

Estimates and trends of waterbird numbers wintering in Ireland, 1994/95 to 2003/04

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Capsule There has been a decline in the numbers of waterbirds wintering in Ireland between 1994/95 and 2003/04, including a 5% decline in wildfowl and an 11% decline in waders.

Aims To provide estimates of numbers and trends in relative abundance of selected waterbird species wintering on the island of Ireland.

Methods Waterbird counts were undertaken at key wetland sites in Ireland each winter (September to March) between 1994/95 and 2003/04. For each species, estimates were calculated for two five-season periods (1994/95–1998/99 and 1999/2000–03/04), while trends in relative abundance were analysed over the entire ten-season period. Counts were modelled using a multiplicative log-linear index model, with site, year and month factors.

Results National estimates of overwintering numbers were produced for 42 species of waterbirds, and used to produce all-Ireland 1% thresholds (which are used to evaluate the importance of wetland sites). In winter, large proportions of several populations occur in Ireland, particularly Whooper Swan *Cygnus cygnus*, Greater White-fronted Goose (Greenland race) *Anser albifrons flavirostris*, Brent Goose (Canadian Light-bellied race) *Branta bernicla hrota* and Black-tailed Godwit *Limosa limosa islandica*. Of the 39 species for which trends were measured, 18 showed annual declines in excess of 2%, while ten species had increased. Numbers of the remaining 11 species were relatively stable. For many species, the trends measured appear to be continuations of longer-term changes since the 1970s.

Conclusion These most recent estimates of waterbird numbers have been improved compared with those previously generated, due to improved levels of coverage and better analytical methods. This study highlights that there have been significant changes in the numbers of waterbirds wintering in Ireland over the past 30 years. The fact that many of these trends parallel wider flyway-scale population trajectories implies that large-scale drivers (e.g. climate change) may be responsible. However, many of the observed declines are likely to be a consequence of increased economic development which has led to direct habitat loss to industrial and residential development.

Each winter, the island of Ireland supports large numbers of migratory waterbirds on passage and/or for the duration of the winter period. Most species originate from breeding grounds to the north and northwest (principally Iceland, Greenland and Canada), or from the northeast (northern Europe, Fenno-Scandia, Russia and Siberia), moving south to winter predominantly in west and northwest Europe, and west Africa (Wetlands International 2002,

Wernham *et al.* 2002). This large geographical area is known as the East Atlantic Flyway, and is one of the eight major global migratory flyways (Davidson & Pienkowski 1987). Ireland's relatively mild climate and high diversity of wetland habitats and agricultural land provide feeding throughout the winter period, particularly when freezing conditions in parts of north-west Europe may limit access to feeding areas. Both these factors make Ireland particularly attractive for wintering waterbirds.

Waterbird numbers have been monitored in Ireland since the 1970s, with the Birds of Estuaries Enquiry in

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Northern Ireland and the Wetlands Enquiry in the Republic (Hutchinson 1979), and later the Winter Wetlands Survey (Sheppard 1993). The Wetland Bird Survey (WeBS) in Northern Ireland and the Irish Wetland Bird Survey (I-WeBS) in the Republic were initiated during the late 1980s and mid-1990s, respectively. Both these surveys are ongoing, and aim to monitor wintering waterbird species and the wetlands upon which they rely in Ireland.

Criteria developed under the Ramsar Convention include that a site be considered of international importance if it regularly supports 1% of the flyway population of a migratory waterbird species, or 20 000 waterbirds in total (Ramsar Convention Bureau 2000). In Britain and Ireland, any site which meets these criteria may be considered for designation as a Special Protection Area (SPA) under the EC Birds Directive (79/409/EEC). Furthermore, any site which regularly supports at least 1% of the all-Ireland total of a species listed in Annex I of the Birds Directive may also be considered for designation as a SPA (Stroud *et al.* 2001, Biosphere Environmental Services 2004).

Estimates of the numbers of waterbirds in Ireland are fundamental to setting these 1% threshold values. Further, species totals are summed across the entire range of a population to calculate flyway population estimates. These population estimates are regularly updated through ongoing reviews by Wetlands International (Rose & Scott 1994, 1997, Wetlands International 2002). By placing national estimates in this wider flyway context, the importance of the country as a whole for a species can be evaluated, and national conservation objectives can then be prioritized accordingly.

This paper gives the most comprehensive and up-to-date estimates of numbers and 1% thresholds for waterbirds wintering in Ireland based on the data from I-WeBS and WeBS. These estimates benefit from improvements in coverage over previous surveys and also advanced statistical techniques to deal with some data deficiencies. We also present trends in numbers measured over the period 1994/95 to 2003/04.

METHODS

Sources of data

Counts of wintering waterbirds have been collated as part of I-WeBS and WeBS in the Republic and Northern Ireland respectively since the mid-1990s. Both these surveys are based on counts carried out once

per month, between September and March inclusive, each winter. Although counts are made in all seven months, most observer effort is concentrated on the mid-winter period, particularly January, when peak numbers of most species are present. Additionally, the January counts are submitted to the International Waterbird Census, which monitors wintering waterbirds on a global level (Wetlands International 2002). Counts are conducted on predetermined dates to maximize synchrony, and thereby minimize the risk of duplicating counts arising from bird movements within and between sites.

These surveys are carried out by a combination of amateur birdwatchers and professional staff of the schemes' partner organizations. Efforts are made to ensure that the main wetland sites are counted at least once each season.

The estimates of numbers and trends in relative abundance presented in this paper were largely based on I-WeBS and WeBS 'core counts'. However, core count methodology alone is inappropriate for surveying several waterbird species, especially swans and geese, European Golden Plover, Northern Lapwing and Eurasian Curlew, which regularly use grasslands for feeding. Furthermore, a variety of wader species, particularly Purple Sandpiper and Ruddy Turnstone, occur along non-estuarine coast which is not extensively monitored during core counts. In these cases, data from a number of other published (Colhoun & Newton 2000, Colhoun *et al.* 2000, Merne & Walsh 2003, Rehfisch *et al.* 2003a, Robinson *et al.* 2004a, 2004b, 2004c) and unpublished sources were integrated to improve the overall estimate. The scientific names of all species included in these analyses are presented in Table 1 and those for other species are given where first mentioned in the text.

These analyses were based on a combination of the above data collated between 1994/95 and 2003/04 inclusive. All waterbird species that are relatively widespread in Ireland were included, and were grouped into two main categories: wildfowl (28 species, including swans, geese and ducks, and their allies, defined here as Red-throated Diver, grebes, Great Cormorant, herons, rails and Common Coot); and waders (15 species, including Eurasian Oystercatcher, plovers and sandpipers). Elusive species, such as Water Rail *Rallus aquaticus*, Jack Snipe *Lymnocyptes minimus*, Snipe *Gallinago gallinago* and Woodcock *Scolopax rusticola*, which have a secretive and retiring nature, and marine species such as Long-tailed Duck *Clangula hyemalis*, Black-throated Diver *Gavia arctica* and Great Northern

Table 1. Population estimates of wildfowl and waders wintering in Ireland, and estimates of numbers occurring in Ireland during earlier wetland bird surveys.

Species	Scientific name	Population	Flyway estimate	1970s	1980s
Mute Swan	<i>Cygnus olor</i>	Ireland ^a	11 440 ^a	5500	10 000
Tundra Swan	<i>Cygnus columbianus bewickii</i>	NW Europe (wintering)	29 000	2000	2300
Whooper Swan	<i>Cygnus cygnus</i>	Iceland	20 900	5000	1000
Greater White-fronted Goose	<i>Anser albifrons flavirostris</i>	W Greenland	33 000	13 500	14 000
Greylag Goose	<i>Anser anser</i>	Iceland	89 100	875	3800
Barnacle Goose	<i>Branta leucopsis</i>	Greenland	54 100	4400	8000
Brent Goose	<i>Branta bernicla hrota</i>	Canada, Greenland ^b	21 750 ^b	10 000	20 000
Common Shelduck	<i>Tadorna tadorna</i>	NW Europe	300 000	8000	12 500
Eurasian Wigeon	<i>Anas penelope</i>	NW Europe	1 500 000	105 000	100 000
Gadwall	<i>Anas strepera</i>	NW Europe	60 000	325	450
Eurasian Teal	<i>Anas crecca</i>	NW Europe	400 000	40 000	50 000
Mallard	<i>Anas platyrhynchos</i>	NW Europe	4 500 000	35 000	50 000
Northern Pintail	<i>Anas acuta</i>	NW Europe	60 000	5000	2000
Northern Shoveler	<i>Anas clypeata</i>	N, NW, Central Europe	40 000	7500	4000
Common Pochard	<i>Aythya ferina</i>	NE & NW Europe	350 000	35 000	30 000
Tufted Duck	<i>Aythya fuligula</i>	NW Europe (non-br)	1 200 000	20 000	30 000
Greater Scaup	<i>Aythya marila</i>	W Europe (non-br)	310 000	–	2600
Common Eider	<i>Somateria mollissima</i>	^c	1 548 000 ^c	–	2200
Common Scoter	<i>Melanitta nigra</i>	N & NW Europe, W Siberia	1 600 000	–	10 000
Common Goldeneye	<i>Bucephala clangula</i>	NW & Central Europe (non-br)	400 000	–	10 000
Red-breasted Merganser	<i>Mergus serrator</i>	NW & Central Europe (non-br)	170 000	–	2500
Red-throated Diver	<i>Gavia stellata</i>	Europe, Greenland	550 000	–	–
Little Grebe	<i>Tachybaptus ruficollis</i>	Europe, NW Africa	340 000	–	3000
Great Crested Grebe	<i>Podiceps cristatus</i>	NW Europe	475 000	–	3500
Great Cormorant	<i>Phalacrocorax carbo</i>	NW Europe	120 000	–	10 500
Grey Heron	<i>Ardea cinerea</i>	W Europe, NW Africa	274 500	–	10 500
Common Moorhen	<i>Gallinula chloropus</i>	Europe & N Africa	3 550 000	–	–
Common Coot	<i>Fulica atra</i>	NW Europe (non-br)	1 750 000	–	30 000
Eurasian Oystercatcher	<i>Haematopus ostralegus</i>	Europe, NW Africa	1 020 000	32 500	70 000
Ringed Plover	<i>Charadrius hiaticula</i>	Iceland, N & NW Europe	73 000	7500	10 000
European Golden Plover	<i>Pluvialis apricaria</i>	Iceland & the Faeroes	930 000	200 000	150 000
Grey Plover	<i>Pluvialis squatarola</i>	E Atlantic	247 000	875	4000
Northern Lapwing	<i>Vanellus vanellus</i>	Europe	3 400 000	175 000	200 000
Red Knot	<i>Calidris canutus</i>	Canada, Greenland	450 000	42 500	25 000
Sanderling	<i>Calidris alba</i>	E Atlantic, W & S Africa	123 000	2000	2000
Purple Sandpiper	<i>Calidris maritima</i>	E Atlantic	75 000	–	1500
Dunlin	<i>Calidris alpina</i>	W Europe (non-br)	1 331 000	115 000	100 000
Black-tailed Godwit	<i>Limosa limosa</i>	Iceland, the Faeroes	35 000	8000	8000
Bar-tailed Godwit	<i>Limosa lapponica</i>	N Europe, N Russia	120 000	16 000	23 000
Eurasian Curlew	<i>Numenius arquata</i>	W, N & Central Europe	420 000	100 000	100 000
Common Redshank	<i>Tringa totanus</i>	^d	190 000 ^d	14 500	25 000
Common Greenshank	<i>Tringa nebularia</i>	Europe	314 500	350	500
Ruddy Turnstone	<i>Arenaria interpres</i>	Canada, Greenland	94 000	>5000	10 000

non-br, Non-breeding population. Sources of data: flyway estimates from Wetlands International (2002); 1970s from Hutchinson (1979); 1980s from Sheppard (1993). ^aThe Irish Mute Swan population has been elevated to biogeographic population (Wetlands International 2002), and the threshold is thus the same as that for all-Ireland. ^bThe entire flyway population winters in Ireland. ^cThe relevant population on which to base the 1% threshold for Common Eider has been taken as the NW European total which comprises the four populations in this region (Britain/Ireland 73 000, Baltic/Wadden Sea 850 000–1 200 000, Norway/NW Russia 300 000–550 000 and White Sea 20 000–30 000). ^dThe relevant population on which to base the 1% threshold for Common Redshank has been taken as a combination of two populations, *robusta* (Iceland & the Faeroes) & *britannica* (Britain & Ireland).

Diver *Gavia immer*, which are difficult to survey from land, have been excluded from analyses. Introduced species, including Greater Canada Goose *Branta canadensis*, Greylag Goose (the naturalized population) and Ruddy Duck *Oxyura jamaicensis* have been

excluded as there is no conservation requirement to define 1% thresholds for site assessment. Gulls and terns are not considered here, as they are not routinely counted during regular core counts, and (for the gulls at least) their distributions are generally too wide-

spread for adequate monitoring by these methods alone.

Analysis of data

Estimates of waterbird totals

All-Ireland estimates were calculated for two consecutive five-season periods, 1994/95–1998/99 and 1999/2000–03/04. A five-year mean, consistent with approaches applied elsewhere in Europe, including Britain (Kershaw & Cranswick 2003, Rehfishch *et al.* 2003b), was used to minimize the potential confounding effects of cold-weather movements (causing large-scale displacement) and disturbance (causing 'local' survey under- and overestimation).

An index model similar to that used in the UK (Kershaw & Cranswick 2003, Rehfishch *et al.* 2003b), which includes data from a number of months, was used for calculating estimates and trends in abundance. Counts were modelled using a multiplicative log-linear index model, with site, year and month factors (Underhill & Prys-Jones 1994). Fitted values were then used to impute values where counts were missing (because the site was not visited). These fitted values were also used to compensate for 'low quality' counts, defined here as those for which the count was believed to be markedly lower than the true number present, because the count was affected by poor visibility or high disturbance levels, or because the site was only partially counted (for large wetland complexes with a number of count areas, a count was identified as potentially incomplete if less than 75% of the count areas were surveyed, and less than 75% of the average number of birds present in previous years was recorded). For such low quality counts, fitted values that exceeded actual counts were used. In all other cases, the actual count was retained.

Estimates for wildfowl species were based on data from all months between September and March inclusive. Unlike the wildfowl, many wader species that winter in Ireland also have populations that winter elsewhere (mostly further south on continental Europe and/or Africa), but occur in Ireland while on passage during the early autumn and later in spring. Therefore, to minimize inclusion of counts of passage populations, the wader estimates have been based on data from the November to February period.

For those species which occur on non-estuarine coast (e.g. Ruddy Turnstone), a bootstrapped estimate from this habitat (Colhoun & Newton 2000, Rehfishch *et al.* 2003a) was added to the modelled counts. Where

available, the results of other censuses (see 'Sources of data' above) were used in preference to modelled counts based on I-WeBS/WeBS core counts, as the species-specific targeting of survey effort is believed to provide better estimates of wintering numbers of these species.

Trend analysis

Annual indices were produced for each species for the ten-season period between 1994/95 and 2003/04. An index for the final season (2003/04) was constrained to a value of one, and indices for all prior seasons were expressed relative to this value. For each wildfowl species, monthly indices, which describe the patterns of change within a season, were used to assess the most appropriate months for inclusion in a species index. The month with the highest value was selected (so that the index was based on maximum bird numbers), and all months with overlapping 90% consistency intervals (Underhill & Prys-Jones 1994) were also included. These months were then used to calculate annual indices. For waders, counts from November to February inclusive, were used to calculate indices.

As recommended by Underhill & Prys-Jones (1994), only those sites which were covered on at least 50% of possible occasions were included in the calculation of species trends. This ensured that the number of imputed counts (calculated as described above) in the model was relatively low.

For the purpose of this paper, a species was deemed to be increasing or declining if the overall annual rate of change was equal to or greater than 2% (i.e. indicating an increase or decrease of 20% over the ten seasons); species with rates of change in between these values were considered to be stable.

RESULTS

Coverage

Over the ten-winter period some 750 wetland sites were covered by I-WeBS and WeBS (Fig. 1), including 92 in Northern Ireland and 658 in the Republic. These included most of the major wetlands in Ireland. Coverage embraced the full range of main wetland types in Ireland including coastal (total of 181) sites, predominantly estuaries, and inland (569) sites, mostly lakes, turloughs and rivers, although the smaller predominantly oligotrophic wetlands of western regions as well as linear waterways (rivers, streams and canals) were undersampled. These sites do not typically hold large

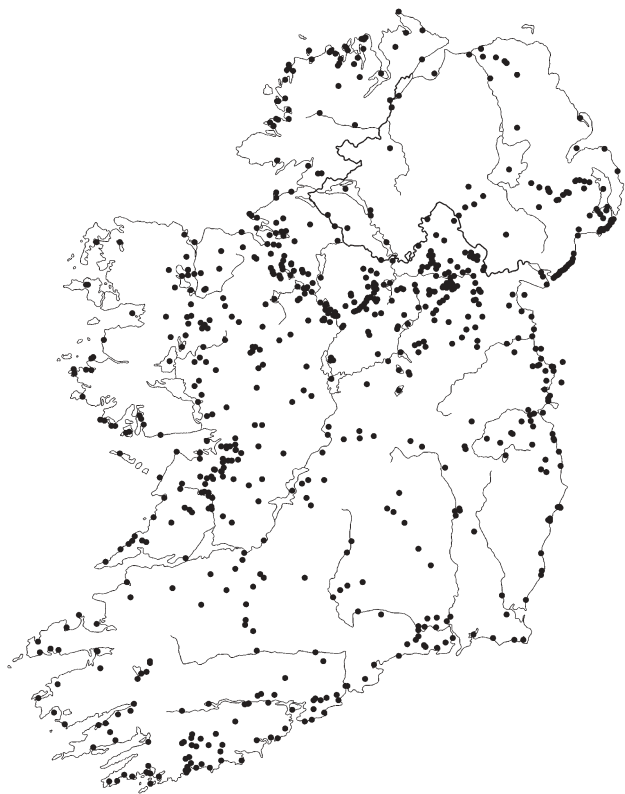


Figure 1. Wetland site coverage in Ireland between 1994/95 and 2003/04.

concentrations of wintering waterbirds. The number of sites covered in a given season between 1994/95 and 2003/04 averaged 348, with consistently highest levels of coverage in January (range 74–89% of sites).

Waterbird estimates

All-Ireland estimates were derived for 42 species, including 27 wildfowl and their allies and 15 waders. Summing these estimates suggests that Ireland played host to almost 1.15 million wintering waterbirds during the period 1999/2000 to 2003/04. The estimates calculated for 14 of the 42 species, including Mute Swan, Eurasian Wigeon, Eurasian Teal, Mallard, Common Eider, Common Scoter, Red-throated Diver, Little Grebe, Great Crested Grebe, Great Cormorant, Grey Heron, European Golden Plover, Northern Lapwing and Eurasian Curlew, must be considered conservative because their widespread distributions mean that a significant proportion is likely to occur on sites that have not been monitored during core counts or other related surveys.

Waders wintering in Ireland constitute almost 65% of the total numbers of waterbirds (Tables 2 & 3).

Northern Lapwing, European Golden Plover, Dunlin and Eurasian Oystercatcher were the most numerous species present. Among the wildfowl, Eurasian Wigeon, Eurasian Teal, Mallard, Common Pochard and Tufted Duck were most numerous, with Eurasian Wigeon alone constituting almost 20% of the total wildfowl recorded.

Non-estuarine habitat supported substantial proportions of many species, particularly Ringed Plover, Sanderling, Purple Sandpiper and Ruddy Turnstone (Table 3). Proportions of wildfowl species using non-estuarine coast were much lower (Table 3), except for marine species which use nearshore waters (particularly Common Eider, Common Scoter and Red-throated Diver).

Ireland supports sizeable proportions of the flyway populations of a number of waterbird species (Tables 2 & 3), principally Whooper Swan (61%), Greater White-fronted Goose (34% of the Greenland race), Barnacle Goose (17% of the Greenland race), Brent Goose (100% of the Nearctic light-bellied race), Ringed Plover (20%), Black-tailed Godwit (40% of *islandica*) and Common Redshank (16%). Mute Swans in Ireland, owing to their sedentary nature, have recently been classified as constituting a separate population (Wetlands International 2002).

Waterbird trends

Combined estimates for all species included in this analysis have shown that there was a 9% decline in the total number of waterbirds in Ireland between 1994/95 and 2003/04 (Tables 2 & 3). The magnitude of this decline was greater in waders (11%) than in other waterbirds (5%). Tundra Swan, Common Eider and Common Scoter were excluded from trend analyses because of the small sample of sites where they occur and the lack of consistency in detecting flocks of sea-ducks. Thus, trends were calculated for 39 species overall, almost half (18) of which showed annual declines in excess of 2%, including 11 wildfowl and seven waders (Tables 2 & 3). Increases were evident in just ten species (five wildfowl and five wader species). A further 11 species (eight wildfowl and three waders) remained stable.

The greatest declines (in excess of 5% per year) were apparent in Common Pochard, Tufted Duck, Common Goldeneye, Grey Plover, Northern Lapwing, Red Knot and Dunlin (Fig. 2). In contrast, there were considerable increases in numbers of Grey Heron, Barnacle Goose and Brent Goose. The greatest increases for

Table 2. All-Ireland estimates and trends in relative abundance of wildfowl (and their allies) between 1994/95 and 2003/04. Most of the estimates presented are based on the mean of peaks with imputation, unless otherwise indicated. The 1% thresholds provided are calculated (with rounding) as 1% of the respective all-Ireland totals.

Species ¹	1994/95 to 1998/99		1999/2000 to 2003/04			Trend		Annual Percentage of flyway in Ireland ⁶
	Total ²	1% threshold ³	Total ²	Proportion NEWS ⁴	1% threshold ³	Percentage change in estimates	change 1994/95 to 2003/04 ⁵	
<i>Mute Swan</i>	12 150	120	11 440	0.12	110	-5.8	-1.1	100
<i>Tundra Swan</i>	600	20	380		20	-36.6	*	1.3
<i>Whooper Swan</i>	9880 ^a	100	12 730 ^a		130	28.9	2.8	60.9
<i>Greater White-fronted Goose</i>	14 120 ^a	140	11 340 ^a		110	-19.7	-1.6	34.4
<i>Greylag Goose (Iceland)</i>	4480 ^b	45	5030 ^b		50	12.2	1.9	5.6
<i>Barnacle Goose</i>	8665 ^a	85	9035 ^a		90	4.3	5.5	16.7
<i>Brent Goose</i>	16 870 ^a	170	21 750 ^a		220	28.9	5.9	100
<i>Common Shelduck</i>	14 600	150	14 610		150	0.1	0.8	4.9
<i>Eurasian Wigeon</i>	89 260	890	82 370	0.06	820	-7.7	-2.9	5.5
<i>Gadwall</i>	660	20	630		20	-4.5	-0.1	1.1
<i>Eurasian Teal</i>	45 600	460	45 010	0.11	450	-1.3	-0.4	11.3
<i>Mallard</i>	48 040	480	38 250	0.07	380	-20.4	-2.3	0.9
<i>Northern Pintail</i>	1 650	20	1 235		20	-25.2	-2.2	2.1
<i>Northern Shoveler</i>	3 010	30	2 545		25	-15.4	-2.6	6.4
<i>Common Pochard</i>	49 030	490	37 780		380	-22.9	-6.7	10.8
<i>Tufted Duck</i>	41 590	420	36 610		370	-12	-7.5	3.1
<i>Greater Scaup</i>	6 340	65	4 430		45	-30.1	-4.3	1.4
<i>Common Eider</i>	2 820	30	2 890	0.22	30	2.5	*	0.2
<i>Common Scoter</i>	18 590	185	23 190	0.31	230	24.7	*	1.4
<i>Common Goldeneye</i>	11 850	120	9 665	0.01	95	-18.4	-5.7	2.4
<i>Red-breasted Merganser</i>	3 660	35	3 390	0.39	35	-7.4	-3.4	2
<i>Red-throated Diver</i>	1 255	20	1 025	0.73	20	-18.3	-2.3	0.2
<i>Little Grebe</i>	2 630	25	2 345	0.02	25	-10.8	-3.8	0.7
<i>Great Crested Grebe</i>	5 130	50	5 385	0.01	55	5	-1.1	1.1
<i>Great Cormorant</i>	12 840	130	13 710	0.22	140	6.8	3.5	11.4
<i>Grey Heron</i>	2 750	25	2 960	0.28	30	7.6	6.9	1.1
<i>Common Coot</i>	28 300	280	33 160		330	17.2	-0.8	1.9
Overall wildfowl	456 370		432 895	0.07		-5.1		

¹Species listed in italics are highly dispersed, and the estimates provided should be treated as known underestimates. Totals were not estimated for Great Northern Diver, Little Egret or Long-tailed Duck, but are likely to be less than 2000 (i.e. threshold of 20). ²Estimates in 'Total' columns were derived by summing the core counts with that in 'NEWS (1997/98)', and were rounded as follows: 1–1000 to the nearest one; 1001–10 000 to the nearest five; 10 001–100 000 to the nearest ten; >100 000 to the nearest 100. ³A minimum threshold of 20 has been applied for all species with totals less than 2000. Remaining 1% threshold values are rounded as follows: 21–100 to the nearest five; 101–1000 to the nearest ten; >1000 to the nearest 100. ⁴Non-estuarine Coastal Waterbird Survey (NEWS) 1997/98: data from Colhoun & Newton 2000 (Republic), Rehfish *et al.* 2003a (Northern Ireland waders) and unpublished WeBS data (Northern Ireland wildfowl). ⁵Percentage change overall based on the line of best fit (annual change). ⁶Based on the 1999/00 to 2003/04 estimate. See Table 1 for flyway population estimates. ^aBased on data from additional censuses: Swans 1995 (Robinson *et al.* 2004a, 2004b) and 2000 (Colhoun *et al.* 2000), Greater White-fronted Goose (provided by D. Norriss), Barnacle Goose (spring, every 4–5 years, from Merne & Walsh 2003), Brent Goose (annual, October since 1996/97, from Robinson *et al.* 2004c). ^bBased on sites known to support Iceland Greylag Geese. Lough Swilly and Lough Neagh are the only known sites with mixed Iceland/feral birds – a mean of 450 present in 6 out of 10 seasons, has been subtracted from the means calculated. *No indices were estimated for Tundra Swan, Common Eider or Common Scoter due to the relatively low number of sites at which these species are present.

waders included Eurasian Oystercatcher, Sanderling and Black-tailed Godwit (Fig. 2), although none of these increases exceeded 5%.

It is apparent that many of the observed changes over the ten-winter period are continuations of longer-term changes (spanning some 30 years) when these results

are compared with those from previous wetland bird surveys in Ireland during the mid-1970s and mid-1980s (Table 1). These include long-term increases seen for Whooper Swan, Greylag Goose, Barnacle Goose, Common Shelduck, Gadwall, Great Cormorant, Ringed Plover, Sanderling, Black-tailed Godwit,

Table 3. All-Ireland estimates and trends in relative abundance of waders between 1994/95 and 2003/04. Most of the estimates presented are based on the mean of peaks with imputation, unless otherwise indicated. The 1% thresholds provided are calculated (with rounding) as 1% of the respective all-Ireland totals.

Species ¹	1994/95 to 1998/99		1999/2000 to 2003/04			Trend		Annual Percentage of flyway in Ireland ⁶
	Total ²	1% threshold ³	Total ²	Proportion NEWS ⁴	1% threshold ³	Percentage change in estimates	change 1994/95 to 2003/04 ⁵	
Eurasian Oystercatcher	65 700	660	67 620	0.28	680	2.9	3.1	6.6
Ringed Plover	14 350	140	14 580	0.57	150	1.6	1.1	20
European Golden Plover	163 200	1 600	166 700	0.08	1 700	2.1	0.1	17.9
Grey Plover	6 435	65	6 315	0.24	65	-1.9	-5.7	2.6
Northern Lapwing	258 000	2 600	207 700	0.1	2 100	-19.5	-5.5	6.1
Red Knot	28 720	290	18 970	0.04	190	-33.9	-5.6	4.2
Sanderling	6 240	60	6 680	0.64	65	7.1	4.6	5.4
Purple Sandpiper	3 420	35	3 330	0.86	35	-2.6	-3.6	4.4
Dunlin	119 100	1 200	88 480	0.14	880	-25.7	-5.9	6.6
Black-tailed Godwit	13 660	140	13 880		140	1.6	3.2	39.7
Bar-tailed Godwit	15 520	160	16 280	0.04	160	4.9	0.5	13.6
Eurasian Curlew	61 070	610	54 650	0.26	550	-10.5	-3.1	13
Common Redshank	29 450	290	31 090	0.15	310	5.6	2.3	16.4
Common Greenshank	1 180	20	1 265	0.43	20	7.2	4	0.4
Ruddy Turnstone	13 160	130	11 810	0.61	120	-10.3	-3.3	12.6
Overall waders	799 205		709 350	0.15		-11.2		
Overall wildfowl and waders	1 255 575		1 142 245	0.12		-9		

¹⁻⁶See footnotes to Table 2.

Common Redshank and Common Greenshank, while declines include Tundra Swan, Eurasian Wigeon, Northern Pintail, Northern Shoveler, Little Grebe, Red Knot, Eurasian Curlew and Ruddy Turnstone.

DISCUSSION

Since 1994/95, I-WeBS and WeBS have achieved a high level of coverage of key wetlands in Ireland, encompassing a broad range of wetland biotopes. Counts have spanned the entire wintering period (September to March) for at least some sites, and levels of coverage have been broadly consistent between winters. These most recent estimates of waterbird numbers have been improved compared with previous figures by high levels of coverage, as well as analytical methods which take account of gaps in coverage of sites during monthly core counts, as well as inaccuracies resulting from 'poor quality' counts caused by incomplete coverage, poor visibility or high disturbance levels.

Despite the improvements to these analyses, the present estimates appear comparable with those based on less consistent levels of coverage and more simplistic computational methods in the 1970s (Hutchinson 1979) and 1980s (Sheppard 1993). Both

these former surveys in Ireland were relatively short-term, carried out over just three seasons each, and estimates were calculated solely on the basis of summed counts across sites for which counts were available.

The traditional approach of estimating the total number of waterbirds wintering in a particular country or region was to use count data from a single month only (January, when most waterbirds are present in largest numbers). The pattern of occurrence of wintering waterbird species in Ireland is, however, highly variable. Cold weather, which often occurs between December and February, may result in some of the greatest fluctuations in abundance in many species, due to both local and broad-scale between-country movements. Such large-scale movements between countries may have a considerable effect on when largest numbers of several species occur in Ireland. January counts alone are also inappropriate for assessing species with large resident populations (e.g. Mute Swan, Mallard, Little Grebe, Great Crested Grebe, Great Cormorant and Grey Heron) as peak numbers are usually recorded during early autumn (September/October) (Crowe 2005). Mallard numbers are also augmented in September and October by several thousand captive-reared birds released for shooting (O. Merne pers. comm.). Furthermore, as

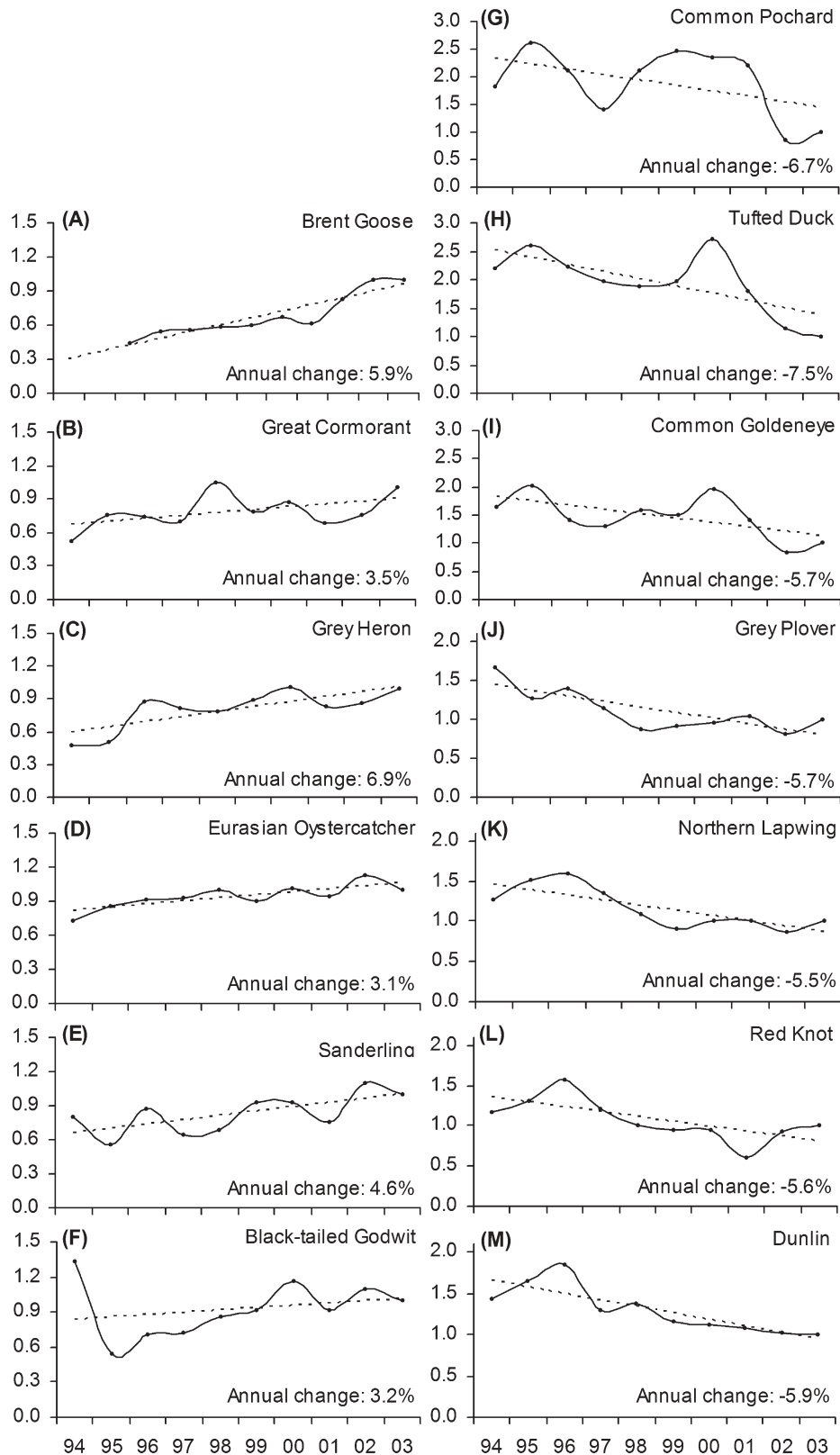


Figure 2. Indices (solid lines) and fitted linear trends (hatched lines) for 13 species showing increasing (A–F) and declining (G–M) trends in numbers.

winter progresses, and as rivers and smaller wetlands fill with water, several of these species disperse to such smaller sites, many of which are not covered by the monitoring schemes. Hunting also causes a reduction in numbers, due to enhanced dispersal (Madsen 1998, Evans & Day 2001), as well as direct mortality (A. Walsh pers. comm.). For a fuller discussion of the limitations, see Kershaw & Cranswick (2003) and Rehfisch *et al.* (2003b).

The total number of wildfowl and waders wintering in Ireland is considerably less than in Britain, where a minimum of five million waterbirds has been recorded (Kershaw & Cranswick 2003, Rehfisch *et al.* 2003b). This is to some extent expected, given that Britain is considerably larger, with a greater latitudinal range than Ireland, and is also situated closer to mainland Europe. Also, despite the proximity of the two islands, the origins of several wintering waterbird species differ. Both receive a large proportion of the flyway populations migrating from the north and northwest, i.e. those populations breeding from Iceland to Canada, while Britain tends to support much larger concentrations of populations migrating from the east, i.e. those breeding from northern Europe to eastern Siberia.

Changing status of wintering waterbirds in Ireland

There have been significant changes in the numbers of waterbirds wintering in Ireland over the past 30 years. For most species, these changes are consistent with those occurring at flyway level (Delany *et al.* 1999), and in most cases the cause is extrinsic. However, there has been significant modification of several wetland sites in Ireland, particularly for industry or housing, and many have also been subject to increased levels of, largely recreational, disturbance. Nutrient input from a range of polluting activities such as sewage outfalls, farming and industry, has caused eutrophication at some sites, although both these activities are now being alleviated and are under much stricter control by the Environmental Protection Agency (Toner *et al.* 2005). The declines observed in most duck species may reflect a reduction in habitat quality, particularly as they are predominantly stable or increasing elsewhere along their flyway. For example, significant declines in dabbling ducks have occurred at Rahasane Turlough and the Inishcarra Reservoirs, while diving duck numbers have declined at Lough Leane (Crowe 2005) and more recently Lough Neagh (Allen *et al.* 2004). This latter decline is highly significant, as this lake has regularly supported at least double the number of

Common Pochard, four times the number of Tufted Duck and Greater Scaup, and over 30 times the number of Common Goldeneye recorded at any other site in Ireland (Crowe 2005).

Allen *et al.* (2004) have suggested that most of these species declines at Lough Neagh may be attributed to redistribution of these species along their respective flyways, caused by global warming, although Maclean *et al.* (2006) thought that the balance of evidence suggested that site-related issues (such as high levels of nutrient input) were primarily responsible. In recent decades, increasingly mild winters, especially warmer temperatures and less prolonged frost and snow cover in the northern hemisphere (Houghton *et al.* 2001), have increased the availability of suitable wintering habitat closer to the Arctic breeding areas used by most of these species. This appears to have resulted in the short-stopping of many species, and may explain the relatively recent large-scale decline in numbers of Tundra Swans wintering in Ireland, from 2000 in 1990 (Beekman 1997) to just 382 in 2000 (Colhoun *et al.* 2000) and 224 in 2005 (Crowe *et al.* 2005). This eastward shift in range is also apparent in Britain, where numbers between 1995 and 2005 declined in northwest and southwest England, while they increased or remained stable in eastern England (Worden *et al.* 2006).

Redistribution due to climate change has been shown in a number of other species groups (MacLeod *et al.* 2005, Walther *et al.* 2005). Austin & Rehfisch (2005) have attributed a decline in wader numbers wintering in southwest Britain and an increase in eastern Britain to global warming. The wintering distribution of several wader species appears to be shifting in a northwest direction towards their breeding grounds as a result of the increasingly favourable conditions there (Rehfisch *et al.* 2004). A general northward shift in range caused by a lack of cold winters in recent decades (in conjunction with a reduction in persecution in southern Europe) has caused the relatively recent expansion of the Little Egret *Egretta garzetta* into Ireland and Britain during the late 1990s (Smiddy & Duffy 1997, Musgrove 2002). This species has since continued to increase in numbers and range throughout Ireland (I-WeBS unpubl. data).

The majority of waterbird populations migrating to Ireland from the north and northwest, including Whooper Swan, Greylag Goose, Barnacle Goose, Brent Goose, Ringed Plover, European Golden Plover, Black-tailed Godwit, Common Redshank and Ruddy Turnstone, have increased or remained stable through-

out most of their range in recent decades (Wetlands International 2002), and most have remained stable or increased in Ireland at least since the mid-1990s. This is particularly encouraging, as Ireland supports substantial proportions of several of these flyway populations, particularly Whooper Swan, Brent Goose and Black-tailed Godwit. Notable exceptions to this general increasing trend at the flyway level include the Greenland race of Greater White-fronted Goose (Fox *et al.* 2006) and Red Knot (Stroud *et al.* 2004). Numbers of the former have undergone a dramatic decline in recent years, thought to be an indirect consequence of global warming; the increasingly mild climate in west Greenland has rendered the Greater White-fronted Goose breeding areas in west Greenland suitable also for an expanding Lesser Canada Goose population. Breeding numbers of Lesser Canada Goose have increased, and it is now excluding the Greater White-fronted Goose from former, more optimal, breeding areas (Kristiansen & Jarrett 2002). As a consequence, Greenland White-fronted Goose productivity has declined (Kristiansen & Jarrett 2002), and the overall population has been in decline, particularly since the late 1990s. The autumn hunt in Iceland has had an additional impact, with up to 3000 shot each year while on passage (Fox 2003, Fox *et al.* 2006). However, with their numbers having declined so rapidly in recent years, the Icelandic Ministry of the Environment declared an end to the hunting of Greenland White-fronted Geese in Iceland as from autumn 2006.

The population of Red Knot that winters in Ireland (*C. c. islandica*) has been in decline throughout most of its wintering range, particularly since the late 1990s (Stroud *et al.* 2004). A longer-term decline has been evident in Ireland. The decline in Ruddy Turnstone in Ireland since the mid-1990s is consistent with that shown in Britain (Collier *et al.* 2005), but is contrary to the trend at flyway level (Stroud *et al.* 2004).

Accuracy of the estimates presented

The limited number of counters, many of whom are volunteers, leads to a bias in coverage by I-WeBS and WeBS core counts, with the largest and most important wetland sites being relatively well covered, and smaller and more remote sites receiving fewer visits. Accepting methodological limitations, the estimates presented for 28 waterbird species are considered accurate, while the estimates derived for the remaining 15 species should be treated as minima. Although they are likely to

reflect numbers on the surveyed sites reasonably accurately, they represent underestimates of the all-Ireland totals. While the additional periodic surveys carried out for swans and geese, as well as a survey of the waterbirds occurring along non-estuarine coasts (NEWS), have served to provide a greater understanding of the distribution of these species, as well as improved confidence in the estimates produced, potentially large proportions of a number of widespread species are overlooked. It is possible that cumulatively, substantial proportions of the national totals of a range of species, particularly Mute Swan, Eurasian Wigeon, Eurasian Teal, Mallard, the grebes, Great Cormorant and Grey Heron, are present on rivers and/or other smaller wetlands which do not receive coverage during core counts. Estimates of waterbird totals in Britain (Kershaw & Cranswick 2003) showed that over 50% of Mute Swan and Mallard, and 40% of Little Grebe and Great Crested Grebe are unaccounted for through core counts alone. Some wader species, particularly European Golden Plover, Northern Lapwing and Eurasian Curlew, are known to use a variety of non-wetland habitats. Estimates derived for marine species, particularly the seaducks and Red-throated Diver, are also likely to be considerable underestimates. It is likely that sizeable numbers of these species are present at distances offshore that are too far for detection from land-based observation points and so will have been missed by I-WeBS and WeBS counts (e.g. see accounts for Common Scoter and Red-throated Diver in Cranswick *et al.* 2005).

In Ireland, the importance of a site for a wintering waterbird species is determined by the proportion of the flyway population and/or the all-Ireland total that site holds. To this end, almost 150 SPAs have been at least partially designated for birds in Ireland, with the majority (almost 70%) partially or wholly designated for wintering waterbirds. These analyses have served to provide the most comprehensive and up-to-date estimates for the majority of waterbird species wintering in Ireland. Accordingly, threshold values have also been updated for the assessment of site importance for wintering waterbird species in Ireland.

There is an increased body of evidence that climate change is affecting waterbirds in their breeding, staging and/or wintering areas, and has resulted in a shift in the distribution ranges of several populations. It is therefore crucial that effective monitoring across flyways continues to be delivered through schemes such as these, so that species decline can be detected. Furthermore, periodic reviews of national totals and

flyway population sizes are essential in order to guide national approaches to site-based conservation designations.

ACKNOWLEDGEMENTS

I-WeBS is a joint project of BirdWatch Ireland and the National Parks and Wildlife Service of the Department of Environment, Heritage and Local Government, and the Wildfowl & Wetlands Trust. It has received additional support from the Heritage Council and the World Wide Fund for Nature. WeBS is a partnership scheme of the British Trust for Ornithology, the Wildfowl & Wetlands Trust, the Royal Society for the Protection of Birds and the Joint Nature Conservation Committee. The latter acts on behalf of the four national agencies, Natural England, Scottish Natural Heritage, the Countryside Council for Wales and the Environment and Heritage Service (Northern Ireland). Swan and goose surveys were organized by BirdWatch Ireland, the Wildfowl & Wetlands Trust, the Greenland White-fronted Goose Study (GWGS), the Irish Whooper Swan Study Group (IWSSG) and the Irish Brent Goose Research Group (IBGRG). Comments from Stephen Newton, Oscar Merne, John O'Halloran and Helen Boland greatly improved this paper. We also thank Matthieu Guillemain and an anonymous reviewer for their comments. We are grateful to the Irish Air Corps and Weston Airfield for providing pilots and aircraft for the aerial censuses. Finally, these analyses would not have been possible without the dedicated commitment of previous national organizers, regional organizers and the input from hundreds of enthusiastic birdwatchers and staff of the partner organizations who have participated in these surveys in Ireland.

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(MS received 24 November 2006; revised MS accepted 1 June 2007)