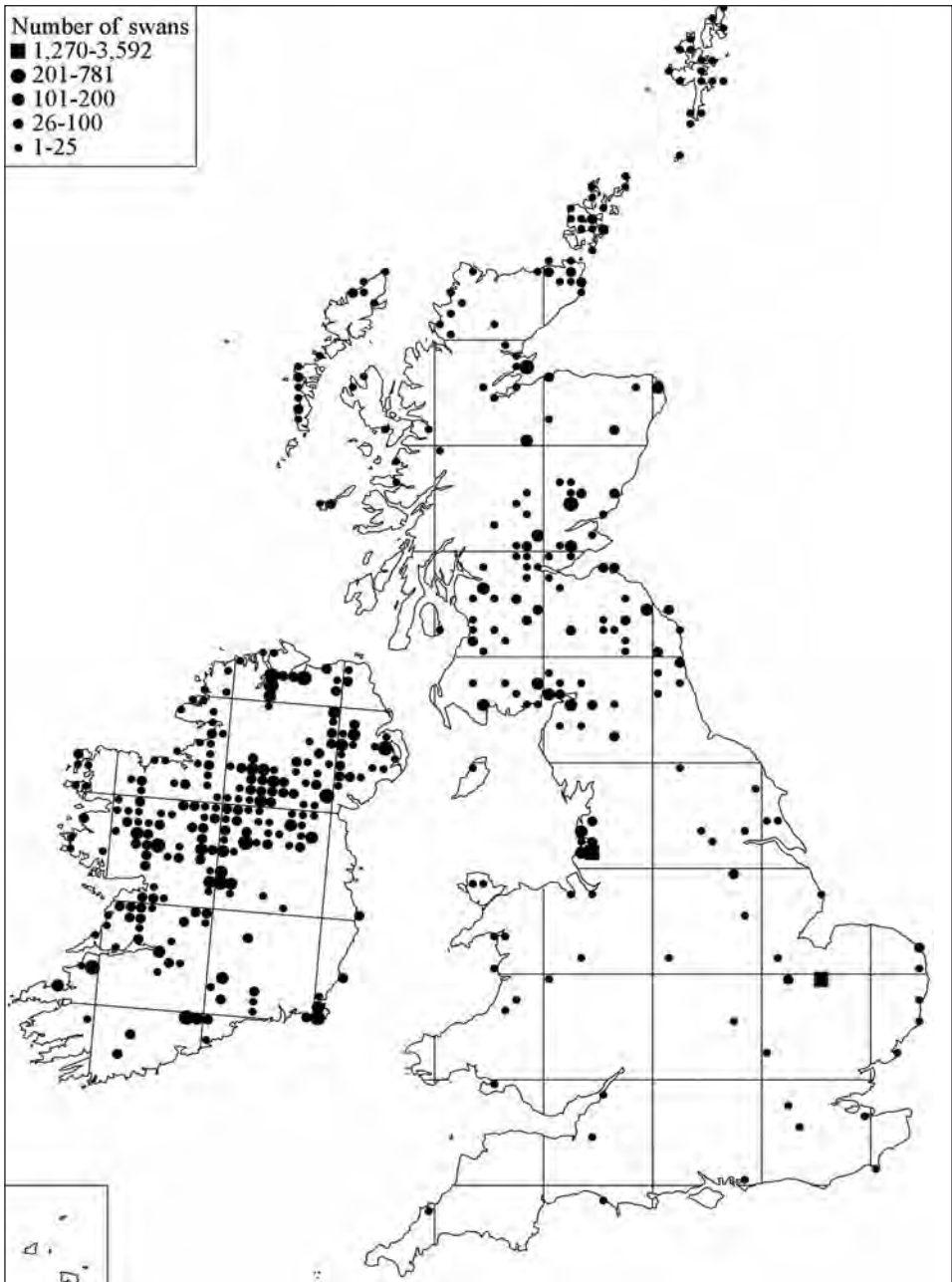


Figure 1. Distribution of Whooper Swans in Britain and Ireland in January 2005. Counts are summed by 10-km square; grid lines indicate 100-km squares.

Table 2. Total numbers of Whooper Swans in Iceland, Britain and Ireland in January 2000 and 2005, and percentage change between censuses. Numbers of flocks in Iceland were not recorded in the 2000 census.

	January 2000		January 2005		%	%
	Number of flocks	Number of birds	Number of flocks	Number of birds	change in flock number	change in number of birds
Iceland	N/A	1,200	126	1,556	N/A	29
Northern Ireland	97	3,663	102	4,331	5	18
Republic of Ireland	317	9,067	289	9,748	−9	8
Wales	6	112	11	94	83	−16
Scotland	148	2,861	219	4,142	48	45
Isle of Man	1	14	1	15	0	7
England	58	3,939	67	6,480	16	65
Total	622	20,856	815	26,366	31	26

Distribution in Iceland was restricted to three main areas: the southwest, southern lowlands and north Iceland, with most birds located in the south and southwest of the country (Fig. 2). The largest concentrations were found in the Mývatn area (Mývatnssveit) in the north (59 birds on Lake Mývatn, 51 on the River Laxá), and at Vogar (107 on the coast between Kálfatjörn and Vogastapi), Grindavík (57 birds) and Reykjavík (106 birds on Tjörnin) in the southwest, with numerous smaller flocks scattered across the southern lowlands. These included a combined count of 191 birds seen in small flocks in Vestur-Skaftafellssýsla, in the eastern part of the southern lowlands (Fig. 2). Although the swans similarly occurred in small groups

along the Ytri-Rangá River, Hróarslækur River and Eystri-Rangá River in south Iceland, totals of 69, 201 and 146 were recorded for these freshwater river systems, respectively. These spring-fed rivers are invariably ice-free and traditionally hold good numbers of Whooper Swans in winter.

A total of 815 Whooper Swan flocks was recorded, of which 53% held fewer than 10 birds and 84% fewer than 50 birds. Mean flock size was 32.6 (s.e. \pm 4.0), ranging from 12.3 (\pm 1.6) in Iceland (where counts were grouped by region because small numbers of birds were dispersed over large areas) to 83.0 (\pm 37.0) in England (Table 3). Most flocks consisted of 25 birds or fewer, accounting for 74% of all flocks recorded in Britain, Ireland

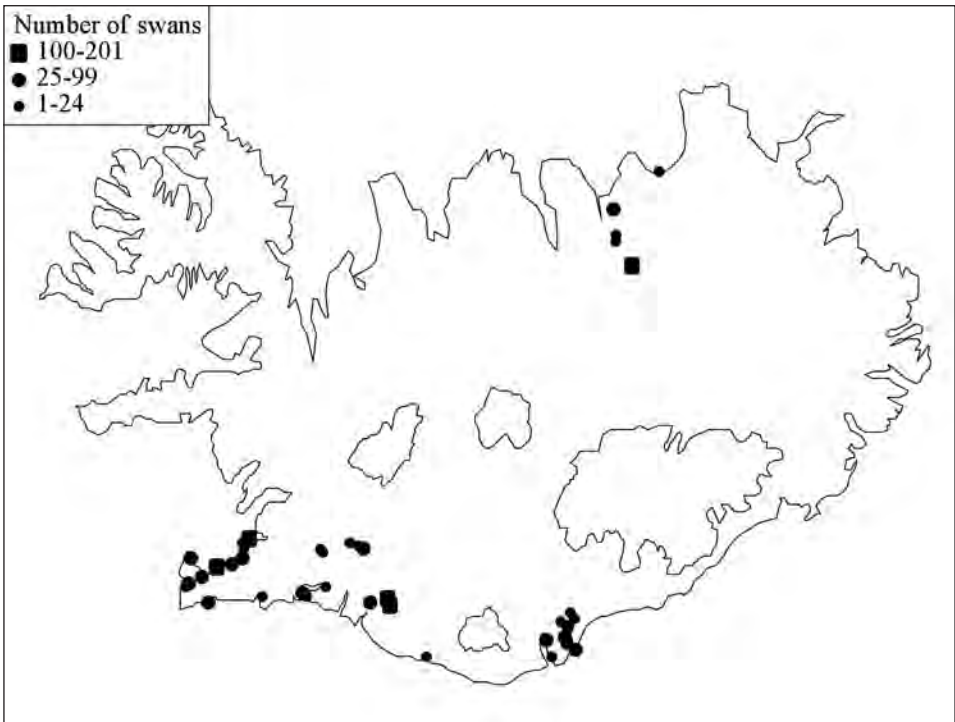


Figure 2. Distribution of Whooper Swans in Ireland in January 2005.

and Iceland (Fig. 3). As flock size increased, the frequency of occurrence decreased; flocks of 26–100 birds represented 20% of the census total and flocks of > 100 birds less than 8%. Only four flocks were of > 500 birds. These were found at the Ouse Washes, Norfolk, at Martin Mere, Lancashire, at Lough Swilly, Co. Donegal, and at Lough Foyle, Co. Londonderry.

Eighteen sites in Ireland and five sites in Britain had numbers that exceeded the current threshold used to indicate sites of international importance for the Icelandic Whooper Swan population (*i.e.* 210 birds) (Wetlands International 2002) in January 2005 (Appendix 2). Only three sites in

Britain and 11 in Ireland exceeded numbers equivalent to 1% of the January 2005 census total (264 birds). However, 22 sites in Ireland exceeded the current all-Ireland threshold (130) (Crowe 2005) and 25 sites in Britain exceeded the Great Britain threshold for national importance (57) (Kershaw & Cranswick 2003) (Appendix 2).

Changes in numbers and distribution between the 2000 and 2005 censuses

Increases in the number of Whooper Swans were recorded in all countries in 2005, with the exception of Wales, which saw a 16% decrease when compared with 2000 (Table 2). The most marked increases occurred in

Table 3. Number of flocks and average flock sizes during censuses in 2000 and 2005. Numbers of flocks in each country in 2005 were compared with those in 2000 using Chi-square tests with d.f. = 1 for comparison of each country with the rest of the range, and d.f. = 3 for overall comparison. Wilcoxon sign rank tests were used to compare flock sizes within each country and overall between 2000 and 2005. Flock size data were not available for Iceland in 2000 because the Icelandic counts were grouped by region.

Country	2000		2005		Flock number comparison		Flock size comparison	
	<i>n</i>	Mean flock size ± s.e.	<i>n</i>	Mean flock size ± s.e.	χ^2	<i>P</i>	<i>z</i>	<i>P</i>
Iceland	—	—	126	12.3 ± 1.6	—	—	—	—
Northern Ireland	97	38.2 ± 5.0	102	42.6 ± 8.5	0.05	n.s	0.34	n.s
Republic of Ireland	317	28.2 ± 2.5	289	33.8 ± 3.2	9.77	<0.005	1.33	n.s
Scotland	148	17.9 ± 2.4	219	18.9 ± 2.4	10.46	<0.005	−0.61	n.s
England and Wales	65	63.0 ± 27.0	79	83.0 ± 37.0	0.36	n.s	0.30	n.s
Overall (excluding Iceland)	622	30.8 ± 3.2	689	41.0 ± 5.7	13.18	<0.005	−0.21	n.s
Overall (including Iceland)	—	—	815	32.6 ± 4.0	—	—	—	—

England (65%) and Scotland (45%). Northern Ireland saw an increase of 18% in comparison with just 8% in the Republic of Ireland, while the Isle of Man saw a similar increase of 7%. Numbers of Whooper Swans remaining in Iceland for the winter increased by 30% overall since 2000 and 60% since 1995. The southwest of Iceland showed the largest regional increase at 57% while numbers in the north remained similar.

The proportion of swans recorded in the Republic of Ireland decreased from

43% to 37% between 2000 and 2005, and likewise a decrease of 18% to 16% was seen in Northern Ireland. Conversely, the proportions in England and Scotland increased from 19% to 25%, and 14% to 16%, respectively, although prior to 2005 the census data indicated a declining proportion of swans wintering in Scotland. A similar proportion of the census total remained in Iceland in winter when compared to January 2000 (5.9% and 6% for 2005 and 2000, respectively).

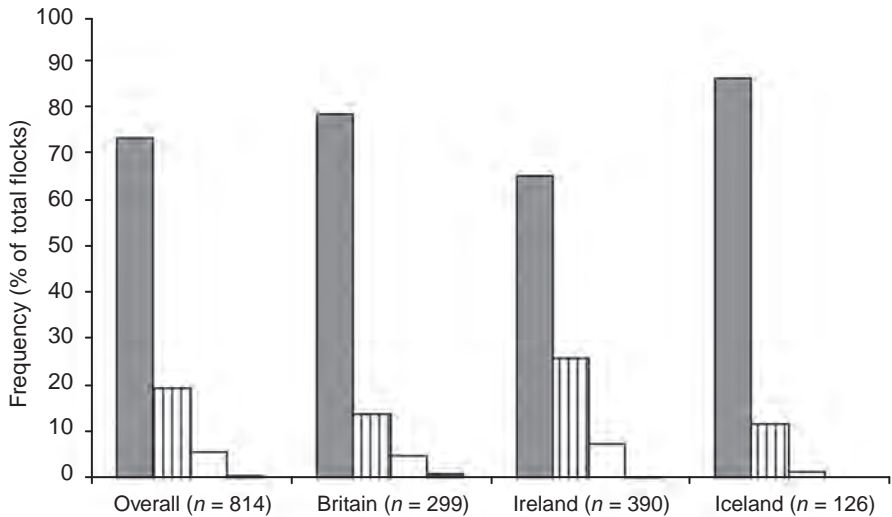


Figure 3. Number of Whooper Swan flocks of each size category recorded in January 2005 in Britain and Ireland, with the frequency of numbers per site given for Iceland (grey bars denote flock size 1–25, vertical lines 26–100, white 101–500, and black > 500 birds). Because of the tendency for Whooper Swans in Iceland to disperse into very small groups, the frequency is for numbers per count area rather than flock size *per se*.

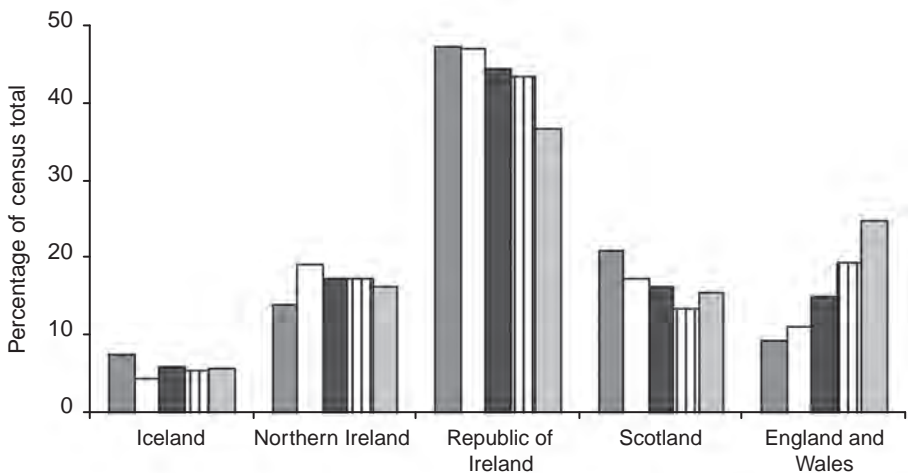


Figure 4. Changes in the distribution of Whooper Swans across Iceland, Britain and Ireland between censuses (1986–2005). Numbers of swans are expressed as percentage of the census total in each year: dark grey (1986), white (1990), black (1995), vertical lines (2000) and pale grey (2005).

The distribution of swans across countries between 2000 and 2005 differed significantly ($\chi^2_4 = 320.2$, $P < 0.001$), largely due to the increase in the proportion of swans wintering in England, as opposed to numbers elsewhere in the range (Fig. 4). The decrease in the proportion of swans found in the Republic of Ireland in relation to the rest of the range was significant ($\chi^2_1 = 205.4$, $P < 0.01$) as was the decrease in Northern Ireland ($\chi^2_1 = 10.70$, $P < 0.01$). Increases in the proportion of swans wintering in England/Wales/Isle of Man and Scotland were also significant when compared with the rest of the range ($\chi^2_1 = 201.6$, $P < 0.01$ and $\chi^2_1 = 36.57$, $P < 0.01$, respectively). There was no significant difference, however, in the proportion of swans in Iceland compared with the rest of the range between census years ($\chi^2_1 = 0.46$, $P = 0.496$, n.s.).

Norfolk and Lancashire held 86% of all birds recorded in England with Northumberland and Cumbria holding a further 10%. Numbers in the former two counties increased 2.6 fold and 1.7 fold, respectively, between the 2000 and 2005 censuses. An increase in the frequency of records of small numbers of birds (less than five) was also noted in southern England.

As in 2000, the Highlands region held the largest numbers of birds (829) in Scotland in 2005, although many areas experienced substantial changes in numbers between the two censuses. Decreases were apparent in central Scotland and the Borders, but there were increases of $> 50\%$ in the Lothians, Fife, Tayside, Grampian, Highlands and Shetland regions. Increases of 25–50% occurred in Dumfries & Galloway, the Western Isles and Orkney.

In Northern Ireland, numbers decreased in Co. Fermanagh and Co. Antrim but increases were seen elsewhere, particularly in Co. Londonderry and Co. Tyrone (80% and 71%, respectively). Nine counties in the Republic of Ireland recorded lower numbers when compared with the previous census but increases occurred in 15 counties, the largest of which were seen in Counties Meath, Laois, Wexford, Cork and Kerry ($> 50\%$).

Although flock size did not change significantly between censuses, either overall or within countries, there was a significant difference in the overall number of flocks found across the range between 2000 and 2005 (Table 3). This was due to a decrease in the number of flocks found in the Republic of Ireland (8%) and an increase in Scotland (48%). Changes in the number of flocks recorded in Northern Ireland and England/Wales were not significant.

Age and brood data

A total of 67% of the birds counted was aged: 82% in Iceland, 89% in Northern Ireland, 71% in the Republic of Ireland, 68% in Scotland and 42% in England and Wales. The overall percentage of young recorded was 19.2% ($n = 17,661$) and ranged from 17.9% in Iceland to 20.6% in Britain (Table 4). This is the highest percentage of young found during international censuses since 1986, when 22.9% was recorded. In the interim, 9.8%, 17.9% and 16.8% young were recorded in Whooper Swans counted during the 1991, 1995 and 2000 censuses, respectively.

There was no significant difference in the proportion of young recorded at sites in

Table 4. Age structure and brood sizes of Whooper Swans in Ireland, Britain and Iceland in January 2005 (see Appendix 1 for regional definitions). Note that brood size data were not collected by all observers.

	% Cygnets	Number aged	Mean brood size	Number of broods recorded
Iceland				
Southwest	19.5	411	3.0	21
South	19.0	700	2.3	54
North	9.3	162	—	0
Total	17.9	1,273	2.5	75
Northern Ireland				
Total	18.5	3,830	2.1	290
Republic of Ireland				
Northwest	19.1	3,215	2.3	211
Northeast	19.6	1,166	2.3	43
Southwest	16.5	1,488	2.3	47
Southeast	19.4	1,100	2.5	54
Total	18.7	6,969	2.3	355
Britain				
Northern Isles	30.6	343	2.3	42
Northwest Scotland	27.9	297	1.5	2
Northeast Scotland	21.5	711	2.2	37
Southwest Scotland	19.1	632	2.5	41
Southeast Scotland	19.4	837	2.5	35
Wales	13.2	76	—	0
Northwest England	20.1	2,112	2.3	13
Northeast England	16.8	279	3.9	9
East central England	14.8	290	1.9	33
South England	42.9	7	3.0	1
Total	20.6	5,584	2.3	213
Grand total	19.2	17,661	2.3	927

England, Scotland, Northern Ireland and the Republic of Ireland when compared at a country level (arcsine transformed data $H_3 = 3.40$, $P = 0.333$, n.s.). Iceland was omitted from the analysis owing to a high proportion of zeros due to the dispersed nature of the birds in several areas, resulting in the recording of many small flocks. Regional comparisons within Britain and Ireland also found no significant difference in the proportion of young recorded between regions (arcsine transformed data, $H_9 = 5.52$, $P = 0.78$; $H_4 = 4.12$, $P = 0.39$ for Britain and all-Ireland respectively, n.s. in each case).

Although regional differences were not significant, numbers of young recorded annually at the Wildfowl & Wetlands Trust (WWT) centres at Martin Mere (Lancashire), Welney (Norfolk) and Caerlaverock (Dumfries & Galloway) show considerable variation, with the proportion of young ranging from 10.2% at Caerlaverock to 17.1%

at Martin Mere in January 2005 (Table 5). Combined assessments of the proportion of young at all three centres also show considerable variation when compared with overall proportion of young across the wintering range, although combined centre estimates in 1995 and 2000 are similar to the census results in those years. Although numbers of young recorded in flocks at Martin Mere have been consistently high in census years, the proportion of young recorded at Welney and Caerlaverock decreased between 1995 and 2005.

Broods of one and two cygnets were most frequently recorded across all parts of the wintering range, jointly accounting for 64% of all families recorded (Fig. 5). No broods larger than six were recorded, and those of four or more cygnets were infrequent (11%, 3% and <1% for brood sizes of four, five and six cygnets, respectively). The frequency of different brood sizes varied significantly between

Table 5. Percentage of Whooper Swan cygnets recorded at WWT Centres during January of census years. Census derived productivity estimates are shown for comparison.

Year	% Cygnets (sample sizes in brackets)				
	Caerlaverock	Martin Mere	Welney	All WWT centres	Census
1991	16.6 (163)	20.6 (321)	14.4 (453)	16.9 (937)	9.8 (10,805)
1995	17.7 (136)	17.3 (723)	17.0 (492)	17.2 (1,351)	17.9 (10,156)
2000	16.0 (175)	17.7 (1,241)	12.3 (381)	16.4 (797)	16.8 (14,627)
2005	10.2 (266)	17.1 (1,274)	11.0 (218)	15.3 (1,758)	19.2 (17,661)

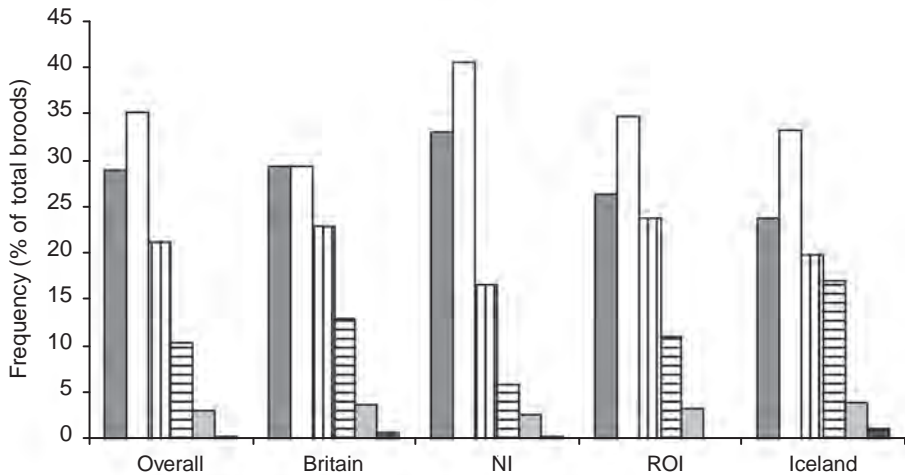


Figure 5. Frequency of broods of different sizes in Britain, Northern Ireland, Republic of Ireland and Iceland in January 2005 (dark grey = 1, white = 2, vertical lines = 3, horizontal lines = 4, pale grey = 5 and black = 6 cygnets).

Iceland, Northern Ireland, the Republic of Ireland and Britain ($\chi^2_9 = 22.52$, $P < 0.01$) but comparison of numbers in each country with the rest of the wintering range showed a significant difference in Northern Ireland only, where a higher than expected frequency of broods of one and two cygnets occurred ($\chi^2_3 = 17.14$, $P < 0.01$).

The overall mean brood size was 2.3 cygnets ($n = 927$ families), ranging from an average of 1.5 cygnets per family in northwest Scotland to 3.9 cygnets in northeast England (Table 4). While pair-wise comparisons of brood size by country revealed significant differences between Northern Ireland and Iceland (respective mean values: 2.06, 2.48; $H_{4,922} = 13.17$, $P = 0.01$), no other significant differences between countries were detected (Scotland, England and Republic of Ireland respective mean values: 2.34, 2.38, 2.30). Comparisons of brood sizes across regions

within countries also found no significant differences.

Habitat use

Habitat was recorded for 79% of all swans counted (Table 6). Birds remaining to winter in Iceland were recorded mostly on river and associated freshwater marsh habitats with a smaller proportion using coastal areas – two habitat types that were infrequently used over the rest of the wintering range. There was no significant difference in habitat use across countries however, when comparing Iceland, Northern Ireland, the Republic of Ireland and Britain ($\chi^2_3 = 5.06$, n.s.).

Within Britain and Ireland, birds were recorded most commonly on pasture (44.8%), of which improved, dry grassland was most frequently used (19.8%). Arable land and permanent standing water held 27% and 20% of the total, respectively

Table 6. Percentage of Whooper Swans recorded on different habitat types in January 2005. Definitions of habitat classifications: 1) Permanent standing water = natural permanent lake, artificial lake/reservoir, gravel pit; 2) River = non-tidal river, freshmarsh; 3) Coastal = tidal river/estuary, saltmarsh, brackish lake, open coast; 4) Improved pasture (dry) = dry pasture managed to improve sward including reseeded pasture; 5) Rough/unimproved pasture (dry) = dry, unmanaged sward; (6) Improved pasture (wet) = improved pasture (flooded), reseeded pasture (wet), callow – improved; 7) Rough/unimproved pasture (wet) = rough/unimproved pasture (flooded), turlough – rough/unimproved, callow – rough/unimproved; 8) Arable (waste) = stubble, potatoes, carrots, sugar beet; and 9) Arable (growing) = winter cereal, oil seed rape.

Habitat type	Iceland	Northern Ireland	Republic of Ireland	Britain	Britain and Ireland
Number of swans	1,556	4,331	8,755	6,458	19,332
Permanent standing water	6.8	4.7	19.9	29.9	20.0
River	63.2	2.9	5.2	5.3	4.8
Coastal	29.9	0.0	0.8	4.2	1.8
All pasture	0.0	64.0	52.5	20.6	44.8
Improved dry	0.0	38.4	17.5	10.4	19.8
Improved wet	0.0	16.0	13.5	5.5	11.4
Rough/unimproved dry	0.0	2.3	0.9	0.1	0.9
Unimproved wet	0.0	7.3	20.6	4.9	12.6
All arable	0.0	28.4	19.8	39.9	27.0
Arable waste	0.0	28.4	16.4	14.1	17.7
Arable growing	0.0	0.0	3.4	23.4	9.4
Bog/moorland	0.0	0.0	0.1	0.2	0.1
Other	0.0	0.0	1.7	2.4	1.6

(Table 6). Use of arable land (stubble fields and harvested potato fields) was greater in Northern Ireland compared with the Republic of Ireland and Britain (28.4%, 16.4% and 14.1%, respectively). No swans were recorded using arable land supporting

growing crops in Northern Ireland, but in contrast, of those birds using arable habitats in the Republic of Ireland and Britain, 17% and 62.5% were found on winter cereal and oil seed rape.

The distribution of swans on the three

most frequently used habitats (permanent standing water, pasture and arable) differed significantly between the 1995, 2000 and 2005 censuses ($\chi^2_4 = 2,434$, $P < 0.01$) largely due to the increased use of arable land and a decrease in the number of swans recorded on permanent standing water (Fig. 6). In 1995, only 7% of birds were found on arable habitats, increasing to 27% in 2005. Conversely, 32% of swans were recorded using permanent standing waters during the 1995 census, decreasing to 20% in January 2005.

Discussion

The total of 26,366 Whooper Swans recorded in January 2005 in Britain, Ireland and Iceland was the highest to date, equating

to a 26% increase on numbers counted in 2000. This represents an average annual population growth rate of 4.8%.

Counts were performed with a high degree of local and regional coordination; local organisers and counters not only ensured that sites known to hold swans in previous years were visited, but that adjacent sites and additional areas of suitable habitat with potential to support swans were investigated. Coverage was thought to be similar to the previous census in 2000, with many new sites, not routinely counted as part of any waterbird monitoring scheme, identified. Systematic checking of individual counts minimised potential errors caused by double-counting or missed sites. Incomplete coverage occurred at only a small number of sites, estimated to hold a combined total of

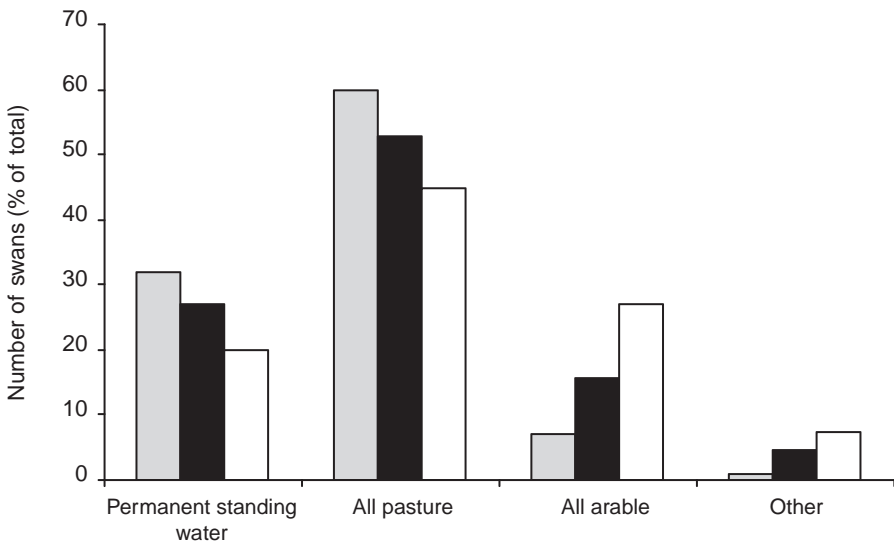


Figure 6. Distribution of Whooper Swans on permanent standing water, pasture and arable habitats in Britain and Ireland in January 1995 (grey bar, $n = 12,033$), 2000 (black bar, $n = 16,063$) and 2005 (white bar, $n = 21,805$).

918 birds based on past census data. As a result, the total number of birds counted is thought to be representative of the true population size and distribution in January 2005, although it is likely, as with previous censuses, that a small proportion of birds was missed.

The distribution of Whooper Swans across the wintering range was largely similar between censuses. Changes in the numbers of swans were apparent at a county level, with decreases of more than 10% seen in 18 counties (excluding those with very small numbers, or occasional records of Whooper Swans). This was more than compensated for, however, by increases (of >10%) in a total of 30 counties. Although flock sizes in Iceland appear smaller than in earlier censuses, this is due to the Iceland counts having previously been grouped by count area rather than as separate flocks.

There was a disproportionate increase in the number of birds using sites in Britain during January 2005 compared with the rest of the range. Numbers increased by just 11% in Ireland, in contrast to 55% in Britain, between 2000 and 2005 (compared with 29% and 36% increases between 1995 and 2000). The increase in numbers of birds in England was not accompanied by a significant increase in the number of flocks recorded, and distribution remains concentrated at relatively few sites. Only six counties in England held over 50 birds, and 86% of the birds were localised around two main sites in Norfolk and Lancashire, where the greatest increases in numbers has occurred. In fact, the continuing increase in the size of flocks on the Ouse Washes in Norfolk accounted for 82% of the rise in

total numbers found in England. In contrast, Scotland saw more widespread increases with an overall rise in the number of flocks recorded.

The number of Whooper Swans recorded in Iceland in January 2005 was the highest yet, although numbers have fluctuated between censuses (range 831–1,556). Over recent years, several species of wildfowl, including Bewick's Swan, have shown evidence of distributional changes in their winter range, and a tendency to winter closer to the breeding grounds (Worden *et al.* 2006). The international Whooper Swan census, however, provides little evidence of a growing proportion of the population over-wintering in Iceland. The proportion of swans remaining in Iceland in January 2005 was similar to that of January 2000, and comparable to the range of previous censuses (4.6–7.8%). Furthermore, the increases of 24% between 1995 and 2000, and 30% between 2000 and 2005, are similar to the overall increase in population size over this time. A detailed analysis of the annual mid-winter wildfowl counts in Iceland (organised by the Icelandic Institute of Natural History) will help to clarify further any such changes in numbers and distribution.

Past census results show small changes in population size over the years 1986–1995, with numbers fluctuating between 15,842–18,030 birds (Salmon & Black 1986; Kirby *et al.* 1992; Cranswick *et al.* 1997). However, more recent censuses have shown a period of sustained growth with a 32% increase in numbers from 1995–2000 (Cranswick *et al.* 1997), and 26% from 2000–2005 (described here).

Almost 70% of birds counted during the census were aged across the range, giving a reasonable representation of the proportion of young following the 2004 breeding season. The overall percentage of young in flocks was 19.2%, the highest recorded in a census year since 1986, when 22.9% was reported (Salmon & Black 1986). For the 1995 and 2000 censuses, the combined estimates of breeding success for Whooper Swans wintering at three WWT centres corresponded well with estimates made throughout the range, when numbers aged at centres corresponded to > 10% of the census total. It is important to quantify whether annual productivity assessments conducted at a limited number of sites between censuses are representative of the population as a whole. However, the proportion of young at WWT centres in 2005 (15.3%) was substantially lower than that derived from census data. Regional variation in the percentage of young recorded during the 2005 census was substantial. Excluding regions with small sample sizes, figures ranged from 9.3% in northern Iceland to 30.6% in the Northern Isles. Although variation between countries and across regions was not found to be significant, higher numbers of young were seen in flocks in the north of Scotland and northwest England, indicating that comprehensive collection of age-related data is necessary across the range in order to achieve a realistic estimate of annual productivity. Census data from January 2000 and 2005 show lower numbers of young in flocks at Caerlaverock and Welney in comparison with those at Martin Mere. The mean percentage of young derived from data

collected over a longer winter period at WWT Centres during 2003/04 and 2004/05 have also shown a low percentage of juveniles at Caerlaverock and the Ouse Washes in comparison with the rest of the range (WWT unpubl. data). Such variations may be partly due to families preferentially selecting wintering sites closer to their breeding grounds (Rees *et al.* 1997).

Despite the recent increase in numbers, the Icelandic population remains one of the smaller of the Whooper Swan populations. A coordinated international census of the Northwest European population, which breeds from Fenno-Scandia to northwest Russia and winters in continental Europe, recorded 59,000 birds in January 1995 (Laubek *et al.* 1999). Counts made at selected sites as part of the International Waterbird Censuses have estimated that there are 17,000 birds in the Black Sea/East Mediterranean population, 20,000 birds in the Caspian/Central Asian population and 60,000 birds in the East Asia population (Wetlands International 2002, 2006). Very little is currently known regarding movements and interchange between the Northwest European breeding population of Whooper Swans and those from the Icelandic population. Ring re-sighting information has confirmed that there is limited interchange in both directions, but the extent of such movements remains unclear. Major increases in the Northwest European population since the 1980s (Laubek *et al.* 1999) have led to the suggestion that the increasing numbers of Whooper Swans in Britain, particularly in east-central England, may be inflated by an increasing proportion of birds from this

population wintering in Britain. Such movements from the continent may be influenced by severe weather, although conditions in January 2005 were generally mild and wet, making a cold weather influx immediately prior to the census weekend unlikely. Further information generated through ring sightings of both Icelandic birds on the continent and Northwest European birds in Britain is required to assess the extent of interchange and dispersal of birds from different parts of the breeding range. This could be further clarified by an autumn pre-migration census in Iceland, to help assess the true number of birds from the Icelandic population wintering in Britain and Ireland, such as those conducted in Iceland during the 1980s (Gardarsson & Skarphedinnsson 1984).

Comparison of habitat use over the last three censuses has indicated some change in preferred feeding habitat selection. Use of permanent standing water was almost 7% lower compared to the last census, although the wet, often flooded, conditions in many areas in January 2005 may have influenced a shift away from permanent waterbodies, towards flooded grassland. A continued decrease in the number of birds recorded during the census on permanent inland waters over the last ten years has occurred, however, from 32% of birds in 1995, to 27% in 2000 and 20% in 2005. Although permanent waterbodies are likely to be used commonly as safe roost sites, this may perhaps indicate that feeding now occurs more frequently away from these wetland habitats.

The proportion of birds recorded on all types of farmland (pasture and arable) was found to be 72%, representing an increase

on that of 1995 and 2000 (67% and 68% respectively). Although pasture was the most frequently used farmland habitat and the proportion of birds found on this habitat was similar to other census years, use of arable land has increased over the last three censuses from 7% to 27%. No swans were recorded on growing crops in Northern Ireland and very few (3%) in the Republic of Ireland; however, in Britain 23% of swans were found on winter cereals and oil seed rape (Table 6). The proportion of birds on growing crops in Britain in 2005 was similar to that recorded during the 2000 census; 23% in both cases.

The January 2005 census has demonstrated a substantial and sustained growth of the Icelandic Whooper Swan population since the mid 1990s. Based on current trends and consistently good breeding success over the last ten years, a continued increase seems probable. Continued monitoring of this population will help to clarify trends in distributional changes and determine potential conflict owing to the species' apparent increasing use of agricultural habitats. A greater understanding of the extent of interchange between populations, and use of British and Irish wintering grounds by the Northwest European population, is also necessary to ascertain the true size of these growing populations.

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Appendix 1. Regional definitions, by country.

Iceland

West: Vestur-Barðastrandarsýsla to Kjósarsýsla

Southwest: Reykjavík and Reykjanes Peninsula

South: Árnessýsla, Rangarvallasýsla, Vestur-Skaftafellssýsla

Southeast: Austur-Skaftafellssýsla, Suður-Múlasýsla

North: Suður- and Norður-Þingeyjarsýsla

Northern Ireland

Down, Antrim, Armagh, Londonderry, Tyrone, Fermanagh

Republic of Ireland

Northwest: Donegal, Leitrim, Sligo, Mayo, Roscommon, Galway

Northeast: Longford, Westmeath, Cavan, Monaghan, Louth, Meath, Dublin

Southwest: Clare, Limerick, Kerry, Cork

Southeast: Tipperary, Offaly, Laois, Kildare, Wicklow, Wexford, Carlow, Kilkenny, Waterford

Scotland

Northern Isles: Orkney, Shetland

Northwest: Highland South West, Western Isles

Northeast: Grampian, Highland South East, Highland North

Southwest: Dumfries & Galloway, Strathclyde

Southeast: Borders, Lothians, Central, Fife, Tayside

Wales

Gwent, Mid Glamorgan, South Glamorgan, West Glamorgan, Dyfed, Powys, Gwynedd, Clwyd

England

Northwest: Cheshire, Merseyside Greater Manchester, Isle of Man, Lancashire, Cumbria

Northeast: Cleveland, Durham, Tyne & Wear, Northumberland

East Central: Northamptonshire, Bedfordshire, Cambridgeshire, Suffolk, Norfolk, Lincolnshire, Leicestershire, Nottinghamshire, Humberside, Warwickshire, West Midlands, Staffordshire, Shropshire, Derbyshire, South Yorkshire, West Yorkshire, North Yorkshire

South: Cornwall, Devon, Dorset, Somerset, Avon, Gloucestershire, Wiltshire, Hampshire, Isle of Wight, West Sussex, East Sussex, Kent, Surrey, Greater London, Essex, Hertfordshire, Buckinghamshire, Berkshire, Oxfordshire, Hereford & Worcester

Note that Britain comprises Scotland, Wales and England. The United Kingdom comprises Britain and Northern Ireland.

Appendix 2. Sites in Britain and Ireland exceeding current 1% thresholds for international importance (*i.e.* 210 birds; Wetlands International 2006) and national importance (57 and 130 for Britain and all-Ireland, respectively) in January 2005.

Location	County	No. of swans
Sites in Britain and Ireland exceeding the threshold for international importance in January 2005		
Ouse Washes	Norfolk	3,392
Martin Mere/Ribble Estuary	Lancashire	2,081
Loughs Neagh & Beg	Antrim, Londonderry, Tyrone, Armagh, Down	1,517
Lough Foyle	Londonderry, Donegal	950
Upper Lough Erne	Fermanagh	621
Blackwater Callows	Waterford, Cork	525
Lough Swilly	Donegal	501
Wetlands east of Ballinrobe	Mayo, Galway	456
River Foyle	Donegal, Londonderry, Tyrone	444
Shannon Callows	Offaly, Galway, Roscommon, Tipperary, Westmeath	432
Solway Estuary	Dumfries & Galloway	508
River Suck	Roscommon, Galway	324
North Central Galway Lakes	Galway	294
Lough Oughter Complex	Cavan	272
Finn-Lacka Catchment	Monaghan, Fermanagh	260
Loans of Tullich/Cromarty Firth	Ross & Cromarty	253
Rinn Lough Lakes	Leitrim	241
Glen Lough	Westmeath	237
Strangford Lough	Down	233
Cashen River & Estuary	Kerry	229
Tacumshin Lake	Wexford	221
River Isla; Bridge of Crathies	Perth & Kinross	220
Shannon & Fergus Estuary	Clare, Limerick, Kerry	220
Sites in Britain exceeding the Great Britain threshold for national importance in January 2005		
River Tweed, Norham	Northumberland	184
Loch of Strathbeg	Aberdeenshire	181
Wigtown Bay	Dumfries & Galloway	149
Loch Leven	Fife	125
Loch Insh & Spey Marshes	Inverness	115
Farmland near South Kinkell	Perth & Kinross	111
Newton Marsh, Moricambe Bay	Cumbria	106
Black Cart Water	Renfrewshire	105
River Nith near Flatts of Cargen	Dumfries & Galloway	100
Caistron Quarry	Northumberland	92
R. Clyde, Carstairs–Thankerton Bridge	Lanarkshire	84
Nene Washes	Cambridgeshire	79
Vasa Loch, Shapinsay	Orkney	76
River Tweed: Kelso to Coldstream	Roxburgh	75
Broubster Leans	Caithness	75
Farmland near East Fenton	East Lothian	73
Lindisfarne	Lindisfarne	70
Farmland near Money Musk	Aberdeenshire	65
Loch Thymistear, Isle of Lewis	Western Isles	63
Farmland near Whitekirk	East Lothian	61
Sites in Ireland exceeding the all-Ireland threshold for national importance in January 2005		
Lyonstown Stud Farm	Tipperary	142
Tara Mines Tailings Ponds	Meath	142
Turraun Nature Reserve	Offaly	141
Tralee Bay, Lough Gill & Akeragh Lough	Kerry	130