Trends in the numbers of Coot *Fulica atra* and wildfowl *Anatidae* wintering in France, and their relationship with hunting activity at wetland sites

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Abstract

Monitoring numbers of wintering wildfowl *Anatidae* and Coot *Fulica atra* is an important tool for their management and conservation. Twenty species of wildfowl and Coot have been counted monthly from December–February over 21 winters (1987–2008) at 88 French wetlands of national and international importance for these birds, covering 597 different count sites. Trends in average winter numbers were positive for 15 species, stable for Smew *Mergus albellus*, and indicated a decline in numbers for the five remaining species. Models assessing trends over time and also the effect of hunting status at the different sites (with sites grouped according to whether the area was hunted, partly hunted, or protected), found that bird numbers varied between sites of different status for all species except Red-crested Pochard *Netta rufina*. The immediacy with which hunting status affected local trends was less clear. There was no significant interaction between trends in numbers and the hunting status of the count sites for 10 of the 20 *Anatidae* species, including four of six species protected from hunting. For two protected species, trends were more favourable at fully hunted than at fully protected sites. Ten of the 14 quarry species did not show more favourable trends in protected than in hunted sites. Hunting activity at sites therefore does not, in itself, seem sufficient to explain differences in local trends in waterbird numbers.

Key words: *Anatidae*, Coot, France, hunting, trends in numbers, winter.

International treaties and agreements relating to wildfowl and wetlands (such as the Ramsar Convention, the EU Birds Directive and the Agreement on the Conservation of African-Eurasian Migratory Waterbirds) and international species programmes (such as the International Union for Nature Conservation's Red List of Threatened Species) generally aim to identify those species in greatest need of conservation action, mostly relying on criteria such as trends in population size (Atkinson *et al.* 2006). Population monitoring schemes, such as the International Waterbird Census (IWC) coordinated by Wetlands International (Gilissen *et al.* 2002), are typically required to provide such data. Accurate analysis of the data generated by long-term monitoring schemes is then required to determine not only trends in population abundance over time, but also the direction, magnitude, and timing of changes in abundance. Such information is essential for identifying species of conservation concern and, on incorporating demographic data into the analysis, for providing preliminary indications of the reasons for population change (Pannekoek & van Strien 2005; Atkinson *et al.* 2006).

In France, a national waterbird monitoring scheme coordinated by the Game and Wildlife National Agency (Office National de la Chasse et de la Faune Sauvage: ONCFS) and the National Hunting NGOs (Fédération Nationale des Chasseurs: FNC) was initiated in winter 1987/88 to estimate the size and distribution of the wintering wildfowl populations, to determine the most important sites for each species, and to assess their trends in numbers over time. The paper describes analyses of the long-term data from this scheme, to provide a broad and updated assessment of trends in numbers of wildfowl wintering in France over the last 21 years. These are compared with trends recorded for the two biogeographical populations to which birds wintering in France belong, the Northwest European population and the Black Sea/Mediterranean population (Wetlands International 2006), to determine whether trends in France reflect trends for the population as a whole. The link between trends in numbers and the extent to which birds are hunted at count sites (*i.e.* whether hunting occurs over the whole site, over part of the site, or the area is protected from hunting) is also assessed. The hypothesis was that trends should be more strongly positive for quarry species in protected areas in comparison with hunted sites, but that there should be no difference between hunted and protected sites for protected species even if, to some extent, protected species may be disturbed by hunting of other species. The analysis of the relationship between trends in numbers and hunting status of sites was possible here because the hunting status of count sites was consistent throughout the study, since the majority of reserves in France were created before the 1990s.

Methods

Bird counts

Wildfowl were counted over 88 wetlands (varying from 21–57,811 ha in size) located across France, selected for the monitoring programme because they hosted ≥1% of the national population of at least one of the 30 species of *Anatidae* and Coot *Fulica atra* regularly present in the country (Fouque *et al.* 2005a; Fouque *et al.* 2007; FNC & ONCFS 2008). Each of these wetlands encompasses one or several individual count sites, totalling 597 such sites. These cover a total of 280,700 ha, or *c.* 30% of the national wetland area (after BD CARTHAGE® 2005 and ESRI® water bodies 2002). At each of these sites, wildfowl were counted every winter in mid-December, mid-January and mid-February from 1987/1988 to 2007/2008 inclusive. Counts were made during daylight hours, when these gregarious species flock at day-time roosts or, in the case of some goose species, at their feeding sites. Counts generally were coordinated across sites by ensuring they were made on the same day at each of the 88 wetlands, although occasionally an interval of up to one week before or after the 15th of each month was necessary. Fieldwork was mainly performed by professionals specifically trained in counting wildfowl, mostly technical staff from the ONCFS and from the Departmental Hunting Associations (Fédérations Départementales des Chasseurs: FDC). This formed a national network of observers named "Oiseaux d'eau & Zones humides", coordinated by ONCFS. Some additional count data from other sources was also included, from the Station Biologique de la Tour du Valat, the Réserve Nationale de Camargue, the Association des Amis des Marais du Vigueirat, the Parc Naturel Régional de Brière, the Conseil Général de la Moselle and the Fondation Pierre Vérots, where these organisations are responsible for the monitoring and management of particular sites.

Statistical analyses

Few statistical methods are fully adapted to analyse time series data from wildfowl counts and generate population indices and trends. The major problems are usually due to missing values (the gaps in coverage caused by sites not being visited every year), which tend to be characteristic of large-scale and long-term census schemes. The necessity of identifying non-linear trends in populations is also a common statistical issue (ter Braak *et al.* 1994; Thomas 1996; Pettifor 1997; Atkinson *et al.* 2006). To overcome the latter problem, analyses were undertaken using log-linear regressions in programme TRIM (TRends and Indices for Monitoring data; TRIM software version 3.5, Pannekoek & van Strien 2005, see http://www.cbs.nl/en-GB/menu/themas/natuur-milieu/methoden/trim/default.htm). The software permits assessment of curvilinear patterns when they occur, by splitting long-term non-linear trends into short-term segments with constant slope, then averaging those slopes. Details of the TRIM procedure used in analysing French wildfowl counts, including how the software imputes missing data, are described in Fouque *et al.* (2005a,b, 2007).

In the present study, most gaps in the count data were due to practical problems in completing the counts, such as bad weather or a lack of observers, but some were due to new sites being added to the monitoring scheme several years after the project started. These were treated as missing values in TRIM. The assumption that missing values are distributed randomly therefore was not met, because >25% of the sites had missing values up to winter 1990/91, whereas the percentage of missing values varied between 5–15% in subsequent years. Nevertheless, using TRIM to impute missing values was considered reasonable because the software estimated <20% of the dataset for any one species and the literature indicates that this is acceptable (Pannekoek & van Strien 2005). Moreover, imputed missing values accounted for <13% of the total number of birds, based on the summation of real counts plus (for the missing counts) model predictions (Table 1). Missing values generally were from the least important sites and the proportion of numbers estimated in relation to the total counts low for each species except for Northern Shoveler *Anas clypeata*, Smew *Mergus albellus* and Tundra Bean Goose *Anser fabalis*, for which the share of missing values was 22.7%, 35.7% and 22.2%, respectively (Table 1).

A second assumption of such models, that year-to-year changes are similar for all sites, also was not true for all species. Covariates such as geographical region (n = 7 regions), the importance of each site for the birds (*i.e.* whether or not winter numbers ≥1% of the national count for each species), the hunting status of the site (with sites classed as hunted or protected) and the type of wetland habitat (grouped into five categories: lakes, gravel pits/reservoirs, running freshwater, freshwater marshes and coastal brackish waters) were included to try to improve the imputations and the fit of the model, but without success. The assumption therefore could not be met, and the quality of the imputations and the indices generated may be limited due to the lack-of-fit in the data, but TRIM converts any lack-of-fit into higher standard errors (s.e.) of the indices.

The log-linear regression method is based on a third assumption, that counts are distributed under independent Poisson distributions. This assumption was violated for this dataset, as is generally the case for wildfowl counts (van Strien *et al.* 2004), because a relatively high proportion of birds is typically found at a small number of sites, so that the variance is often larger than expected for a Poisson distribution. This overdispersion in the data was high for all species considered here, with values sometimes >100 (a value of 1 stands for no overdispersion) (Table 2). Furthermore, the counts may not be independently distributed because counts on a particular date will often correlate with counts made on the previous count date (serial correlation). In this dataset, half of the species showed relatively high serial correlation, with $r > 0.2$ (with $r = 0$ indicating no serial correlation) (Table 2). However, TRIM takes overdispersion and serial correlation between counts into account: these may actually enlarge the s.e. of the indices, but should have little influence on the index values produced by TRIM. The results section indicates that the total numbers imputed at the national scale as well as the annual indices had relatively low s.e. values for most species, suggesting that the models applied were probably

Table 1. Number and proportion of the 597 sites in the monitoring programme with at least one positive count for each species ("occupied sites"), together with the proportions of missing counts and of estimated numbers (difference between observed and imputed counts) over the 21-year (1987/88–2008/09) period. Numbers recorded in winter 2008/09 are also given for each of the 21 species.

Species		No. of occupied sites % (*n*)	Proportion of missing counts %	Proportion of estimated numbers %	Wintering numbers in 2008/09 (individuals)
Mute Swan	*Cygnus olor*	77.05 (460)	19.14	10.91	7,000
Greylag Goose	*Anser anser*	41.88 (250)	15.64	6.86	12,000
Tundra Bean Goose	*Anser fabalis*	9.55 (57)	10.78	22.23	650
Dark-bellied Brent Goose	*Branta b. bernicla*	18.09 (108)	10.27	11.82	70,000
Common Shelduck	*Tadorna tadorna*	54.94 (328)	12.94	12.61	32,000
Eurasian Wigeon	*Anas penelope*	78.06 (466)	16.24	12.51	34,000
Gadwall	*Anas strepera*	75.88 (453)	17.26	6.09	28,500
Common Teal	*Anas crecca*	91.79 (548)	18.83	10.49	90,000
Mallard	*Anas platyrhynchos*	97.65 (583)	20.07	9.90	140,000
Northern Pintail	*Anas acuta*	61.31 (366)	15.51	11.92	15,000
Northern Shoveler	*Anas clypeata*	73.03 (436)	16.98	22.68	25,000
Red-crested Pochard	*Netta rufina*	36.01 (215)	13.18	0.88	5,000
Common Pochard	*Aythya ferina*	86.43 (516)	19.11	13.05	60,000
Ferruginous Duck	*Aythya nyroca*	8.71 (52)	9.43	8.60	11
Tufted Duck	*Aythya fuligula*	80.40 (480)	18.33	8.88	30,000
Greater Scaup	*Aythya marila*	28.31 (169)	9.69	2.09	580
Goldeneye	*Bucephala clangula*	38.19 (228)	14.56	5.83	1,425
Red-breasted Merganser	*Mergus serrator*	28.31 (169)	10.34	7.58	750
Smew	*Mergus albellus*	24.79 (148)	13.87	35.74	100
Goosander	*Mergus merganser*	31.99 (191)	11.09	5.91	280
Common Coot	*Fulica atra*	91.79 (548)	19.81	11.21	120,000

Table 2. Average annual rates of change (± 95% confidence intervals) for 21 species of wildfowl and Coot counted at 88 wetlands in France from winters 1987/88–2008/09 inclusive, calculated using linear models (log-linear Poisson regressions) in TRIM. Trends are described according to TRIM classification; n.s. = no significant trend. Parameters taken into account by TRIM software (overdispersion and serial correlation) are also provided.

Species	**Over-dispersion**	**Serial correlation (*r*)**	**Annual rate of change (%)**	**95% Confidence intervals (%)**	***P* (%)**	**Trend in numbers**
Mute Swan	26.40	0.24	6.92	[6.37 ; 7.47]	1%	Strong increase
Greylag Goose	73.55	0.13	12.62	[11.68 ; 13.56]	1%	Strong increase
Tundra Bean Goose	34.55	0.03	–2.14	[–3.20 ; –1.08]	1%	Moderate decline
Dark-bellied Brent Goose	362.2	0.32	0.51	[0.10 ; 0.92]	5%	Moderate increase
Common Shelduck	90.73	0.34	1.41	[1.04 ; 1.78]	1%	Moderate increase
Eurasian Wigeon	106.15	0.26	1.47	[1.14 ; 1.80]	1%	Moderate increase
Gadwall	53.65	0.20	4.79	[4.48 ; 5.10]	1%	Moderate increase
Common Teal	194.50	0.29	3.95	[3.64 ; 4.26]	1%	Moderate increase
Mallard	248.95	0.40	1.66	[1.41 ; 1.91]	1%	Moderate increase
Northern Pintail	111.56	0.26	3.17	[2.56 ; 3.78]	1%	Moderate increase
Northern Shoveler	92.18	0.21	1.92	[1.55 ; 2.29]	1%	Moderate increase
Red-crested Pochard	31.11	0.14	2.48	[2.03 ; 2.93]	1%	Moderate increase
Common Pochard	341.86	0.19	0.49	[0.08 ; 0.90]	5%	Moderate increase
Ferruginous Duck	2.81	0.02	10.45	[–4.31 ; 25.21]	5%	Uncertain
Tufted Duck	137.49	0.28	–3.12	[–3.41 ; –2.83]	1%	Moderate decline
Greater Scaup	36.37	0.03	–6.21	[–7.13 ; –5.29]	1%	Steep decline
Goldeneye	19.63	0.21	–0.88	[–1.43 ; –0.33]	1%	Moderate decline
Red-breasted Merganser	23.96	0.13	–9.81	[–10.93 ; –8.69]	1%	Steep decline
Smew	5.70	0.00	–0.55	[–1.98 ; 0.88]	n.s.	Stable
Goosander	8.88	0.17	3.12	[2.49 ; 3.75]	1%	Moderate increase
Common Coot	421.63	0.24	1.12	[0.81 ; 1.43]	1%	Moderate increase

acceptable, and that the indices were reasonably accurate. In addition to the production of annual imputed indices, their interpretation as trends in numbers was considered to be sufficiently reliable because the time series spanned 21 years, a period considered to be long enough to provide long-term trends that are not simply a reflection of sporadic variation. Furthermore, the number of sites with at least one positive count of a particular species over the 21 year period was large for all species except for Bean Goose and Ferruginous Duck *Aythya nyroca* (Table 1), which also strengthens the results. Index 1 was ascribed to the value for the first winter of the dataset, to obtain a trend over the 21 years of the study. The trend was expressed as the slope describing the average annual rate of change over the whole study period, together with its s.e. and 95% confidence interval (C.I.). If the C.I. did not include the value of 1 (or 0 when converted into a percentage) then the trend was statistically significant at $P \leq 5\%$ (Pannekoek & van Strien 2005).

The TRIM software classed the trends in numbers according to one of six categories depending on whether the rate of change over the study period was more or less than 5% per year: a strong increase or decrease (>5% per year), a moderate increase or decrease (<5% per year), a stable trend, or an uncertain trend with large C.I. values (Pannekoek & van Strien 2005). Trends in numbers within France were compared to those at the European (flyway) scale described by Wetlands International (2006) to determine whether national trends were reflecting total population trends, or whether trends within France were potentially related to local policy or environmental conditions.

To determine the relationship between trends in numbers and the hunting status of sites, the sites were classed as one of three categories: 1) hunting over the whole of the site (n = 417; 62,080 ha), 2) hunting over part of the site (n = 43; 93,856 ha), and 3) hunting prohibited (n = 137 sites; 125,818 ha). Ferruginous Duck was omitted from this analysis as numbers were too low and the species was present at only a few sites. General Linear Models (GLM) with a Poisson distribution and a log link function, and using Pearson χ^2 as a scale parameter to control for overdispersion, were used to test how bird numbers (imputed numbers from TRIM analyses) were affected by years (as a continuous variable), the hunting status of the sites (as a categorical variable) and the interaction between these two terms. This final model was tested against other possible models which incorporated a combination of these factors and variables, but the final model was accepted as the one that provided the best and most parsimonious fit to the data.

Results

Trends in numbers in France and comparison with trends in biogeographical regions

Trends in numbers of wildfowl and Coot within France are presented in Table 2 (illustrated in Appendix 1), while trends for the two biogeographical populations from which birds wintering in France originated (the Northwest European population and the Black Sea/Mediterranean population) are given in Table 3. There was a substantial increase in numbers for both the Mute Swan *Cygnus olor* and the Greylag Goose *Anser anser* in France, with an average annual increase of >5% per year over the 21-year period. These national trends were similar to those recorded at the population level. All six dabbling ducks (Northern Shoveler, Northern Pintail *Anas acuta*, Mallard *Anas platyrhynchos*, European Wigeon *Anas penelope*, Gadwall *Anas strepera*, and Common Teal *Anas crecca*) showed a moderate (<5% per year) but significant increase. These trends were similar or more favourable for France than for the two biogeographical populations. A moderate increase was also recorded for Goosander *Mergus merganser*, Common Shelduck *Tadorna tadorna*, Red-crested Pochard *Netta rufina*, Common Pochard *Aythya ferina*, Coot and Dark-bellied Brent Goose *Branta b. bernicla*, but trends were significant at the 5% instead of the 1% level for the last three cases. Trends in the French data were again similar or more favourable than those recorded at the biogeographical scale (Table 3).

The trend in numbers was stable only for Smew, and unknown only for Ferruginous Duck. France hosts very small numbers of these birds (Table 1), so a comparison of trends for France with those for the European populations would not be meaningful. Tufted Duck *Aythya fuligula*, Goldeneye *Bucephala clangula* and Tundra Bean Goose showed a moderate decline, <5% per year on average. The trends were less favourable in France than at the biogeographical scale for Tufted Duck and Goldeneye, but were similar at the different scales for the Tundra Bean Goose (Table 3). Red-breasted Merganser *Mergus serrator* and Greater Scaup *Ayhtya marila* showed more major declines in France than elsewhere in Europe, with an average decline in France of >5% per year, but again France holds only a small proportion of these two species.

Relationships between trends and wetland hunting status

Models which included both long-term (21-year) trends in numbers and hunting activity at particular sites as explanatory variables provided a significant fit to the count data for all species except Red-crested Pochard, and also proved to be the most parsimonious model for each species (Table 4).

The hunting status of the site was significant when included as a single term (*i.e.* no significant year * hunting status interaction) for nine species (Table 4, Fig. 1). Of these, three quarry species (Teal, Greylag Goose and Shoveler) and one protected species (Common Shelduck) were significantly more numerous on fully protected than on hunted sites. Conversely, one quarry species (Greater Scaup) and one protected species (Red-breasted Merganser), which had the worst trends (significant declines) in numbers of the 21 species, were more numerous on fully hunted sites. Lastly, Common Pochard and two protected species (Smew and Goosander) were significantly less abundant on partly protected sites than on fully hunted or fully protected sites.

GLM models showed significant interactions between years and the status of sites for the 10 remaining species (Table 4).

Table 3. Comparison of trends in the numbers of wildfowl and Coot counted in France in winters 1987/88–2008/09 inclusive with trends recorded for their biogeographical populations. A dash (–) indicates species where birds from the Black Sea/Mediterranean region rarely occurred in France. Trends for the two biogeographical populations are from Wetlands International (2006).

Species	Trend in numbers in France	Population trends		Trend more favourable in France
		NW Europe	Black Sea/ Mediterranean	
Mute Swan	Strong increase	Increase	–	Same trend
Greylag Goose	Strong increase	Increase	–	Same trend
Tundra Bean Goose	Moderate decline	Decrease	–	Same trend
Dark-bellied Brent Goose	Moderate increase	Decrease	–	Yes
Common Shelduck	Moderate increase	Stable	Stable	Yes
Eurasian Wigeon	Moderate increase	Stable	Decrease	Yes
Gadwall	Moderate increase	Increase	Stable	Same trend
Common Teal	Moderate increase	Increase	Uncertain	Poss. same trend
Mallard	Moderate increase	Decrease/stable	Stable?	Yes
Northern Pintail	Moderate increase	Stable	Decrease	Yes
Northern Shoveler	Moderate increase	Stable	Stable	Yes
Red-crested Pochard	Moderate increase	Increase	Same trend	
Common Pochard	Moderate increase	Decrease	Decrease	Yes
Ferruginous Duck	Uncertain	Decrease	–	Uncertain
Tufted Duck	Moderate decline	Stable	Stable	No
Greater Scaup	Steep decline	Stable	–	No
Goldeneye	Moderate decline	Stable	–	No
Red-breasted Merganser	Steep decline	Uncertain	–	Uncertain
Smew	Stable	Uncertain	–	Uncertain
Goosander	Moderate increase	Uncertain	–	Uncertain
Common Coot	Moderate increase	Stable	Uncertain	Yes

Table 4. Results of GLM models developed to explain the number of wintering birds counted in relation to Years (Y), hunting status at the sites (H) and the interaction of these two variables (Y*H). Degrees of freedom for the χ^2 values were 38 for the Greylag Goose; d.f. = 57 for all other species. Overdispersion was addressed by fixing the Scaled Pearson χ^2 to 1; such models are significant when the scaled deviance approaches the value of 1. Models fitted to the Red-crested Pochard data did not prove significant. The last column indicates factors that had a significant effect within the model (Wald tests; $P < 0.05$ in each case).

Species	Hunting status	Pearson χ^2	Scaled deviance	Significant parameters
Mute Swan	Protected	24.23	0.99	Y H (Y*H)
Greylag Goose	Quarry	263.57	0.95	Y H
Tundra Bean Goose	Quarry	18.10	0.96	H (Y*H)
Dark-bellied Brent Goose	Protected	577.30	1.01	Y H (Y*H)
Common Shelduck	Protected	293.74	1.01	Y H
Eurasian Wigeon	Quarry	395.95	0.98	H (Y*H)
Gadwall	Quarry	96.84	1.01	Y H (Y*H)
Common Teal	Quarry	666.40	0.97	Y H
Mallard	Quarry	524.78	0.98	Y H (Y*H)
Northern Pintail	Quarry	334.24	1.00	Y H (Y*H)
Northern Shoveler	Quarry	711.60	0.98	Y H
Red-crested Pochard	Quarry	163.47	0.87	–
Common Pochard	Quarry	433.29	0.99	H
Tufted Duck	Quarry	155.20	1.02	Y H (Y*H)
Greater Scaup	Quarry	127.34	0.94	H
Goldeneye	Quarry	22.06	1.02	Y H (Y*H)
Red-breasted Merganser	Protected	94.34	1.06	H
Smew	Protected	21.39	0.91	H
Goosander	Protected	17.51	0.94	Y H
Common Coot	Quarry	619.11	1.00	H (Y*H)

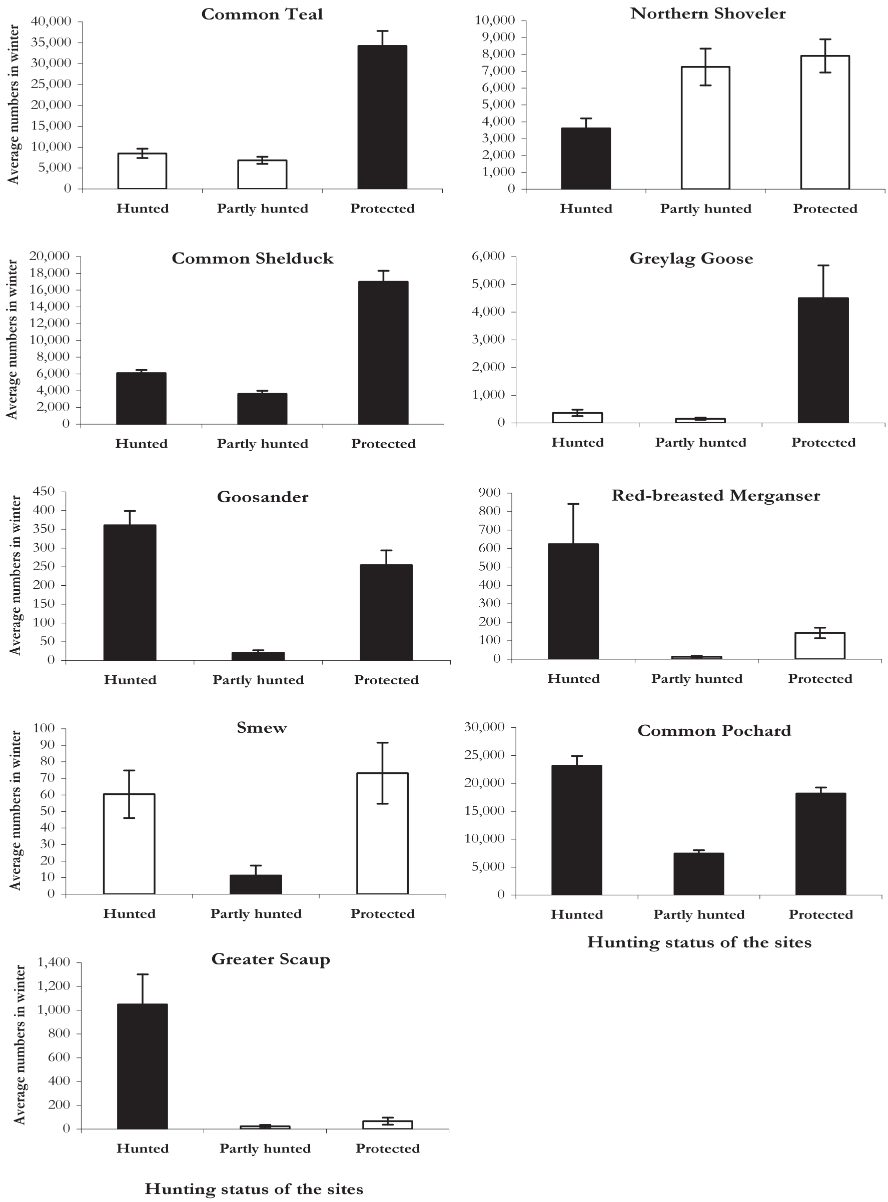

Figure 1. Average winter number of individuals in relation to the hunting status of the count sites for nine species with no significant year*hunting status interaction (*i.e.* trends in numbers over the years did not differ between the hunting status of the sites). Vertical bars show 95% confidence intervals. Black columns indicate where the number of birds at sites of different hunting status differed significantly in relation to one of the other two columns at $P = 0.01$ after Bonferroni-adjusted *t*-tests.

In all cases, there was also a significant effect of site hunting status. Thus both average numbers and also trends in numbers varied in relation to the hunting status of the sites (Fig. 2). Pintail and Wigeon were more numerous and showed more positive trends on fully protected sites than on hunted sites. Tundra Bean Goose was also more abundant on protected sites (where most birds actually were), but their numbers nonetheless showed a negative trend on those sites. Conversely, two protected species (Dark-bellied Brent Goose and Mute Swan) and three quarry species (Gadwall, Goldeneye and Tufted Duck) were more numerous on fully hunted sites. There was an increase in the trends in numbers at fully hunted sites for the three first species, but a decrease for the other two. Mallard and Coot were more numerous on fully hunted and fully protected sites than on partly protected ones. Trends in numbers were more favourable on fully hunted sites for Coot and on fully protected sites for Mallard.

Discussion

Most species of wildfowl and Coot wintering in France appear to have increased in numbers over the 21 years of this study. A comparison with the most recent IWC data for France (Deceuninck 2004) is not ideal because although the IWCs cover more sites they are limited to January only, and there is also a difference in the study periods (1983–2002 for French IWC data published to date; 1987–2008 for the present study). However, both studies indicate a decrease in the numbers of Tufted Duck and Greater Scaup wintering in France, and an increase in Common Shelduck, Gadwall, and Goosander. The French IWC data could not provide clear trends for the other *Anatidae* species wintering in France, due to large inter-annual fluctuations. The present scheme, which has made mid-month counts in December and February as well as in January since winter 1987/88, provides valuable additional information for improving the estimates of numbers wintering in France, thus making it possible to calculate trends for more species.

In general, the trends in winter numbers were similar (five species) or more favourable (eight species) in France than for the two biogeographical populations (Wetlands International 2006). The latest IWC data suggest, however, that most wintering *Anatidae* populations have increased in northwest Europe over the period 1996–2005 (Delany *et al.* unpubl. data), probably due to favourable environmental conditions on the birds' breeding grounds. Among the exceptions are Common Pochard, Goldeneye, Red-breasted Merganser and Goosander, whose populations appear to have declined (Delany *et al.* unpubl. data). These latest international results are in accordance with those of the present study, suggest that common processes are acting on these birds across the whole flyway, and indicate that numbers in France simply reflect trends at a broader geographic scale. Tufted Duck, Tundra Bean Goose and Greater Scaup, however, seem to have decreased in France but not at the population level. Conversely, numbers of Common Pochard have increased in France but decreased across Europe. In such cases, factors acting at the national level may

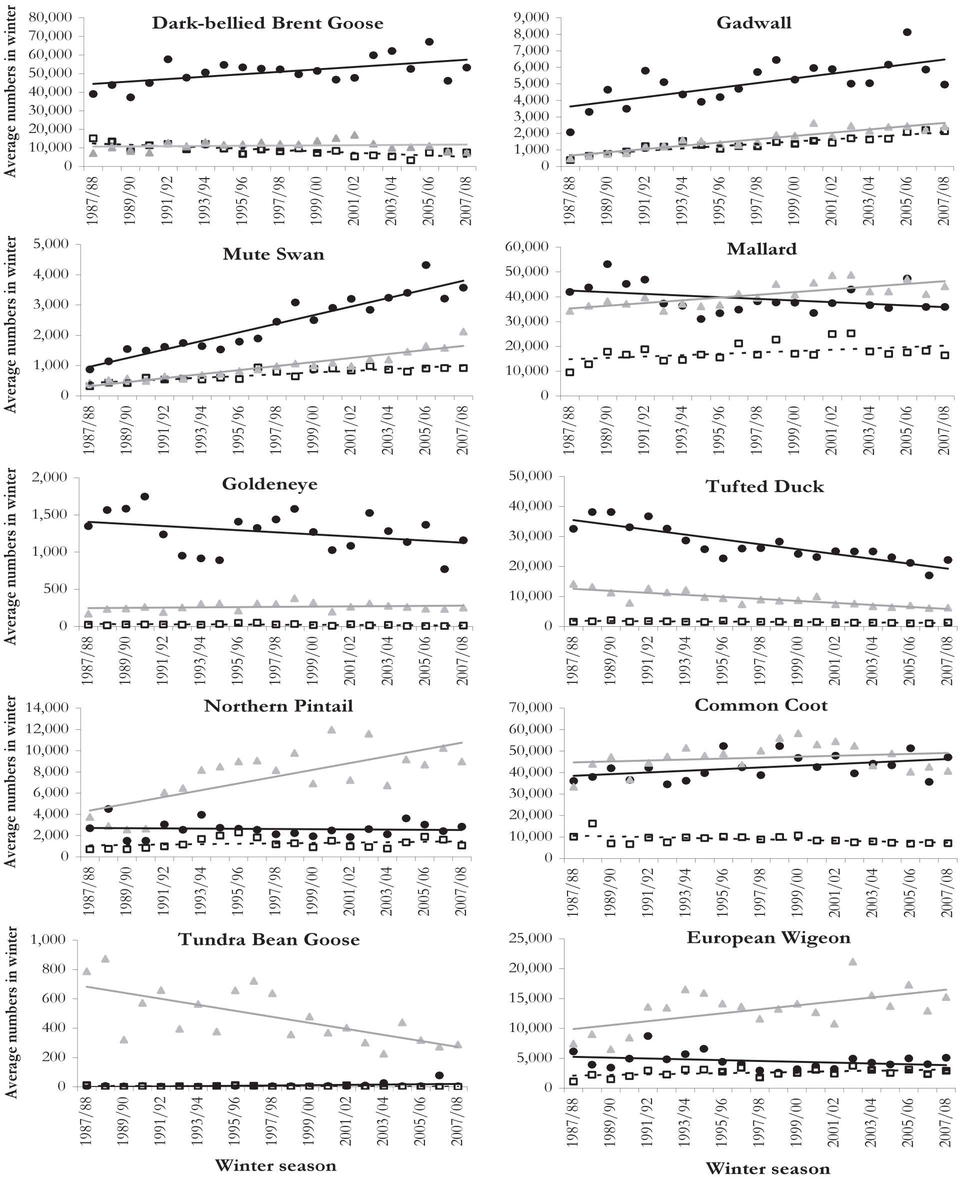

Figure 2. Average winter number of individuals in relation to the hunting status of count sites for the 10 species with a significant year*hunting status interaction (*i.e.* trends in numbers over the years varied in relation to the hunting status of the site). Fully hunted sites are indicated by black dots and plain black line. Partly hunted sites are indicated by white squares and dotted lines. Protected sites are indicated by grey triangles and grey lines.

explain such discrepancies, and the negative trends in France for the first three species should be taken as a signal to pay closer attention to the status of these species, including assessing the factors driving the decline in numbers within the country.

Linking trends in numbers to causal factors is generally difficult. The inclusion of environmental covariates in future analyses should provide further explanation of the variation in the count data, and should also improve the quality of trend indices computed by TRIM (Pannekoek & van Strien 2005). To date, no covariate has been found that would explain the trends in French waterbird numbers. In the present study, the hunting status of the sites did not explain the trends in waterbirds wintering in France because the trends in numbers did not show consistent patterns across species. Only some species (Wigeon, Pintail, Mallard, Tufted Duck, Goldeneye) increased, or increased more markedly, at fully protected sites than on hunted sites. It is not known if these species increased more markedly in protected areas because they are more susceptible to hunting disturbance. Although the hunting status of sites did not change during the study, the length of the hunting season has changed in the recent years. It is therefore possible that hunting activity may still have played a role in influencing trends in numbers, with some hunted sites perhaps being more attractive to wildfowl, particularly in February when the hunting season is now closed. Moreover, the number of hunters in France has decreased. Hunted sites therefore may have changed more than protected areas, which could at least partly explain the lack of a consistent effect of site hunting status, but this is difficult to quantify. Protected species did not always increase more at protected sites. These species may have been affected by other species-specific parameters. For example, the decline of the Greater Scaup and Red-breasted Merganser in France may be attributed to habitat degradation at unprotected marine sites, for instance where industrial development and intensive mussel farming is underway, which may influence their numbers elsewhere in the country (Fouque & Caizergues 2008). Including more biologically relevant covariates for each species therefore may be a valuable, but potentially difficult, task for future studies.

How trends in France link to trends recorded in other parts of the wintering range may be worth considering in further detail. For example, the decline in Tufted Duck wintering in France, which contrasts with its increase across Europe (BirdLife International 2004; Delany *et al.* unpubl. data), may indicate a northward shift in the species' wintering distribution. Similarly, the decline of the Tundra Bean Goose in France seems to coincide with its disappearance as a wintering species in Spain, most likely due to climatic change (Persson & Urdiales 1995). Changes in migration routes or migration dates may also explain observed trends in the bird count data. A change in the timing of migration is the most likely explanation for differences in the monthly trends in numbers recorded for Common Pochard wintering in France. Earlier analyses have shown that fewer Pochard have been recorded in early winter in recent years, but numbers in mid-winter are stable and late winter numbers are increasing, suggesting a delay in both the arrival and departure dates (Fouque *et al.* 2005b; Fouque *et al.* unpubl. data).

Overall, trend estimates are useful because they are often relatively easy to obtain, and can highlight potential conservation problems with a minimum of resources. However, standardisation of the methods used to monitor wildfowl (*e.g.* by making several counts each winter) and to calculate trends (*e.g.* by combining national TRIM indices) at the flyway scale could improve knowledge and diagnosis abilities, as proposed by van Strien *et al.* (2001) or applied in the UK (Austin 2004). This paper reports several differences between national and international trends in numbers, which provide a signal for studying in greater detail those species declining more markedly in France than elsewhere. It also calls for more coordinated research among ornithologists throughout the flyway.

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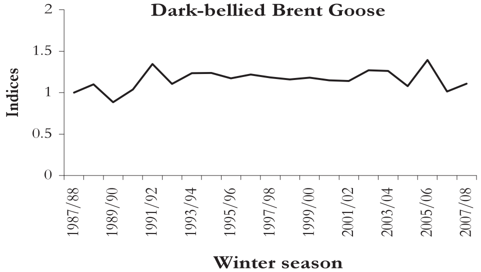
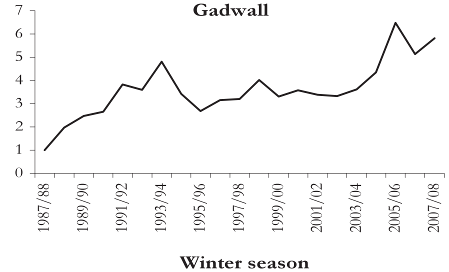
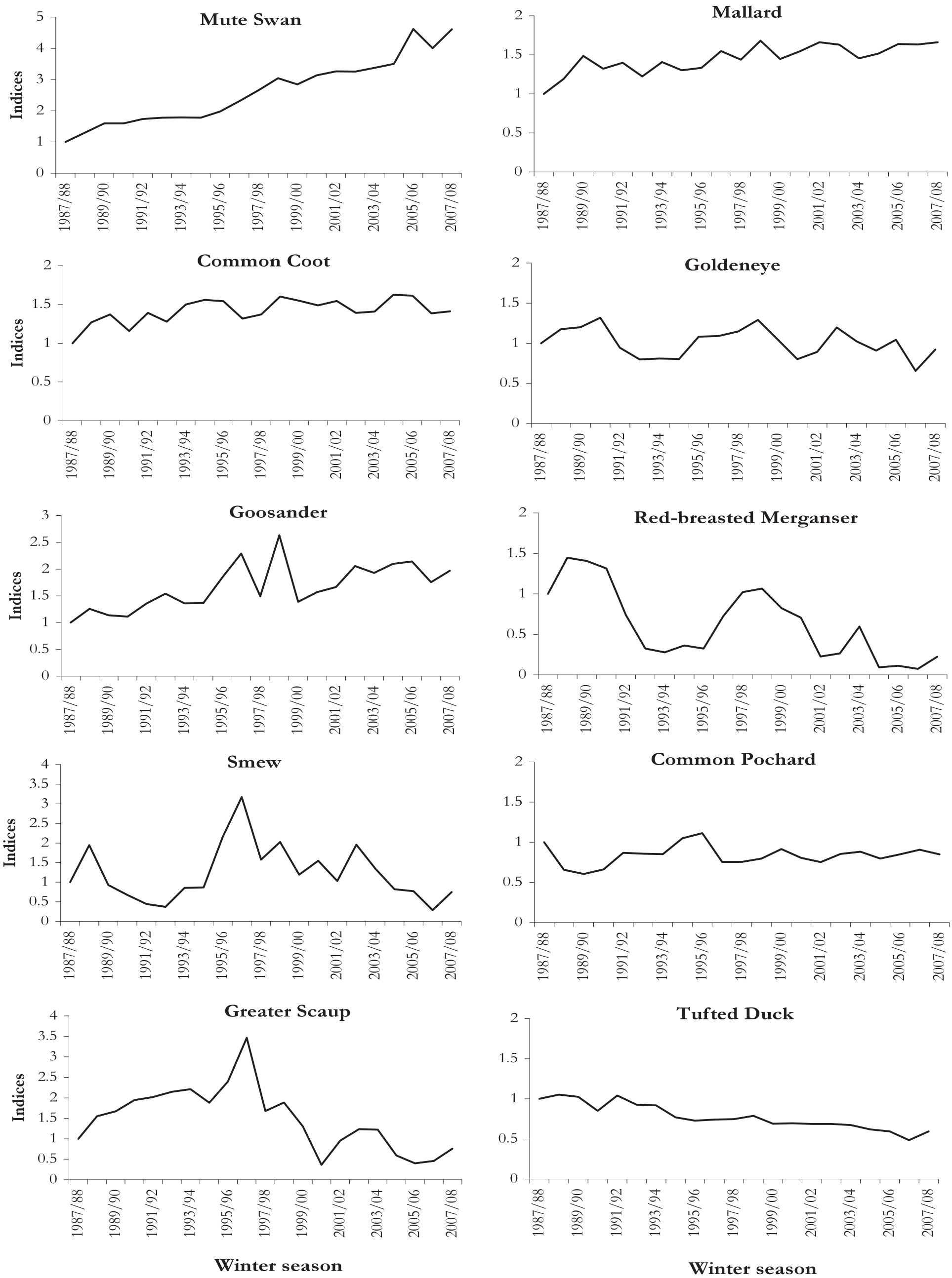
Appendix 1. Trends in numbers of Anatidae and Coot wintering in France from 1987/88 to 2007/08.





Appendix 1. (*continued*)



Appendix 1. (*continued*)