The future of wader monitoring on Europe's non-estuarine coasts

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Estimates of the sizes of wader populations need to be regularly updated as they provide the basis for flyway and site conservation, and likewise information on population trends is required to be able to identify priorities for action aimed at conserving these species' populations. Determining population estimates and trends entails the need for a more systematic approach to the survey of the internationally important numbers of waders that spend the non-breeding season on Europe's non-estuarine coasts. Here, we describe various approaches that can be used to gather the data required to generate population estimates and provide information on population trends, and we make the plea that the methods used to collect data across national boundaries should whenever possible generate directly comparable data. This is important as only with such data will it be possible to detect how wader populations are changing across their wintering quarters and to determine the broad-scale factors (for example, climate change) that might be driving any observed changes.

Introduction

Monitoring of wintering wader populations on Europe's non-estuarine coasts has been highly variable between countries, both in terms of spatial and temporal coverage and how results have been reported (Burton *et al*. 2008). Much of the non-estuarine coasts of Belgium (Devos 2008), the Netherlands (van Roomen *et al.* 2008) and Germany (Blew *et al.* 2008) are counted as part of the January International Waterbird Census (IWC) counts. In most other countries, monitoring of the coast has previously been limited away from estuaries and the number of waders wintering in non-estuarine habitat is poorly known. Clearly, due to the importance of non-estuarine habitats for waders, regular monitoring is essential to help update wader biogeographic population estimates and species' population trends.

In this chapter we suggest a strategy for the future monitoring of non-estuarine coasts and describe how the results of such surveys could contribute to wader conservation and research.

Existing monitoring of wader populations on Europe's non-estuarine coasts

As summarised in Burton *et al.* (2008), the overall European Non-Estuarine Waterbird Survey (Europe-NEWS) estimates will have underestimated the total numbers of individuals on European non-estuarine habitats, due to the omission of data from some key countries and in some instances the methodology used. There are no accurate estimates of the number of wintering waders on the non-estuarine habitats of many European countries including Finland, Estonia, Latvia, Lithuania, Russia (Baltic coast), Poland, Norway, the Faeroes, Iceland, the Channel Isles, the Mediterranean coast of France and the whole of the Mediterranean east of Croatia. The key omissions are Norway, Iceland and to a lesser extent, the Faeroes, which are likely to hold significant proportions of the Purple Sandpipers *Calidris maritima* wintering population in the East Atlantic (Burton *et al*. 2008). At present, relatively few other waders probably winter on the non-estuarine habitats of the other countries listed above. Nevertheless, given that recent work has shown that the winter distribution of waders in north-west Europe is moving northwards and eastwards along the winter isotherms (Rehfisch *et al*. 2004, Austin & Rehfisch 2005, Maclean *et al*. 2008), it is important that the Baltic, and northern European countries are counted in future.

The approaches used by different countries to estimate the sizes of non-estuarine wader populations and the present frequency of non-estuarine wader counts in each country that took part in Europe-NEWS are summarised in Table 1. In many cases, Europe-NEWS represented the first time that the sizes of the populations of waders wintering on the country's non-estuarine coast had been estimated. In only three cases – Belgium (Devos 2008), the Netherlands (van Roomen *et al.* 2008) and the UK (Rehfisch *et al.* 2003) – was it possible to determine trends in the numbers of waders wintering on non-estuarine coasts through comparison with data from previous surveys (Burton *et al.* 2008).

In this paper, we outline a vision for the future monitoring of the waders wintering on Europe's non-estuarine coasts, detailing the aims of such a scheme and the possible methodologies that could be used to achieve these aims. We then detail how surveys of the non-estuarine coast could contribute to wader conservation and research.

A vision for wader monitoring on Europe's non-estuarine coasts

To promote focused conservation and research, non-estuarine coasts should be counted frequently enough to allow changes in the national and flyway population size of each wader

Table 1. Approaches used by different countries to estimate the sizes of non-estuarine wader populations and the present frequency of non-estuarine wader counts in each country. Frequency of counts: 1 = complete or near complete annual counts, 2 = partial annual counts, 3 = occasional or non-systematic coverage, 4 = NEWS was the first attempt at widespread counts. (Summarised from: Blew *et al.* 2008, Colhoun *et al.* 2008, Cortes 2008, Deceuninck *et al.* 2008, Devos 2008, Hortas *et al.* 2008, Mendes *et al.* 2008, Nilsson 2008, Radović *et al.* 2008, Rehfisch *et al.* 2003, van Roomen *et al.* 2008, Soldatini *et al.* 2008, Thorup *et al.* 2008.)

Country	Frequency of counts	NEWS Coverage				
		Complete count	Statistical extrapolation		Expert extrapolation	Minimum estimate
			Random sampling	Pseudo-random sampling		
Belgium	1	✓				
Croatia	4				✓	
Denmark	3					✓
France	2					✓
Germany	2					✓
Gibraltar	4	✓				
Ireland	2		✓			
Italy	3				✓	
Netherlands	1	✓				
Portugal	4			✓		
Spain	3					✓
Sweden	3				✓	
UK / Isle of Man	2		✓			
Isle of Man	2		✓			

species to be identified with confidence, and robustly enough to allow association with large scale environmental change.

A strategy for wader monitoring on Europe's non-estuarine coasts

Aims

At the start of any monitoring scheme it is good practice to clearly define the scheme's aims. The non-estuarine coasts of Europe hold significant proportions of the biogeographic populations of several species of wader during the non-breeding season and, as stated by the Cadiz Declaration, there is evidence that globally nearly half of the populations of waders are in decline, possibly as a result of environmental change (Wader Study Group 2003, Stroud *et al*. 2004, 2006). As signatories to the Birds and Habitats Directives, European Union countries have an obligation to maintain the favourable conservation status of these species. To determine whether this obligation is being met requires monitoring of this important component of biodiversity that is sufficiently accurate, precise and frequent to detect any changes with statistical confidence. The gathering of such information is the basic need of any monitoring scheme. However, if changes in numbers are to be associated with possible causal factors, a greater monitoring effort may be required. At the very least, information on the local factors that could be affecting wader numbers (weather, habitat loss, disturbance, bait-digging and shellfisheries, dredging, etc.) will have to be collected either during the counts (e.g. bait-digging, human disturbance) or from other sources (e.g. weather records, long-term habitat loss). The really detailed studies necessary to understand population change can be very demanding. For instance, to understand the causes of numerical change may require the marking and subsequent recapture or resighting of marked birds to assess individual survival.

In this paper we assume that the two main aims of the monitoring are to provide the data needed to:

- provide regular estimates of the sizes of national (and thus potentially biogeographic) wader populations and,
- detect numerical change over pre-determined time periods.

Indices showing how populations change may be calculated from counts undertaken at a relatively few regularly-monitored (and representative) sites. However, confidence in the accuracy of such indices and the ability to estimate the sizes of the populations being monitored improves as coverage increases.

Species

All wader species should be counted. Counts of other waterbirds, such as grebes, wildfowl, terns, gulls and auks, are also presented in this volume in the accounts for Croatia-NEWS (Radović *et al.* 2008), Denmark-NEWS (Thorup *et al.* 2008), Italy-NEWS (Soldatini *et al*. 2008) and Sweden-NEWS (Nilsson 2008). During UK-NEWS, the presence of mammals including Otter *Lutra lutra* was recorded; at the time very little was known about their distribution in the habitat. However, care must be taken to ensure that the recording of additional species should not impinge on the effort directed towards obtaining reliable counts of the focus species, in this instance, waders.

Survey frequency

The non-estuarine population estimates provided in this volume typically required extensive coverage (of at least sample stretches of coast) and, for most countries, it would be unrealistic to expect such coverage to be obtained on an annual basis. In Belgium (Devos 2008) and the Netherlands (van Roomen *et al.* 2008), species' non-estuarine populations could be estimated annually, as most of the non-estuarine coastline in these countries is covered each year during IWC

counts. However, even with 3,000 enthusiastic volunteer counters, such a count frequency is presently not considered possible for the 13,000 km of non-estuarine coast of the United Kingdom, as it would lead to counter fatigue. A more realistic aspiration for many countries may thus be to carry out substantial surveys every three or six years, to coincide respectively with the need to update national and international (biogeographic) population estimates. It is clearly important that such estimates are robust enough to allow the detection of change.

If it is not possible to estimate the sizes of non-estuarine populations on an annual basis, annual indices showing how populations change may be calculated from counts undertaken at a relatively few regularly-monitored (and representative) sites. This may be possible by striving to include more non-estuarine coast into other regular monitoring programmes, as has occurred in Italy (Soldatini *et al.* 2008) and the UK (Rehfisch *et al.* 2003). If only a single visit is possible it should be timed to be as close to the January International Waterbird Count as possible may be feasible.

Survey coverage, accuracy and precision

For counts to be of value they must be accurate and precise enough to allow a significant change in population size to be detected, either through comparison of population estimates or from indices. In designing a monitoring scheme, data from past surveys can be used to determine the confidence with which a given pre-defined level of change would be detected. Thus reliable historical counts can be used to estimate the variation in wader densities on the non-estuarine coast of a country, information that can be used to estimate the count coverage required for a new survey (Bibby *et al*. 2000). The estimate of count coverage necessary can be improved by allowing for major differences in wader density on non-estuarine coast habitats, such as sandy beaches and rocky coast, and with longitude and latitude. As wader habitat preference and distribution vary considerably between species, it is likely that a compromise will have to be reached between the number of counters available and the precision of the population estimates and trends obtained for each species. It may be necessary to prioritise the population estimates and trends of some species over others. This process can rationally be guided by the relative global importance of the country in question for the various wader species; in Britain, for example, logically any new survey of the non-estuarine coasts could prioritise obtaining precise population estimates or indices for species such as Common Ringed Plover *Charadrius hiaticula*, Purple Sandpiper and Ruddy Turnstone *Arenaria interpres* (as the UK holds particularly significant proportions of these species' biogeographic populations: Rehfisch *et al*. 2003).

Survey design and estimation of species populations

Approaches taken by different countries in the European Non-Estuarine Coastal Waterbird Survey in estimating the sizes of wader populations are summarised in Table 1. If a complete census is not possible, it is generally best practice to concentrate counting effort in high density areas of coast and least effort in areas with few birds. Using a stratified sampling approach should lead to population estimates with narrower confidence intervals, making it more likely that any population changes can be detected. Some design options for surveys intending to provide population estimates or trends are listed below; in all cases it is assumed that the counts that make up the surveys have no counter error associated with them, and that the only error in the population estimate is due to incomplete sampling of the coast. The approach taken to design surveys that aim to produce waterbird trends, but not necessarily population estimates, is broadly similar to that used to generate population estimates; the most efficient design of such surveys tends to be based on randomised stratified coverage (see below).

i. Complete coverage (national or regional)

The best option if sufficient counters and financial resources are available. Even if a complete census is possible on a single occasion the information gathered will form a very useful baseline for the design of future randomised stratified surveys (see randomised stratified below). During Europe-NEWS, Belgium (Devos 2008) and the Netherlands (van Roomen *et al.* 2008) were able to obtain total survey coverage of their non-estuarine coasts (partly because of the relatively limited length of their coastlines).

ii. Randomised stratified coverage

If complete or near complete (baseline) count data already exist for the coastline to be surveyed, it is possible to determine how the likely accuracy of a planned survey would change as the proportion of the coastline surveyed increases. For a detailed description of randomised and stratified survey designs see Bibby *et al*. (2000). Put simply, the effect of relative coverage can be estimated by sampling without replacement, for example, the counts made on 5%, 10%, 20%, 30%, etc. of the coastline. The number of repetitions is chosen such that the median and 95% confidence limits correspond to a whole number of repetitions e.g. after sorting 119 repetitions by ascending population estimate, the median, lower and upper confidence limits correspond to the 60th, 5th & 114th ordered observations. This approach makes it possible to generate a distribution of the central population estimates with confidence limits that could be expected from a survey achieving coverage equivalent to that being simulated. The distribution of these estimates can be assessed by comparison to the real population estimate generated from the baseline data. The survey designer must then decide on the level of precision that is necessary for the new survey and then aim to get the required randomly selected proportion of the coast covered during the new survey. Such a survey will be said to have been based on randomised coverage.

If further information can be associated with the original baseline then the survey design can be based on randomised stratified coverage. Such surveys tend to be more efficient in resources than their non-stratified equivalents as most effort can be directed to the areas of the coast that hold most birds thus improving the accuracy of the survey per unit effort. Surveys can be stratified according to habitat (e.g. rocky or sandy shores), longitude and latitude, or other environmental factors that affect wader density, or practical issues that are important to the survey organiser such as the availability of counters in different areas of the coast. The approach is similar to that described above but the sampling without replacement is carried out for each stratum, the estimates for each stratum are then summed across all strata, and repeated a set number of times.

Whichever approach is used, the proportion of the coast covered increases the precision of the population estimates

generated by the final survey (Bibby *et al*. 2000). It is important to note that although this is probably the best approach to survey design, it is dependent on the bird distribution described by the original survey being representative of the present distribution. This may not be the case if birds are changing distribution rapidly with climate change (Austin & Rehfisch 2005, Rehfisch *et al*. 2004).

iii. Pseudo-random coverage

If a randomised or randomised stratified coverage survey of the coast is not possible, perhaps due to a combination of no reliable bird distribution information and few counters being available, a pseudo-random survey design may be considered. For example, a survey could aim to sample a proportion of the coast at intervals. Thus, the coast to be counted could be divided into a series of 100 km units, the first 10 km of which are counted. In this instance, the final estimate of bird numbers would be ten times the number of birds counted. Boot-strapped population estimates could be provided by sampling the counts with replacement. A survey can be described as pseudo-random when the reference used to select sites is believed to be unrelated to bird distribution.

This approach was used for Portugal-NEWS (Mendes *et al.* 2008) and was the initial survey design used for Spain-NEWS (Hortas *et al.* 2008; though population estimates were not extrapolated from these data, as they were considered too few). This approach is more likely to generate good numerical estimates if the birds are reasonably evenly distributed along the coastline. If the birds are concentrated on a few particularly attractive areas, the pseudo-random approach can give very misleading results according to whether the high density areas by chance are sampled more or less frequently than they occur in nature.

iv. Partial coverage

If the distributions of the study species are well known it may be possible to get very good population estimates by complete or partial surveys of those parts of the coast where they occur. In terms of counter effort this can be a very efficient way of generating good estimates of the numbers present, but it is good practice to sample at least a small randomly selected proportion of the coast where the species are not thought to occur just in case their distributions have changed.

Partial coverage may be the only option possible where few counters are available. In such a case the numbers of birds recorded are only likely to provide an estimate for the area covered. Unless the area covered is known to be representative of the wider region/country of interest it is poor practice to generate an estimate for the region/country by extrapolation.

How surveys of the non-estuarine coast can contribute to wader conservation and research

Europe-NEWS provides a useful baseline of counts for the non-estuarine coasts of much of Western Europe and will contribute towards updating national and biogeographic population estimates and the associated 1% thresholds used for identifying sites of national or international importance. The data that it has provided may also be used to identify stretches of non-estuarine coast worthy of designation as Special Protection Areas under the EC Birds Directive or under national designations.

Data from Europe-NEWS and future monitoring of the waders wintering on Europe's non-estuarine coast will be particularly valuable in determining the factors affecting their populations. This is particularly important given that the populations of many wader species are currently in decline (Stroud *et al*. 2004, 2006).

The observed changes in the wintering wader population on the non-estuarine coast and elsewhere could be due to a variety of factors. For example, lemming cycles on the northern breeding grounds of waders are associated with varying levels of nest predation and this has been linked to wader return rates to wintering grounds (Underhill *et al*. 1989), and the breeding performance of the waders that overwinter in Europe may have changed (Thorup 2006). Even though coverage has improved recently, the many species of wader recorded by Europe-NEWS that breed predominantly in areas such as Greenland, Fennoscandia, Siberia and Russia are poorly monitored on their breeding grounds and it could take a long time for declines in productivity to be noticed. In Europe, the breeding populations of Northern Lapwing *Vanellus vanellus*, Dunlin *Calidris alpina*, Common Snipe *Gallinago gallinago*, Black-tailed Godwit *Limosa limosa*, Eurasian Curlew *Numenius arquata* and Common Redshank *Tringa totanus* are probably declining (BirdLife International 2000/European Bird Census Council). Changes in the quality of the wintering grounds also could be affecting populations. Loss of intertidal habitat to human developments can lead to a decline in the survival of individual waders for several years (Burton *et al*. 2006). Decreasing amounts of nutrients entering into coastal waters as a result of the EC Bathing Water and Urban Waste Water Treatment Directives are resulting in a decline in the biomass of the invertebrate prey of some wader species and this may impact wader survival or site-fidelity and thus numbers (Burton *et al*. 2002, 2004, 2005, Burton & Goddard 2007). Shellfishery pressure on such species as Common Mussel *Mytilus edulis* and the Common Cockle *Cardium edule* has led to a decline in the survival of waders and a decrease in their numbers on individual sites (Camphuysen *et al*. 1996, Atkinson *et al*. 2003, 2005). In Britain, climate change is leading to an eastwards shift in the non-breeding distribution of estuarine waders along the winter isotherms, small species being most affected (Austin & Rehfisch 2005). NEWS and Winter Shorebird Count (WSC: Moser & Summers 1987) data have also revealed that an increase in winter temperatures in the UK between 1984/85 and 1997/98 has been associated with a predominantly eastwards and/or northwards shift in the distribution of non-estuarine coast waders (Rehfisch *et al*. 2004). A similar pattern can be seen across north-west Europe as a whole, with the non-breeding areas of waders shifting to the north and east as winter temperatures increase (Maclean *et al*. 2008).

Data from non-estuarine surveys, such as the UK's WSC (Summers *et al.* 1988) have previously been used to identify the habitat preferences of waders during the winter. Repeated surveys of the non-estuarine coasts are not essential to identify some of the past and future determinants of wader numbers as point in time studies of several sites can be used to associate wader numbers with a particular variable (van Impe 1985). However, repeated surveys may help associate factors such as the changing invertebrate biomass resulting from the implementation of the Urban Waste Water Treatment Directive, or increases in recreational or other disturbance, with wader declines, as the identifiable impacts of such changes might be delayed in such long-lived birds as waders. Furthermore, due to the wide wintering range of these species it is recommended that the work should be carried out at a wide spatial scale for it is most likely that the factors leading to population

change are multiple and may vary spatially. In conjunction with focused investigations, analyses of data from surveys of Europe's non-estuarine coast should help determine why several of Europe's internationally important populations of wader are declining, in particular those of Common Ringed Plover and Ruddy Turnstone (Wetlands International 2006). Regular surveys would also ensure that up-to-date information exists on the rapidly changing distribution of waders with climate change, and thus help guide conservation effort. The increasing rate of climate change (IPCC 2001a, 2001b, 2007) makes this particularly important, especially if conservation measures are going to be necessary to help birds adapt to the rapidly changing environmental conditions by improving the resilience of the habitats that their survival depends upon (e.g. Rehfisch 2007).

Recommendations

The results reported in this volume highlight the importance of Europe's non-estuarine coasts for wintering waders. The decline in numbers in many species of waders (Wader Study Group 2003, Stroud *et al*. 2004, 2006) makes it important that wader numbers are monitored at regular intervals on all their habitats including non-estuarine coasts. We therefore recommend the establishment of sound monitoring schemes, that generate data that are comparable across national borders. The capability to set up such monitoring schemes for waders wintering on non-estuarine coasts has increased in recent years, for example, because of the increased co-ordination and synchronization of existing waterbird count schemes (e.g. for estuarine waterbirds across the three Wadden Sea countries: *http://www.waddensea-secretariat.org/TMAP/Migratory_birds.html*) and because of improvements in the survey design of these schemes and approaches to assessing species' status. The establishment of non-estuarine monitoring schemes (ideally in conjunction with those in existence for estuarine waterbirds) would provide information on trends in wader populations and periodically provide systematic estimates of the numbers of waders wintering on the non-estuarine coasts of Europe. The data generated would contribute towards wader flyway and site conservation, and could be used to determine the effects of environmental change on wader populations. Good survey design should help ensure that progress towards the target of significantly reducing the rate of loss of biodiversity, made by world leaders at their 2002 global summit in Johannesburg, can be reliably assessed.

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