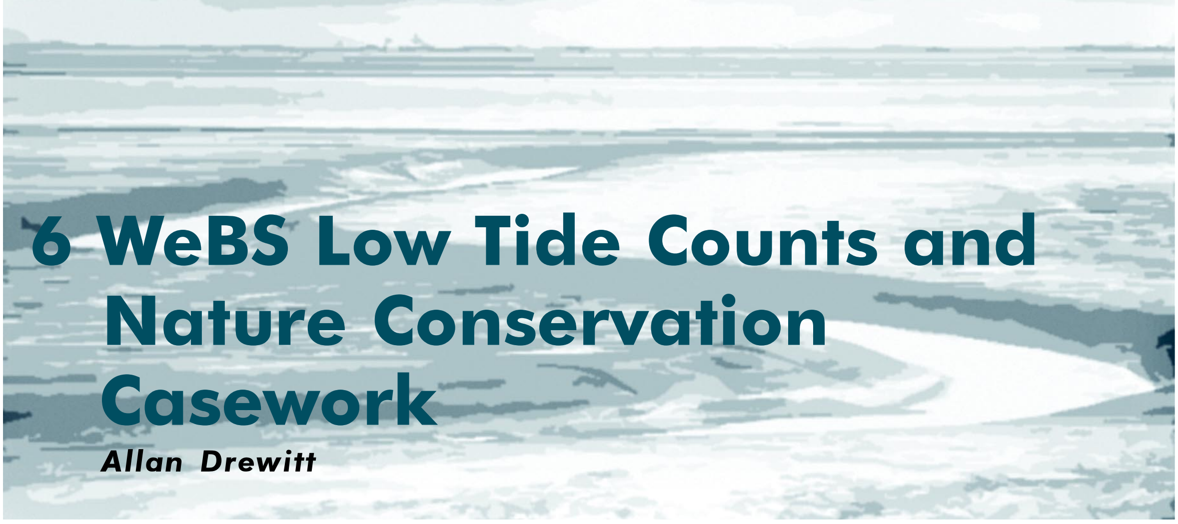

6 WeBS Low Tide Counts and Nature Conservation Casework

Allan Drewitt

INTRODUCTION

The great majority of wetland sites of national importance for non-breeding waterbirds have been designated under the Wildlife and Countryside Act 1981 as Sites of Special Scientific Interest (SSSIs) (in Northern Ireland as Areas of Special Scientific Interest (ASSIs) under the Wildlife (Northern Ireland) Order 1985). Those sites that support nationally important numbers of certain rare or vulnerable waterbirds and/or internationally important numbers of waterbirds may be further protected through designation under the EU Directive on the Conservation of Wild Birds (79/409/EEC) as Special Protection Areas (SPAs). Within SPAs, the UK Government is obliged to take necessary steps to avoid deterioration of natural habitats and disturbance of the species for which sites have been designated. Internationally important sites may also be designated as Ramsar sites under the Convention on Wetlands of International Importance 1971.

The protection afforded by SSSI status has recently been reinforced by the introduction of new legislation in England and Wales in the form of the Countryside and Rights of Way Act 2000 (referred to as the CRoW Act). Under the Wildlife & Countryside Act 1981, owners, occupiers and various other authorities with land management and maintenance duties must consult with the relevant conservation agency (English Nature, Countryside Council for Wales and Scottish Natural Heritage) before undertaking, or permitting to undertake, activities that may harm the special interest of these sites. Under CRoW, the conservation agencies in England and Wales may then withhold consent or, if necessary, secure the appropriate management of an SSSI through a management scheme.

The designation of a wetland site as an SPA confers even stronger protection under The Conservation (Natural Habitats, &c.) Regulations 1994, commonly known as the Habitats Regulations. These regulations have transposed the requirements of the EC Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (known as the Habitats Directive) into national law. They build on existing national nature conservation legislation for the protection of habitats and species and apply the specific provisions of the Habitats Directive to SPAs.

Under the Regulations, any activity requiring a formal consent or licence, which is not necessary for the management of the site but is likely to have a significant effect upon its international interest, must be subject to an 'appropriate assessment' of its implications for the site. So, for example, if a potential developer puts forward a planning application that would, if granted consent, have a significant effect on non-breeding waterbirds within an SPA, then the planning authority must carry out an appropriate assessment of the implications of the proposed development for the site. In carrying out the appropriate assessment, the planning authority must consult with the relevant statutory nature conservation body and have regard to any representations made by that body.

Importantly, a planning authority can only consent to a proposed development if the appropriate assessment determines that it will not adversely affect the integrity (ecological structure and function) of the SPA. Thus the onus is on the developer to show that its proposals will not damage an SPA, rather than on the conservation agencies and planning authority to argue that damage would be caused. If it cannot be ascertained that a site will not suffer an adverse effect then a development can proceed only if there are 'no alternative solutions' and if it is necessary for 'reasons (social, economic, public health and safety or environmental) of overriding public interest'.

THE ROLE OF LOW TIDE COUNTS IN SITE PROTECTION

Low tide data have been used to manage and safeguard both SSSIs and SPAs. However, as the vast majority of waterbird SSSIs, especially on the coast, are within SPAs, and because the legislation protecting SPAs is more powerful than that protecting SSSIs, the following account will focus on the application of low tide counts for the protection of SPAs.

The determination of whether or not a proposed development is likely to have a significant effect on the waterbirds using an SPA should be based on the best *available* information. Firstly, it is important to establish if the habitats that support the bird populations for which the SPA has been designated are likely to be affected, either directly or indirectly, or if the birds themselves are likely to be affected. Amongst other information it is often important to have details on the distribution of different species within the site, including locations of concentrations of birds that may be particularly sensitive to disturbance (for example, key feeding, roosting or nesting areas) and the time of year when birds are present.

On many SPAs, especially coastal sites, this information is readily available in the form of WeBS data. However, although WeBS core count data are often useful in identifying the presence and numbers of different species, they provide limited information on the way in which birds use habitats within a site. This is because core counts are normally undertaken around high tide when birds are generally roosting and are concentrated into small areas of the upper shore or sometimes even outside the SPA on adjacent farmland. If additional information is needed on the location of birds within the site, especially to assess the importance of intertidal habitats for feeding birds, then the low tide data are of critical importance. Often the two datasets can be used together: the core count data can be used to show the longer-term use of a site by particular species, generally over the most recent five winters (to allow assessment of *regularity* of use), whereas the low tide data, although collected over a shorter period, can give more precise distributional information.

In many cases the establishment of the presence of waterbirds, either feeding or roosting, within the area of an SPA likely to be affected by a proposed development, will be sufficient to require a fuller assessment of the implications of a project under the Habitats Regulations. This is particularly important when the proposal is more likely to result in disturbance to birds, rather than the loss, damage or deterioration of their habitats. Generally, the effects of habitat loss or damage are easier to assess than the less tangible effects of disturbance. Although disturbance is considered to be less serious than habitat loss, mainly because it may have only a temporary impact and does not directly affect the physical condition of a site, it is nevertheless an important consideration and is explicitly identified as an issue for concern in the European Directives.

Once the decision has been reached that an activity is likely to have a significant effect on an SPA, it is then necessary to carry out a more detailed assessment of the implications of a proposal for the site's important waterbird populations. This will include the extent and proportion of the habitats affected and the proportion of the population of individual species that would be affected. If disturbance is likely to be a significant issue, it would be important, as well as seeking information on the intensity, duration and frequency of repetition of the disturbance, to assess the numbers of birds that could be affected. Once again low tide data can help provide this detailed information.

MITIGATION AND COMPENSATION

In the context of site protection, mitigation includes measures which are put in place to reduce the impact of an activity on habitats and bird populations. Compensation is the creation of new habitats (usually outside the designated site) to replace those lost as a result of an activity. Low tide data are not only important when assessing the potential impacts upon a site, they are also valuable when considering the potential effectiveness of any mitigation or compensatory measures that accompany development proposals.

With regard to mitigation measures, information on the distribution and activities (roosting or feeding) of waterbirds on a site can help identify measures which may largely offset the impacts of a proposal. In particular, low tide and core count data may help when considering the following issues:

- *the creation or enhancement of habitats within the affected site, including the reduction of disturbance through the creation of refuges;*
- *adjustments to the timing of activities or operations to avoid particularly sensitive periods, for example the period of high tide if roosts would be affected, or breeding vs non-breeding periods;*

- *the positioning of acoustic and visual screening and shielding of light sources to reduce disturbance effects in key feeding and roosting areas;*
- *the need to control access for works personnel during construction, and members of the public following completion if new roads or floodbanks are created;*
- *the restoration of habitats following completion of works.*

Turning to the creation of replacement habitats, it is essential that any compensatory measures designed to accommodate a displaced population of birds should be on a 'like for like' and *at least* an 'area for area' basis. Any replacement habitat should be as similar as possible to that which has been adversely affected. Thus, in the context of feeding waterbirds, it will be important to consider sediment type, tidal range and exposure times, shelter from adverse weather, levels of disturbance and the proximity of suitable roosting areas. Compensatory habitat should be in place and in a suitable condition before the commencement of the development, so that it is immediately available to birds that are displaced. Another criterion for the success of any compensation scheme is that it supports at least the same number of birds as are found on the area due to be lost to development, and that the species composition of this group of birds is similar. Otherwise, the special interest features for which the SPA was designated will be diminished.

MONITORING

A critical requirement for any development, particularly those that incorporate mitigation or compensation, is appropriate monitoring to determine the effectiveness of mitigation or compensation measures and whether any adverse effects take place. Once again, both low tide and core count data are invaluable. The core count data will allow some assessment of effects at the overall site level. However, more precise data on the use of particular mudflats, on or adjoining the development site, or on the use of an area of compensatory habitat, will be of much greater value. In these cases the existing low tide data can provide a useful baseline. Follow up monitoring can then be undertaken by the developer using the WeBS methodology, with the potential addition of more detailed studies.

As stated above, an important test of the success or otherwise of compensatory habitats is an assessment of subsequent bird usage. Thus, in order to establish the success of such compensation, it would be necessary to carry out long-term monitoring of both habitat quality and bird numbers. Appropriate contingency measures should also be agreed in advance in case the primary compensation project fails to deliver its objectives.

CASE STUDIES

In order to gain a better understanding of how low tide count data can be used for assessing possible land-use changes in designated sites, two case studies are set out below: Dibden Bay in Southampton Water and Rock Ferry in the Mersey Estuary. The former is an example of potential habitat loss within an SPA and the latter an example of potential habitat loss and disturbance affecting an area of intertidal mud adjacent to an SPA.

Dibden Bay, Southampton Water

A planning application to build a container terminal on an area of intertidal foreshore and associated grassland in Southampton Water was made in 2000. The development would result in the almost total loss of Dibden foreshore including 42 hectares within the Solent and Southampton Water SPA/Ramsar site. It was estimated that the loss of Dibden foreshore would reduce the extent of the intertidal mud in Southampton Water by 4.6% and in the SPA/Ramsar site by 2.0%. In addition to the loss of intertidal habitat, there would be a loss of 250 hectares of grassland on an area of reclaimed marsh behind the foreshore, which is an important habitat for feeding wildfowl from Southampton Water. The application included a package of measures intended to offset the damage caused by the development, including the creation of an intertidal creek and adjacent freshwater habitat, and the capping of an existing area of allegedly contaminated mudflat.

English Nature and RSPB objected to the application on the basis that the project would result in a net loss of habitat within and adjacent to the Solent and Southampton Water SPA/Ramsar site and that this was likely to have a harmful effect on the internationally important waterbird populations. An appropriate assessment of the project was undertaken by the local authority and this concluded that, because of various mitigation measures including the creation of a new intertidal habitat, there would be no significant adverse effect on the SPA/Ramsar site. At the time of writing, the case remains unresolved and the outcome of a long-running Public Inquiry is awaited. Low tide count data for Southampton Water have played a vital part in the assessment of the impact of this development and their application in this case is described below.

The Solent and Southampton Water SPA/Ramsar site is designated for internationally important non-breeding populations of Dark-bellied Brent Goose, Teal, Ringed Plover and Black-tailed Godwit, as well as an assemblage of over 50,000 non-breeding waterbirds. The SPA is of additional importance for nationally important breeding populations of five species of gulls and terns (Stroud *et al.* 2001). The 1.5 kilometre stretch of Dibden foreshore supports a wide range of waterbirds, including Brent Goose, Shelduck, Oystercatcher, Ringed Plover, Grey Plover, Dunlin, Curlew and Redshank along with Red-breasted Merganser and Great Crested Grebe using the nearby shallow water.

A consistent set of low tide data has been collected annually in Southampton Water since the winter of 1995–96, around the time when the Dibden Terminal was first proposed. These data, along with the WeBS core counts, have been used to assess the importance of Dibden foreshore in the context of Southampton Water and the wider Solent and Southampton Water SPA/Ramsar site. The technique applied in this case was to take the peak low tide count recorded for each species during each winter (November to February) and to calculate peak means for the six-year period 1995–96 to 2000–01. A five-year period is usually considered to be sufficient to calculate a reliable peak mean. In this case, however, it was sensible to use all the available data. A peak mean derived from a number of years serves to 'smooth' annual fluctuations giving a reasonable representation of the peak numbers that are likely to occur in any given year.

The peak, rather than the average, count in each winter was used to better reflect the totals of birds using the site. This approach makes some allowance for the fact that counts will tend to underestimate the true numbers of birds that use a particular area. This is because counts represent only a 'snapshot' of bird usage during a few hours on a single day each month. The likelihood of such a snapshot occurring on the day when peak numbers of birds are present during a particular month is remote, and thus the real importance of an area in terms of the numbers of birds it supports will be underestimated. Furthermore, a single count takes no account of the turnover of birds present. Turnover is a major factor in autumn and spring migration periods, but continues during the winter, albeit at a lower level. Although using the peak mean does not address the issue of turnover, it does reduce the degree of underestimation of bird numbers in general terms. Thus, it is considered that averaging winter peak counts gives a better indication of bird use over time than averaging the mean winter counts.

Having calculated a peak mean for each species that regularly uses the foreshore, these figures were then expressed as a percentage of the total estimated populations for Southampton Water and the SPA/Ramsar site. The results of this comparison are given in Table 6.1.

This simple analysis shows that Dibden foreshore is more important for certain species than it is for others. For many species, Table 6.1 shows that Dibden foreshore supports a significant proportion of the total SPA population. In particular, for many species the Dibden foreshore supports a higher proportion of the population of Southampton Water or the SPA/Ramsar site than would be expected, given its size. For example, Dibden Bay is considered to represent 2% of the area of the SPA/Ramsar site but it supports more than 2% of the population of 11 of the tabulated species (indeed, ten times this value for Goldeneye and Oystercatcher).

Another approach taken to describe the importance of Dibden foreshore was to compare the densities of birds present at low tide with densities recorded elsewhere within Southampton Water. This provided some information on the quality of the intertidal habitat both in terms of the availability of invertebrate food for feeding birds and as a loafing or roosting area. Once again, the peak mean numbers have been used to calculate densities. The densities present at Dibden foreshore can then be compared with the densities present in Southampton Water overall, as shown in Table 6.2.

It can be seen that, although Dibden foreshore is not particularly densely occupied by wildfowl at low tide in the context of Southampton Water, it is clearly of outstanding importance as a habitat for waders, supporting almost four times the average Southampton Water density at low tide. Within this group, the relative importance of Dibden for Oystercatcher, Grey Plover, Dunlin and Curlew is particularly striking.

Both of the above analyses of low tide count data provide contextual information for evaluating the importance of the Dibden foreshore within the larger SPA/Ramsar site. In this particular case, the judgement on whether the loss of Dibden foreshore, when weighed against the proposed offsetting measures, would amount to an adverse effect on the SPA/Ramsar site will be made by the Public Inquiry.

Table 6.1: **Peak mean waterbird numbers using Dibden foreshore or adjacent shallow water at low tide during the winters 1995–96 to 2000–01, along with the proportions present of the population of Southampton Water and of the Solent and Southampton Water SPA/Ramsar site. Species in** blue bold **occur on the SPA/Ramsar site in internationally important numbers. All other species are components of the internationally important waterbird assemblage. It should be noted that totals are derived from the single highest count of all wildfowl, waders and waterbirds respectively, and not the sum of individual species peaks (Dibden Bay data provided by Associated British Ports, Southampton).**

Species	Mean LTC peak	% Southampton Water	% SPA/Ramsar
Great Crested Grebe	16	18.2	11.7
Cormorant	8	5.0	3.8
Dark-bellied Brent Goose	**83**	**4.8**	**1.2**
Shelduck	10	3.9	0.8
Wigeon	12	0.6	0.2
Goldeneye	11	68.8	20.0
Red-breasted Merganser	5	13.5	3.5
Oystercatcher	291	21.8	20.2
Ringed Plover	**19**	**12.5**	**4.7**
Grey Plover	95	26.8	7.6
Lapwing	21	1.4	0.3
Dunlin	880	14.6	7.2
Black-tailed Godwit	**1**	**0.8**	**0.1**
Curlew	121	18.5	6.7
Redshank	30	6.2	2.8
Turnstone	31	12.5	8.9
Total wildfowl	120	2.2	0.5
Total waders	1415	13.8	5.4
Total waterbirds	1514	9.7	3.1

Table 6.2 (right): **Peak mean densities, in birds per hectare, of selected waterbird species using Dibden foreshore and Southampton Water as a whole at low tide during the winters 1995–96 to 2000–01. Species in** blue bold **occur on the SPA/Ramsar site in internationally important numbers. All other species are components of the internationally important waterbird assemblage (Dibden Bay data provided by Associated British Ports, Southampton).**

Species	Mean density at Dibden Bay	Mean density in Southampton Water
Dark-bellied Brent Goose	1.56	1.49
Shelduck	0.19	0.22
Wigeon	0.22	1.69
Oystercatcher	5.49	1.16
Ringed Plover	0.35	0.13
Grey Plover	1.79	0.31
Lapwing	0.40	1.27
Dunlin	16.60	5.26
Black-tailed Godwit	0.01	0.12
Curlew	2.28	0.57
Redshank	0.56	0.42
Turnstone	0.58	0.22
Total wildfowl	2.86	4.72
Total waders	33.69	8.95
Total waterbirds	36.05	13.56

Rock Ferry, Mersey Estuary

This case involves an application made during 2000 to create a 'marine lake' in the Mersey Estuary on an area of intertidal mudflat known as Rock Ferry. Although it was not an SSSI at the time, it was considered that the development of this area of intertidal habitat would have a significant effect on the bird populations of the adjacent Mersey Estuary SPA/Ramsar site, and so an appropriate assessment was carried out by the local authority according to the Habitats Regulations. Once again, low tide count data were used to assess the implications of the proposal.

The appropriate assessment presented low tide data for the winters of 1994–95 to 1998–99 in the form of peak means for the Rock Ferry foreshore. These are summarized below in Table 6.3 for the most numerous, regularly occurring species.

These data clearly identified Rock Ferry as an important area of intertidal habitat for feeding waterbirds, especially for Pintail and Black-tailed Godwit for which numbers exceed the national importance thresholds. However, the appropriate assessment undertaken for the local authority concluded that the loss of habitat resulting from the development would be unlikely to reduce the value of this area for feeding birds to the point where it would affect the SPA/Ramsar site. The reasoning behind this conclusion was that the development would largely avoid the preferred areas of the Rock Ferry foreshore, and that the remainder of the area would remain available to feeding birds.

To illustrate this point, further low tide count data were provided for the individual count sectors of Rock Ferry. The Rock Ferry foreshore is divided into three sectors for the purposes of the low tide count and the data for *average* numbers of birds are given for each sector in Table 6.4.

The marina lake would result in the loss of two-thirds of sector 3 and most of the upper shore of sector 4. Sector 5 (the smallest sector) would remain intact. Although Sector 5 is the most important sector for the largest number of species, it can be seen that Sector 3 holds notable

Table 6.3: **Peak low tide counts at Rock Ferry during the winters 1994–95 to 1998–99. Species in blue bold are those for which the five-year peak mean numbers exceeded their national 1% thresholds values (Young Associates 2000).**

Species	1994-5	1995-6	1996-7	1997-98	1998-9	five-year peak mean	% of national population
Shelduck	130	170	20	278	193	158	0.2
Pintail	**100**	**120**	**230**	**464**	**555**	**294**	**1.1**
Ringed Plover	270	350	200	48	140	202	0.7
Knot	650	300	1000	595	1020	713	0.2
Dunlin	500	450	1825	120	8910	2361	0.4
Black-tailed Godwit	**7**	**40**	**150**	**4**	**587**	**158**	**2.3**
Redshank	1500	750	341	607	757	791	0.7
Turnstone	4	70	100	10	250	87	0.1

Species	Sector 3	Sector 4	Sector 5
Shelduck	10	8	68
Wigeon	3	0	12
Teal	11	9	70
Pintail	28	19	169
Oystercatcher	54	20	14
Ringed Plover	3	10	13
Grey Plover	2	1	1
Knot	41	281	129
Dunlin	610	171	226
Black-tailed Godwit	14	50	107
Bar-tailed Godwit	2	1	0
Curlew	8	3	14
Redshank	216	102	196
Turnstone	8	4	1

Table 6.4 (right): **Average number of birds present in each count sector at Rock Ferry, 1996–97 to 1999–2000 (Young Associates 2000).**

numbers of Oystercatcher, Dunlin and Redshank and Sector 4 holds the highest numbers of Knot.

The appropriate assessment put forward several proposals aimed at preserving the quality of the remaining area as a feeding habitat. These included restrictions to the timing of construction work, so that potentially disturbing activities would be undertaken outside the winter period. It was also recommended that public access to the retaining wall of the marina should be prevented during November to February, again to avoid disturbance to feeding birds.

English Nature and RSPB did not support the conclusions of the appropriate assessment and maintained its objection to the project on the basis of the low tide data. The data indicated that the loss of a substantial proportion of Sectors 3 and 4, although not directly affecting the nationally important numbers of Pintail and Black-tailed Godwit to a significant extent, would result in a considerable displacement of other species. Furthermore, it was felt that the quality of the remaining foreshore would be impaired by the proximity of a high retaining wall (thus reducing visibility for feeding birds) and by an unavoidable increase in disturbance from people using the marina lake. It was considered that because most, if not all, of the birds present on Rock Ferry were likely to be part of the Mersey SPA/Ramsar site population, the displacement of birds from this mudflat would place more pressure on feeding habitat within the SPA/Ramsar site, especially at times of peak numbers. This might have resulted in birds moving away from the Mersey, thus reducing the size of the SPA/Ramsar site population.

Following the objections of English Nature and RSPB, and the proposal to designate Rock Ferry as an SSSI, the developers have withdrawn the application for the project. Rock Ferry is now an SSSI and has been proposed as an extension to the Mersey Estuary SPA/Ramsar site.

CONCLUSIONS

These case studies clearly illustrate the great importance of low tide count data to the work of the nature conservation agencies and non-governmental conservation bodies. In combination with the core counts, these data are invaluable for the identification of accurate and ecologically sensible boundaries for the designation of SSSIs and SPAs. Low tide data are also of enormous importance when making assessments of the potential impact of management changes or habitat loss as a result of proposed developments. Finally, they are also necessary to assist the design, implementation and assessment of effective mitigation measures or compensation for harmful impacts. For these reasons it is essential that low tide data are collected across as wide an area of intertidal habitat as possible, not only within existing SSSIs and SPAs, but also elsewhere in areas that may be of sufficient importance to warrant designation in the future.

7 Discussion

Andy Musgrove and Niall Burton

This book describes a scheme that has been extremely successful in achieving its aims so far. This success is largely due to the dedicated and highly skilled team of 600 volunteer counters and the local organisers who have co-ordinated the counts at a site level. Without them, only a small fraction of the information could have been obtained and the prospects for the conservation of estuarine waterbirds would be greatly reduced.

COVERAGE

During the period covered by this book, the winters 1992–93 to 1998–99, LTCs were carried out at 62 estuarine sites around the UK. These sites were subdivided into almost 2,000 count sections, to which over 10,000 visits were made. Overall, almost nine million bird records were collected. This represents an unprecedented level of information on low tide bird distribution. Moreover, the scheme has continued in years subsequent to those reported upon here, thus adding further value to the dataset.

All of the species most specialised to estuarine habitats were well monitored by the LTCs, as were many more widespread waterbird species also present on estuaries. Intertidal flats were readily surveyed, although saltmarshes proved problematic at times. This is not a problem that can be easily overcome by a volunteer-based survey, due to the difficult and potentially hazardous nature of the terrain. However, there may be occasions when one-off surveys of saltmarshes by professional staff could provide useful information, as was seen on the North Norfolk Coast, for example; a professional fieldworker attempted to walk within 100m of every point within the saltmarshes there, revealing much higher numbers of some species than had been previously observed (M. Rooney pers. comm.). Offshore species which were not too distant were generally well-recorded by the scheme whilst nontidal habitats adjacent to estuaries were included in counts to a varying degree on a site-by-site basis.

The counting of gulls was optional throughout the survey, as it has been with WeBS Core Counts. The interpretation of the resulting gull data therefore requires care. However, Table 2 shows that these are clearly an important component of the estuarine bird assemblage. Whilst recording gulls at some sites can cause difficulties for counters, every encouragement should be given to do so in the future. In situations where counters feel that the recording of gulls would detract from the recording of other waterbirds, some indication of the order of magnitude of the number of gulls present on the section would be very helpful.

INTERPRETATION

The LTCs provide an excellent picture of the distribution of estuarine waterbirds at low tide during the winter. Whilst there are a number of interpretative issues to bear in mind, the consistent methods by which the LTCs are carried out ensure that bird distributions can be well-defined and valid comparisons can be made. It is reasonable to ask, however, to what degree the LTCs can be regarded as representative in a wider sense. For example, LTCs were seen to be most often carried out at weekends; to what extent has this affected the recorded distributions? Similarly, to what extent can LTCs recorded during the day be assumed to be representative of the night-time distribution of birds on intertidal habitats? Clearly, this will vary on a case-by-case basis and will depend upon the underlying reasons influencing bird distribution at a site. In particular, if bird distribution is affected by human recreational disturbance, often there will be a difference in the intensity of the latter between weekends and weekdays (or between night and day). Research into the impacts of man-made landscape features on estuarine waterbirds at low tide showed that the numbers of six species were significantly reduced by the presence of a footpath close to a count section and that whilst this effect was highly significant at weekends, it was much less distinct on weekdays (Burton *et al.* 2002b). Similarly, a study of the Cotswold Water Park looked at the differences between waterbird counts made on weekends and weekdays and concluded that the distribution within the complex did vary between the two (Kershaw 1997). Further investigation of the differences between weekend and weekday distributions would be of value.

How closely do distributions recorded in the winter represent those found at other times of the year? Although relatively few birds are present on estuaries during the summer, many pass through the UK in the autumn and spring. Whilst some characteristics of parts of estuaries remain much the same throughout the year (*e.g.* substrate, tidal regime), others may vary (*e.g.* relative abundance of prey, disturbance, competition and predation). As the LTCs have been confined to the mid-winter period to date, it is difficult to speculate. However, at the Humber Estuary, a series of low tide counts were undertaken throughout a whole year, from September 1998 to August 1999 (Catley 2000). For some species, relative distribution was similar throughout the year, but for others, notable differences occurred. Further work during other periods of the year would be a potentially useful development of the scheme, especially at those sites that are of particular importance for birds on passage.

At most sites, the WeBS LTCs are not undertaken annually but about once every six years. It is reasonable to consider how well distributions recorded in one winter represent those in another. Fortunately, at a number of sites counts have been undertaken more frequently, enabling some level of appreciation of this issue. Experience shows that distributions do change to some extent but that broad-scale distributional patterns are frequently maintained between years. The issue is thus one of the degree of consistency of distributions. However, it is not straightforward to define the manner in which distributions should be compared between years; what is a 'similar' distribution and what is a 'different' one? It may be possible to undertake a broad descriptive overview by a simple visual inspection of mapped distributions, especially for clearly clumped distributions. However, such subjective comparisons may not be suitable in a scientific or legal context and are also less straightforward for assessing more subtle gradations in density across a site. The issue of carrying out such spatial analyses is one which WeBS is keen to tackle in the future.

From a preliminary examination of distributions in different years, it appears that distributions recorded at low tide in a single winter are fairly reliable predictors of longer-term distributions. Particular exceptions are likely, however, where major year-to-year changes occur as a result of highly variable food sources, such as cockles (Atkinson *et al.* in press, Norris *et al.* 1998, Piersma *et al.* 2001). Given the relatively short span of the dataset to date, it would be sensible to revisit this issue in the future when longer runs of data are available for sites. Determining the amount to be gained by collecting additional data will be of great value in ensuring that counter time and effort is utilised as efficiently as possible. Further work should lead to a closer understanding of the factors determining which species are more mobile and at which sites such mobility is greater or lesser.

Finally, the WeBS LTCs are restricted to the period within two hours either side of low tide. However, most estuarine waterbirds also feed at other stages of the tidal cycle. To what extent do the broad distributions recorded at low tide represent the relative importance of parts of a site through the wider tidal cycle? Analogous to this question are the potential similarities and differences in low tide distribution occurring at neap and spring low tides. Clearly, the most complete understanding of the usage of the site by estuarine waterbirds would be achieved by monitoring continuously throughout the tidal cycles. However, as the LTCs are intended as a broad-scale approach to gathering baseline data, it has not been considered reasonable to ask volunteer observers to carry out such intensive monitoring.

The issue has, however, been investigated by Burton *et al.* (in prep.). Waterbird count data from six UK intertidal study sites were analysed to determine whether or not the numbers of birds using these areas changed across the tidal cycle. Additional analyses investigated the required frequency of counts to be undertaken to detect changes in numbers through the tidal cycle and whether low tide counts were representative of the average numbers of birds using a site. Comparison of counts undertaken at low tide and those across the rest of the tidal cycle suggested that low tide counts were representative of the average usage of the study sites in 75% of cases.

There was considerable variation between species and sites and thus it was difficult to produce recommendations about the minimum frequency at which counts would need to be undertaken across the tidal cycle to detect changing usage. However, examination of the variation in species' feeding activity did help to show which were the best tidal states for recording the feeding distributions of different species. While low tide counts were suitable for describing the feeding distributions of many species of wader, it would have been preferable to record the feeding distributions of some species of wildfowl on the ebb or flood tide. Even for these latter species (notably Wigeon), although the proportion feeding dropped at low tide it was not clear that the birds moved away from the feeding area; they may simply have been waiting in the same general area for the tide to rise again. Overall, the work showed that LTCs are a good representation of average site usage through the tidal cycle, although the numbers of study sites and species available for consideration were limited.

Clearly, further information would be gained through additional counts at other states of the tide, but this is largely beyond the scope of a volunteer survey and should be undertaken on a case-by-case basis, as and when the need arises.

USES

The use of low tide count information for applied research topics is of great value for the conservation of estuarine habitats and estuarine birds, whilst more pure research can also provide valuable contextual information.

The value of estuarine waterbird data collected at low tide is clearly demonstrated by the two case studies describing the use of low tide count data in conservation casework. In the case of Rock Ferry, a potentially damaging development was averted. Whilst the results of the public enquiry for Dibden Bay are, at the time of writing, unknown, the LTC data has provided objective information to enable an informed decision to be made. A number of other studies have used counts made at low tide to investigate the effects on estuarine waterbirds of habitat loss, either actual (Evans 1978/79, Evans and Pienkowski 1984, Evans 1997b, Meire 1991, Lambeck 1991) or predicted (Clark and Prys-Jones 1994, Goss-Custard *et al.* 1991, Goss-Custard and Yates 1992, Yates *et al.* 1996, Rehfisch *et al.* 1997, Rehfisch *et al.* 2000, Austin *et al.* 1996), whilst Evans *et al.* (2001) investigated the potential effects of a barrage across the river Tees, where no habitat loss occurred downstream of the development. Further research has been carried out into the potential effects of disturbance on estuarine waterbirds at low tide (Burton *et al.* 2002a, Davidson and Rothwell 1993, Burton *et al.* 2002b, Madsen and Fox 1995, Goss-Custard and Verboven 1993, Owen 1993, Musgrove *et al.* 2001b).

As well as these studies, low tide counts of waterbirds have been used widely for other research purposes. A number of studies have used low tide count data to investigate how waterbird distributions vary according to prey densities and to look at species' habitat use and preferences. Goss-Custard *et al.* (1977, 1988) used low tide counts to describe the distribution of feeding waders on the inner banks of the Wash. In a further study on the Severn Estuary, Goss-Custard *et al.* (1991) used counts undertaken at low tide to relate densities of waders to densities of their favoured prey. Goss-Custard *et al.* (1992) also investigated variation in the densities of Oystercatchers using the Exe Estuary at low tide. Moreira (1993) used low tide counts to investigate species' associations and habitat preferences on the Tagus Estuary in Portugal, whilst on the Mondego Estuary, also in Portugal, Múrias *et al.* (1997) found that species differed in their use of intertidal mudflats and adjacent salinas at low tide. Masero *et al.* (2000) investigated seasonal differences in preferences between intertidal mudflats and salinas in Cádiz Bay in Spain. Weber and Haig (1996) investigated variation in wader densities at low tide between diked, managed wetlands and natural mudflats in South Carolina, whilst Colwell and Landrum (1993) similarly used low tide counts to test whether or not the spatial distribution of waders varied across the Mad River Estuary in California and whether or not wader abundance was related to invertebrate densities. Cresswell (1994) investigated differences in the habitat use of adult and juvenile Redshank at Tyninghame in Lothian partly by using low tide count information. At a much larger scale, Austin *et al.* (1996, in prep.) used low tide count information (obtained by Holloway *et al.* 1996) to look at variation in the densities of waders between British estuaries in relation to factors such as estuary location, sediment type and measures of estuary morphology.

8 The future of the WeBS Low Tide Counts

Andy Musgrove

The WeBS Low Tide Counts have been highly successful in gathering baseline data on inter-tidal waterbird distribution for many sites. It would be short-sighted to consider there to be little need for the scheme to continue. Long-term monitoring schemes have many advantages over occasional, reactive surveys. Firstly, a continuous, long-term scheme, using a standardised method, yields data of a consistent nature. Surveys carried out on an ad hoc basis, instigated as and when particular needs arise, would probably be organised by a number of different organisations, making comparisons with other low tide surveys difficult. Secondly, maintaining the LTCs as part of the wider Wetland Bird Survey maintains the relationship with the WeBS network of volunteer counters and thus is more cost-effective than piecemeal surveys which would have repeated start-up costs and probably would involve professional fieldworkers. The local volunteer counters have the best knowledge of the waterbirds on a site as they are often those who also carry out WeBS Core Counts there. Additionally, a continuous scheme makes use of standardised infrastructure, such as recording forms and instructions, inputting techniques, validation checks and presentation of results. Comparison between sites and between years is therefore straightforward.

Much use is made of LTC data in assessing developments on estuaries. It is important that if such cases come to public enquiry the data are seen to be impartial, with the same figures available to all. If counts were carried out on a purely reactionary basis then this impartiality could be more open to question. Similarly, when there is a need for data, for whatever reason, it is usually required immediately. Faced with a lack of data, one would have to design a survey, recruit counters, carry out counts and analyse the data, a process of many months at the very least. With a continuous scheme, the data from the latest survey of a site, once collated and processed, are immediately available and can provide added value to any additional data collected specifically as part of an environmental impact assessment, as well as providing a suitable method and count sections for the latter.

Finally, carrying out ad hoc surveys can only address short-term issues. However, some important questions are best addressed using a suite of low tide data collected in a standardised fashion at regular intervals over a longer time period. These include the effects of sea-level rise on estuaries or gradual changes in pollution or disturbance. In many cases, waiting until a problem is identified before carrying out a survey greatly reduces the chance of being able to measure its impact.

Therefore, the LTCs should continue to collect vital information on estuarine waterbirds in much the same format as previously. Clearly, improved coverage of partially covered sites and sites not covered at all to date will be a priority. However, some modifications and developments could also be introduced, in the light of this report, to increase the value of the scheme. Additionally, research should be undertaken to address some of the interpretative issues raised by this volume, as well as to increase our knowledge of the between-site movements of estuarine waterbirds, a subject which could be tackled in conjunction with the various colour-ringing and colour-marking schemes that are in operation.

The WeBS Low Tide Counts have clearly been a great success. They have not only gathered a huge amount of novel information but have also been effective in directing the data into areas where it can make a difference. The success of the scheme and its contribution to conservation, to date and in the future, are due to the dedication of the skilled volunteer counters and the network of local organisers. With the continued support of the volunteer network the WeBS Low Tide Counts should continue to be a vital and influential source of information.

References

Alerstam, T, Gudmundsson, G A and Johannesson, K (1992) Resources for long-distance migration – intertidal exploitation of *Littorina* and *Mytilus* by Knots *Calidris canutus* in Iceland. *Oikos*, 65, 179–189

Andrews, D J, Mathers, R G and Rainey, E (1996) Brent Geese feeding on agricultural land around Strangford Lough, Co. Down. *Irish Birds*, 5, 407–412

Armitage, M J S, Rehfisch, M M and Burton, N H K (2000) *The impact of the* Sea Empress *oil spill on the abundance and distribution of waterbirds within Milford Haven. Year 3 Final Report, February 2000*. BTO Research Report No. 227 to the Countryside Council for Wales and the Sea Empress Environmental Evaluation Committee. BTO, Thetford

Aspinall, S J and Tasker, M L (1992) *Birds of the Solent.* JNCC, Peterborough

Atkinson, P W, Austin, G E, Burton, N H K, Musgrove, A J, Pollitt, M and Rehfisch, M M (2000) WeBS Alerts 1998/99: Changes in numbers of wintering waterbirds in the United Kingdom at national, country and Special Protection Area (SPA) scales. BTO Research Report No. 239. BTO, Thetford

Atkinson, P W, Clark, N A, Bell, M C, Dare, P J, Clark, J A and Ireland, P L (2003) Changes in commercially fished shellfish stocks and shorebird populations in the Wash, England. *Biological Conservation*, 114, 127-141

Austin, G E, Musgrove, A J, Rehfisch, M M and Armitage, M J S (2002) An objective method of quantifying the avian interest of an area by means of a weighted population index. *Wader Study Group Bulletin*, 99, 60–63

Austin, G E, Rehfisch, M M, Holloway, S J, Clark, N A, Balmer, D E, Yates, M G, Clarke, R T, Swetnam, R D, Eastwood, J A, Durell, S E A le V dit, West, J R and Goss-Custard, J D (1996) *Estuary Sediments and Shorebirds III. Predicting Waterfowl Densities on Intertidal Areas*. BTO Research Report No. 160 to ETSU. BTO, Thetford

Austin, G E, Rehfisch, M M, Viles, H A and Berry, P M (2001) Impacts on coastal environments. In *Climate Change and Nature Conservation in Britain and Ireland – modelling natural resource responses to climate change* (the MONARCH project) (eds P A Harrison, P M Berry and T P Dawson), pp. 177–228. UKCIP Technical Report, Oxford

Austin, G E, Rehfisch, M M, Yates, M G, Clarke, R T, Holloway, S J, Swetnam, R D, Clark, N A and Goss-Custard, J D (in prep.) Predicting waterbird numbers on British estuaries in relation to estuary morphology and geographic location

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P and Davidson, N C *eds* (1995a) *Coasts and seas of the United Kingdom. Region 5. North-east England: Berwick-upon Tweed to Filey Bay.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P and Davidson, N C *eds* (1995b) *Coasts and seas* *of the United Kingdom. Region 6. Eastern England: Flamborough Head to Great Yarmouth.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S and Doody, J P *eds* (1995c) *Coasts and seas of the United Kingdom. Region 12. Wales: Margam to Little Orme.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P and Davidson, N C *eds* (1996a) *Coasts and seas of the United Kingdom. Region 3. North-east Scotland: Cape Wrath to St. Cyrus.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P and Davidson, N C *eds* (1996b) *Coasts and seas of the United Kingdom. Region 9. Southern England: Hayling Island to Lyme Regis.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1996c) *Coasts and seas of the United Kingdom. Region 10. South-west England: Seaton to the Roseland Peninsula.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1996d) *Coasts and seas of the United Kingdom. Region 11. The Western Approaches: Falmouth Bay to Kenfig.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P and Davidson, N C *eds* (1996e) *Coasts and seas of the United Kingdom. Region 13. Northern Irish Sea: Colwyn Bay to Stranraer, including the Isle of Man.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1997a) *Coasts and seas of the United Kingdom. Region 1. Shetland.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1997b) *Coasts and seas of the United Kingdom. Region 2. Orkney.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1997c) *Coasts and seas of the United Kingdom. Region 4. South-east Scotland: Montrose to Eyemouth.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1997d) *Coasts and seas of the United Kingdom. Region 14. South-west Scotland: Ballantrae to Mull.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1997e) *Coasts and seas of the United Kingdom. Regions 15 & 16. North-west Scotland: the Western Isles and west Highland.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1997f) *Coasts and seas of the United Kingdom. Region 17. Northern Ireland.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1998a) *Coasts and seas of the United Kingdom. Region 7. South-east England: Lowestoft to Dungeness.* Joint Nature Conservation Committee, Peterborough

Barne, J H, Robson, C F, Kaznowska, S S, Doody, J P, Davidson, N C and Buck, A L *eds* (1998b) *Coasts and seas of the United Kingdom. Region 8. Sussex: Rye Bay to Chichester Harbour.* Joint Nature Conservation Committee, Peterborough

Bell, M C, Bannister, R C A, Walker, P, Atkinson, P W and Clark, N A (2001) Fisheries and bird predation as components of cockle (*Cerastoderma edule*) mortality in the Burry Inlet, South Wales. In *The Life History, Dynamics and Exploitation of Living Marine Resources: Advances in Knowledge and Methodology*. CM 2001/J:02. International Council for the Exploration of the Sea.

Bento, C and Rufino, R (2001) Numbers of waders at two sites in Mozambique, April 1999. *Wader Study Group Bulletin*, 92, 21–24

Bowes, C, Lack, P C and Fletcher, M R (1984) Wintering gulls in Britain, January 1983. *Bird Study*, 31, 161–170

Buck, A L (1993a) *An inventory of UK estuaries. Volume 2. South-west Britain.* Joint Nature Conservation Committee, Peterborough

Buck, A L (1993b) *An inventory of UK estuaries. Volume 3. North-west Britain.* Joint Nature Conservation Committee, Peterborough

Buck, A L (1993c) *An inventory of UK estuaries. Volume 4. North and East Scotland.* Joint Nature Conservation Committee, Peterborough

Buck, A L (1997a) *An inventory of UK estuaries. Volume 5. Eastern England.* Joint Nature Conservation Committee, Peterborough

Buck, A L (1997b) *An inventory of UK estuaries. Volume 6. Southern England.* Joint Nature Conservation Committee, Peterborough

Buck, A L and Donaghy, A (1996) *An inventory of UK estuaries. Volume 7. Northern Ireland.* Joint Nature Conservation Committee, Peterborough

Burger, J and Gochfeld, M (1991) Human activity influence and diurnal and nocturnal foraging of sanderlings (Calidris alba). *Condor*, 93, 259–265

Burton, N H K, Armitage, M J S, Raven, M J, Rehfisch, M M and Clark, N A (2001) The effect of the Cardiff Bay Barrage on waterbird populations. 11. Distribution and movement studies August 1999–May 2000. BTO Research Report No. 254 to Cardiff Bay Development Corporation and the County Council of the City and County of Cardiff. BTO, Thetford

Burton, N H K, Rehfisch, M M and Clark, N A (2002a) Impacts of disturbance from construction work on the densities and feeding behaviour of waterbirds using the intertidal mudflats of Cardiff Bay, UK. *Environmental Management*, 30, 865–871

Burton, N H K, Armitage, M J S, Musgrove, A J and Rehfisch, M M (2002b) Impacts of man-made landscape features on the numbers of estuarine waterbirds at low tide. *Environmental Management*, 30, 857–864

Burton, N H K, Musgrove, A J, Rehfisch, M M and Sutcliffe, A (2002c) Winter Gull Roosts in the United Kingdom in January 1993 with recommendations for future surveys of wintering gulls. BTO Research Report No. 277 to English Nature. BTO, Thetford

Burton, N H K, Musgove, A J and Rehfisch, M M (in press) Tidal variation in the numbers of waterbirds: how frequently should birds be counted to detect change and do low tide counts provide a realistic coverage? *Bird Study*

Catley, G (2000) *Humber Estuary Wetland Bird Survey: Twelve months of high and low tide counts September 1998 to August 1999.* English Nature, Peterborough

Cayford, J T and Waters, R J (1996) Population estimates for waders Charadrii wintering in Great Britain, 1987/88–1991/92. *Biological Conservation*, 77, 7–17

Clark, N A and Prys-Jones, R P (1994) Low tide distribution of wintering waders and Shelduck on the Severn Estuary in relation to the proposed tidal barrage. *Biological Journal of the Linnean Society*, 51, 199–217

Clausen, P, Madsen, J, Percival, S M, Anderson, G Q A, Koffiijberg, K, Mehlum, F and Vangeruwe, D (1999) Light-bellied Brent Goose *Branta bernical hrota*: Svalbard. In *Goose populations of the Western Palearctic: a review of status and distribution* (eds J Madsen, G Cracknell and A D Fox), pp 298–311. Wetlands International Publication No. 48/NERI, Denmark

Colhoun, K (2001) *The Irish Wetland Bird Survey 1998–99: Results from the fifth winter of the Irish Wetland Bird Survey*. BWI/NPW/WWT, Dublin

Colwell, M A and Landrum, S L (1993) Nonrandom shorebird distribution and fine-scale variation in prey abundance. *Condor*, 95, 94–103

Cramp, S (1977–1993) *Handbook of the Birds of Europe, the Middle East and North Africa: the birds of the Western Palearctic* (7 Vols). Oxford University Press, Oxford

Cresswell, W (1994) Age-dependent choice of Redshank (*Tringa totanus*) feeding location: profitability or risk? *Journal of Applied Ecology*, 63, 589–600

Cresswell, W (1999) Travel distance and mass gain in wintering Blackbirds. *Animal Behaviour*, 58, 1109–1126

Davidson, N C (1982) Changes in the body condition of Redshanks during mild winters: an inability to regulate reserves? *Ringing & Migration.*, 4, 51–63

Davidson, N C and Evans, P R (1982) Mortality of Redshank and Oystercatcher from starvation during severe weather. *Bird Study*, 29, 183–188

Davidson, N C, Laffoley, D d'A, Doody, J P, Way, L S, Key, R, Drake, C M, Pienkowski, M W, Mitchell, R and Duff, K L (1991) *Nature Conservation and Estuaries in Great Britain*. NCC, Northminster House, Peterborough

Davidson, N C and Buck, A L (1997) *An inventory of UK estuaries. Volume 1. Introduction and methodology*. Joint Nature Conservation Committee, Peterborough

Davidson, N C and Rothwell, P I (1993) Introduction. *Wader Study Group Bulletin*, 68, 1–2

Davidson, N C and Stroud, D A (1996) Conserving international coastal habitat networks on migratory waterfowl flyways. *Journal of Coastal Conservation*, 2, 41–54

Dinsmore, S J, Collazo, J A and Walters, J R (1998) Seasonal numbers and distribution of shorebirds on North Carolina's Outer Banks. *Wilson Bulletin*, 110, 171–181

Dodd, S L and Colwell, M A (1996) Seasonal variation in diurnal and nocturnal distributions of nonbreeding shorebirds at North Humboldt Bay, California. *Condor*, 98, 196–207

Dodd, S L and Colwell, M A (1998) Environmental correlates of diurnal and nocturnal foraging patterns of nonbreeding shorebirds. *Wilson Bulletin*, 110, 182–189

Dugan, P J, Evans, P R, Goodyer, L J and Davidson, N C (1981) Winter fat reserves in shorebirds: disturbance of regulated levels by severe weather conditions. *Ibis*, 123, 359–363

Dunne, P, Sibley, D, Sutton, C and Wander, W (1982) Aerial surveys in Delaware Bay: confirming an enormous spring staging area for shorebirds. *Wader Study Group Bulletin*, 35, 32–33

Ebbinge, B S, Berrevoets, C, Clausen, P, Ganmter, B, Günther, K, Koffiijberg, K, Mahéo, R, Rowcliffe, M, St Joseph, A K M, Südbeck, P and Syroechkovsky Jr, E E (1999) Dark-bellied Brent Goose *Branta bernicla bernicla*. In *Goose populations of the Western Palearctic: a review of status and distribution* (eds J Madsen, G Cracknell and A D Fox), pp 284–297. Wetlands International Publication No. 48/NERI, Denmark

Elkins, N and Lynch, B M (1997) Waterfowl counts on the Tay Estuary, 1985–1995. *Scottish Birds*, 19, 35–54

Ens, B J and Goss-Custard, J D (1984) Interference among Oystercatchers feeding on mussels on the Exe estuary. *Journal of Animal Ecology*, 53, 217–231

Evans, J (1997a) The use of WeBS Low-Tide Counts in predicting the effects of habitat loss. *Proceedings of 10th International Waterfowl Ecology Symposium*, 29–34

Evans, P R (1978/79) Reclamation of intertidal land: some effects on shelduck and wader populations in the Tees Estuary. *Verhandlungen der Ornithologische Gesellschaft in Bayern*, 23, 147–168

Evans, P R and Pienkowski, M W (1984) Implications for coastal engineering projects of studies, at the Tees estuary, on the effects of reclamation of intertidal land on shorebird populations. *Water, Science & Technology*, 16, 347–354

Evans, P R (1997b) Improving the accuracy of predicting the local effects of habitat loss on shorebirds: lessons from the Tees and Orwell Estuary studies. *Proceedings of 10th International Waterfowl Ecology Symposium*, 35–44

Evans, P R, Ward, R M and Bone, M (2001) Preliminary evaluation of the results of the 2000 Monitoring Programmes related to nature conservation concerns arising from the River Tees Barrage and Crossing Act 1990. English Partnerships.

Furness, R W, Galbraith, H, Gibson, I P and Metcalfe, N B (1986) Recent changes in numbers of waders on the Clyde Estuary, and their significance for conservation. *Proceedings of the Royal Society of Edinburgh.*, 90B, 171–184

Gardarsson, A and Gudmundsson, G A (1997) Numbers of Light-bellied Brent Geese *Branta bernicla hrota* staging in Iceland in spring. *Wildfowl* 47, 62–66

Gibbons, D W, Reid, J B and Chapman, R A (1993) *The New Atlas of Breeding Birds in Britain & Ireland*. Poyser, London

Gill, J A, Norris, K and Sutherland, W J (2001) The effects of disturbance on habitat use by Black-tailed Godwits *Limosa limosa*. *Journal of Applied Ecology*, 38, 846–856

Goss-Custard, J D (1980) Competition for food and interference among waders. *Ardea*, 68, 31–52

Goss-Custard, J D, Caldow, R W G and Clarke, R T (1992) Correlates of the density of foraging Oystercatchers *Haematopus ostralegus* at different population sizes. *Journal of Animal Ecology*, 61, 159–173

Goss-Custard, J D, Jones, R E and Newberry, P E (1977) The ecology of the Wash. I. Distribution and diet of wading birds (Charadrii). *Journal of Applied Ecology*, 14, 681–700

Goss-Custard, J D and Verboven, N (1993) Disturbance and feeding shorebirds on the Exe Estuary. *Wader Study Group Bulletin*, 68, 59–66

Goss-Custard, J D, Warwick, R M, Kirby, R, McGrorty, S, Clarke, R T, Pearson, B, Rispin, W E, Durell, S E A le V dit and Rose, R J (1991) Towards predicting wading bird densities from predicted prey densities in a post-barrage Severn Estuary. *Journal of Applied Ecology*, 28, 1004–1026

Goss-Custard, J D and Yates, M G (1992) Towards predicting the effect of salt-marsh reclamation on feeding bird numbers on the Wash. *Journal of Applied Ecology*, 29, 330–340

Goss-Custard, J D, Yates, M G, McGrorty, S, Lakhani, K, Durell, S E A le V dit, Clarke, R T, Rispin, E, Moy, I, Parsell, R and Yates, T (1988) *Wash birds and invertebrates*. Report to the Department of the Environment. ITE

Groves, S (1978) Age-related differences in Ruddy Turnstone foraging and aggressive behavior. *Auk*, 95, 95–103

Gudmundsson, G A and Lindstrom, A (1992) Spring migration of Sanderlings *Calidris alba* through SW Iceland – wherefrom and whereto? *Ardea*, 80, 315–326

Gudmundsson, G A, Lindstrom, A and Alerstam, T (1991) Optimal fat loads and long-distance flights by migrating Knots *Calidris canutus*, Sanderlings *C. alba* and Turnstones *Arenaria interpres*. *Ibis*, 133, 140–152

Harradine, J (1985) Duck shooting in the United Kingdom. *Wildfowl*, 36, 81–94

Holloway, S J, Rehfisch, M M and Clark, N A (1992) *Dispersion of waterfowl on the Mersey in relation to their prey*. BTO Research Report No. 96 to the Mersey Barrage Company

Holloway, S (1997) *Winter distribution and disturbance of wildfowl and waders on Findhorn Bay*. BTO Research Report No. 179. BTO, Thetford

Holloway, S J, Rehfisch, M M, Clark, N A, Balmer, D E, Austin, G, Yates, M G, Clarke, R T, Swetnam, R D, Eastwood, J A, Durell, S E A le V dit, Goss-Custard, J D and West, J R (1996) *Estuary, Sediments and Shorebirds II. Shorebird Usage of Intertidal Areas*. BTO Research Report No. 156 to ETSU. BTO, Thetford

JNCC (1993–1997) *An inventory of UK estuaries. Volumes 1–7.* Joint Nature Conservation Committee, Peterborough. See Davidson and Buck (1997), Buck (1993a), Buck (1993b), Buck (1993c), Buck (1997a), Buck (1997b), Buck and Donaghy (1996).

JNCC (1995–1998). *Coastal Directories Series – Coasts and seas of the United Kingdom.* Joint Nature Conservation Committee, Peterborough. See Barne *et al.* (1995a–c), (1996a–e), (1997a–f), (1998a–b).

Johnson, C (1985) Patterns of seasonal weight variation in waders on the Wash. *Ringing & Migration*, 6, 19–32

Kershaw, M (1997) Comparison of midweek versus weekend waterbird counts using data from the Cotswold Water Park. WWT Research Report to the WeBS partners. WWT, Slimbridge

Kershaw, M and Cranswick, P A (2003) Numbers of wintering waterbirds in Great Britain, 1994/1995–1998/1999: I. Wildfowl and selected waterbirds. *Biological Conservation.*, 111, 91–104

Kirby, J S (1995) Winter population estimates for selected waterfowl species in Britain. *Biological Conservation.*, 73, 189–198

Kirby, J S and Lack, P C (1993) Spatial dynamics of wintering Lapwings and Golden Plovers in Britain and Ireland, 1981/82 to 1983/84. *Bird Study,* 40, 38–50

Lack, P C (1986) *The Atlas of Wintering Birds in Britain & Ireland*. Poyser, Calton

Lambeck, R H D (1991) Changes in abundance, distribution and mortality of wintering Oystercatchers after habitat loss in the Delta area, SW Netherlands. *Acta XX Congressus Internationalis Ornithologici*, 2208–2218

Madsen, J and Fox, A D (1995) Impacts of hunting disturbance on waterbirds – a review. *Wildlife Biology*, 1, 193–207

Masero, J A, Pérez-Hurtado, A, Castro, M and Arroyo, G M (2000) Complementary use of intertidal mudflats and adjacent salinas by foraging waders. *Ardea*, 88, 177–191

Mason, C F and MacDonald, S M (1999) Estuarine feeding by Lapwings *Vanellus vanellus* and Golden Plovers *Pluvialis apricaria*. *Wildfowl*, 50, 205–207

Meire, P M (1991) Effects of a substantial reduction in intertidal area on numbers and densities of waders. *Acta XX Congressus Internationalis Ornithologici*, 2219–2227

Meltofte, H, Blew, J, Frikke, J, Rösner, H-U and Smit, C J (1994) Numbers and distribution of waterbirds in the Wadden Sea. Results and evaluation of 36 simultaneous counts in the Dutch-German-Danish Wadden Sea 1980–1991. IWRB Publication 34/*Wader Study Group Bulletin*, 74 (Special Issue)

Merne, O J, Boertmann, D, Boyd, H, Mitcvhell, C, Ó'Briain, M, Reed, A and Sigfusson, A (1999) Light-bellied Brent Goose *Branta bernicla hrota*: Canada. In *Goose populations of the Western Palearctic: a review of status and distribution* (eds J Madsen, G Cracknell and A D Fox), pp 298–311. Wetlands International Publication No. 48/NERI, Denmark

Metcalfe, N B and Furness, R W (1984) Changing priorities: the effect of pre-migratory fattening on the trade-off between foraging and vigilance. *Behavioural Ecology and Sociobiology*, 15, 203–206

Mitchell, J R, Moser, M and Kirby, J S (1988) Declines in midwinter counts of waders roosting on the Dee estuary. *Bird Study*, 35, 191–198

Moreira, F (1993) Patterns of use of intertidal estuarine areas by feeding bird assemblages: a study in the Tagus Estuary (Portugal). *Ardeola*, 40, 39–53

Moser, M E (1987) A revision of population estimates for waders (Charadrii) wintering on the coastline of Britain. *Biological Conservation*, 39, 153–164

Moser, M E and Summers, R W (1987) Wader populations on the non-estuarine coasts of Britain and Northern Ireland: results of the 1984–85 Winter Shorebird Count. *Bird Study*, 34, 71–81

Múrias, T, Cabral, J A, Lopes, R and Marques, J C (1997) Low water use of the Mondego Estuary (West Portugal) by waders (Charadrii). *Ardeola*, 44, 79–91

Musgrove, A J (1998) *Validation of WeBS Methodology – The Relationship between Waterfowl Counts carried out at High and Low Tide*. BTO Research Report No. 190 to the WeBS Partners. BTO, Thetford

Musgrove, A J (2002) The non-breeding status of the Little Egret in Britain. *British Birds*, 95, 62–80

Musgrove, A J and Holloway, S J (1997) *Counting waterfowl on large estuaries at low tide*. BTO Research Report No. 178 to the WeBS Partners. BTO, Thetford

Musgrove, A J, Pollitt, M S, Hall, C, Hearn, R D, Holloway, S J, Marshall, P E, Robinson, J A and Cranswick, P A (2001a) *The Wetland Bird Survey 1999–2000: Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge

Musgrove, A J, Clark, N A, Gill, J and Ravenscroft, N O M (2001b) *A Review of Wildfowling on the Stour Estuary*. BTO Research Report No. 248 to English Nature. BTO, Thetford

Natural Environment Research Council (1975) *Estuaries research*. Natural Environment Research Council Publications series 'B', No. 9.

Norman, D and Coffey, P (1994) The importance of the Mersey estuary for waders in the cold weather of February 1991. Ringing & Migration, 15, 91–97

Norris, K, Bannister, R C A and Walker, P W (1998) Changes in the number of oystercatchers *Haematopus ostralegus* wintering in the Burry Inlet in relation to the biomass of cockles *Cerastoderma edule* and its commercial exploitation. *Journal of Applied Ecology*, 35, 75–85

O'Briain, M and Healy, B (1991) Winter distribution of Light-bellied Brent Geese *Branta bernicla* hrota in Ireland. *Ardea*, 79, 317–326

Owen, M (1993) The UK shooting disturbance project. *Wader Study Group Bulletin*, 68, 35–46

Pienkowski, M W, Lloyd, C S and Minton, C D T (1979) Seasonal and migrational weight changes in Dunlins. *Bird Study*, 26, 134–148

Pienkowski, M W (1981) How foraging plovers cope with environmental effects on invertebrate behaviour and availability. In *Feeding and survival strategies of estuarine organisms* (eds N V Jones and W J Wolff), pp. 179–192. Plenum Press, New York

Pienkowski, M W (1983) The effects of environmental conditions on feeding rates and prey selection by shore plovers. *Ornis Scandinavica*, 14, 227–238

Pienkowski, M W (1983) Changes in the foraging pattern of plovers in relation to environmental factors. *Animal Behaviour*, 31, 244–264

Piersma, T, Koolhaas, A, Dekinga, A, Beukema, J J, Dekker, R and Essink, K (2001). Long-term indirect effects of mechanical cockle-dredging on intertidal bivalve stocks in the Wadden Sea. *Journal of Applied Ecology*, 38, 976–990

Pollitt, M S, Cranswick, P A, Musgrove, A J, Hall, C, Hearn, R D, Robinson, J A and Holloway, S J (2000) *The Wetland Bird Survey* 1998–99: *Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge

Pollit, M S, Hall, C, Holloway, S J, Hearn, R D, Marshall, P E, Musgrove, A J, Robinson, J A, & Cranswick, P A, (2003) *The Wetland Bird Survey 2000 - 2001: Wildfowl and Wader Counts*. BTO/WWT/RSPB/JNCC, Slimbridge.

Prater, A J (1981) *Estuary Birds of Britain and Ireland*. Poyser, Calton

Prato, E S da and Prato, S R D da (1979) Counting wintering waders on rocky shores in East Lothian, Scotland. *Wader Study Group Bulletin*, 25, 19–23

Raffaelli, D and Milne, H (1987) An experimental investigation of the effects of shorebird and flatfish predation on estuarine invertebrates. *Estuarine Coastal And Shelf Science*, 24, 1–13

Ramsar Convention Bureau (1988) *Convention on Wetlands of International Importance especially as Waterfowl Habitat*. Proceedings of the third meeting of the Conference of the Contracting Parties, Regina, Canada, 1987. Ramsar, Switzerland

Rehfisch, M M, Sim, J, Clark, N A, Donald, P F and Warbrick, S (1991) *Waterfowl distribution and diet on the Mersey Estuary and adjacent areas*. BTO Research Report No. 77 to the Mersey Barrage Company. BTO, Thetford

Rehfisch, M M, Holloway, S J, Yates, M G, Clarke, R T, Austin, G, Clark, N A, Durell, S E A le V. dit, Eastwood, J A, Goss-Custard, J D, Swetnam, R and West, J R (1997) Predicting the effect of habitat change on waterfowl communities: a novel empirical approach. *Proceedings of 10th International Waterfowl Ecology Symposium*, 116–126

Rehfisch, M M, Austin, G E, Clark, N A, Clarke, R T, Holloway, S J, Yates, M G, Durell, S E A le V dit, Eastwood, J A, Goss-Custard, J D, Swetnam, R D and West, J R (2000) Predicting densities of wintering Redshank *Tringa totanus* from estuary characteristics: a method for assessing the likely impact of habitat change. *Acta Ornithologica*, 35, 25–32

Rehfisch, M M, Austin, G E, Armitage, M, Atkinson, P, Holloway, S J, Musgrove, A J and Pollitt, M S (2003) Numbers of wintering waterbirds in Great Britain and the Isle of Man (1994/95–1998/99): II. Coastal waders (Charadrii). *Biological Conservation*, 112, 329-341.

Rose, P M and Scott, D A (1997) *Waterfowl Population Estimates* (2nd Edition). Wetlands International Publ. 44. Wageningen, The Netherlands

Salvig, J C, Asbirk, S, Kjeldsen, J P and Rasmussen, P A F (1994) Wintering waders in the Bijagos Archipelago, Guinea-Bissau 1992–1993. *Ardea*, 82, 137–141

Salvig, J C, Asbirk, S, Kjeldsen, J P, Rasmussen, P A F, Quade, A, Frikke, J and Christophersen, E (1997) Coastal waders in Guinea-Bissau – aerial survey results and seasonal occurrence on selected low water plots. *Wader Study Group Bulletin*, 84, 33–38

Scheiffarth, G, Nehls, G and Austen, I (1996) Modelling distribution of shorebirds on tidal flats in the Wadden Sea and visualisation of results with the GIS IDRISI. In *IDRISI GIS 96, Salzburger Geographische Materialien, Heft 25* (eds E Lorup and J Strobl). Selbstverlag des Instituts für Geographie der Universität, Salzburg

Sharrock, J T R (1976) *The Atlas of Breeding Birds in Britain & Ireland*. Poyser, Berkhamsted

Smiddy, P and O'Sullivan, O (1998) The status of the Little Egret *Egretta garzetta* in Ireland. *Irish Birds*, 6, 201–206

Snow, D W and Perrins, C M (1998) *The Birds of the Western Palearctic, Concise Edition*. Oxford University Press, Oxford

Stroud, D A, Chambers, D, Cook, S, Buxton, N, Fraser, B, Clement, P, Lewis, P, McLean, I, Baker, H and Whitehead, S (2001) *The UK SPA Network: its Scope and Content*. Joint Nature Conservation Committee, Peterborough

Symonds, F L, Langslow, D R and Pienkowski, M W (1984) Movements of wintering shorebirds within the Firth of Forth: species differences in usage of an intertidal complex. *Biological Conservation*, 28, 187–215

Tubbs, C R, Tubbs, J M and Kirby, J S (1992) Dunlin *Calidris alpina alpina* in The Solent, southern England. *Biological Conservation*, 60, 15–24

Tubbs, C R and Wiseman, E J (1992) Severe weather wader kill in The Solent, southern England, during February 1991. *Wader Study Group Bulletin*, 66, 61–62

Unsworth, D J (1994) 1992/93 Low Tide Survey of Portsmouth Harbour. Hampshire Bird Report 1993

Vickery, J A, Sutherland, W J, Watkinson, A R, Lane, S J and Rowcliffe, J M (1995) Habitat switching by Dark-bellied Brent Geese *Branta b. bernicla* (L.) in relation to food depletion. *Oecologia*, 103, 499–508

Voisin, C (1991) *The Herons of Europe*. T & A D Poyser, London

Ward, R M (1991) *The potential for tidal power generation at western European coastal wetlands: Identifica-*

tion of sites and their biological importance. Unpublished MSc thesis, University of Durham

Warnock, S E and Takekawa, J Y (1996) Wintering site fidelity and movement patterns of Western Sandpipers *Calidris mauri* in the San Francisco Bay estuary. *Ibis*, 138, 160–167
Weber, L M and Haig, S M (1996) Shorebird use of South Carolina managed and natural coastal wetlands. *Journal of Wildlife Management*, 60, 73–82

Wernham, C V, Toms, M P, Marchant, J H, Clark, J A, Siriwardena, G M and Baillie, S R (eds) (2002) *The Migration Atlas: movements of the birds of Britain and Ireland*. Poyser, London

Wiersma, P and Piersma, T (1994) Effects of microhabitat, flocking, climate and migratory goal on energy expenditure in the annual cycle of Red Knots. *Condor*, 96, 257–279

Wildfowl & Wader Counts (annual). BTO / WWT / RSPB / JNCC, Slimbridge. See Pollit *et al.* 2003, Musgrove *et al.* 2001, Pollitt *et al.* 2000 for three most recent

Wood, A G (1984) Time and energy budgets of the Grey Plover (*Pluvialis squatarola*) at Teesmouth. Ph.D. thesis, University of Durham

Yates, M G and Goss-Custard, J D (1991) A comparison between high water and low water counts of shorebirds on the Wash, east England. *Bird Study*, 38, 179–187

Yates, M G, Goss-Custard, J D and Rispin, W E (1996) Towards predicting the effect of loss of intertidal feeding areas on overwintering shorebirds (Charadrii) and shelduck (*Tadorna tadorna*): refinements and tests of a model developed for the Wash, east England. *Journal of Applied Ecology*, 33, 944–954

Young Associates (2000) Rock Park Waterfront Marine Lake: Appropriate Assessment for Metropolitan Borough of Wirral Planning and Economic Development Department. Young Associates and Andrews Ward Associates

Zwarts, L (1988) Numbers and distribution of coastal waders in Guinea-Bissau. *Ardea*, 76, 42–55

Zwarts, L and Wanink, J H (1993) How the food supply harvestable by waders in the Wadden Sea depends on the variation in energy density, body weight, biomass, burying depth and behaviour of tidal-flat invertebrates. *Netherlands Journal of Sea Research* 31, 441–476

Glossary

Accuracy
Within the context of the LTCs during the period under review, an accuracy code (1–4) is requested from counters to indicate how accurately they feel each species count reflects the actual number present (see Methods).

Activities
Whilst carrying out LTCs, counters are asked to record any types of human activity present at the site during the count (see Methods).

Density
The number of birds per unit area. Within the context of the LTCs, bird densities are always expressed in birds per hectare. In general, mean densities are used (*i.e.* the mean number of birds per unit area over a given time period, usually a winter (*q.v.*)).

Disturbance
Whilst recording activities (*q.v.*), counters are asked to indicate which of those activities are 'affecting the birds'. Additionally, counters are asked to provide an overall assessment of the level of disturbance on each mudflat (see Methods).

Feeding
Within the context of the LTCs during the period under review, counters are asked to record all birds in the 'number feeding' column except for those birds that are definitely roosting (q.v.).

Great Britain (GB)
Great Britain comprises England, Scotland and Wales, but excludes the Channel Islands and the Isle of Man.

Internationally important
A site is considered internationally important if it regularly holds at least 1% of the individuals in a population of one species or subspecies of waterbird, or if it regularly supports 20,000 or more individual waterbirds (Ramsar Convention Bureau 1988).

Intertidal
Within the context of the LTCs, the area of the intertidal zone is calculated as the area of that part of a count section which lies between mean low water and mean high water.

Nationally important
A site is considered nationally important if it regularly holds 1% or more of the estimated national (British or all-Ireland) population of a species or subspecies of waterbird.

Nontidal
Within the context of the LTCs, the area of the nontidal zone is calculated as the area of that part of a count section which lies above mean high water. It should be noted that, despite the term 'nontidal', some of this area is under tidal influence at times, such as the higher zone of a saltmarsh. The term 'nontidal' has been adopted for use within the scheme only; where the alternative hyphenated phrase 'non-tidal' is used this refers to a habitat not influenced by the tide.

Peak mean
Mostly used within the context of WeBS Core Counts. Calculated by averaging the peak count in each season for a particular species at an individual site. Normally calculated using the most recent five years' data.

Ramsar site
An area designated under the Convention on Wetlands of International Importance (1971).

Raptors
Birds of prey, including owls. Within the context of the LTCs during the period under review, raptors are treated as equivalent to human activities and as potential disturbance, rather than a species to monitor numerically.

Roosting
Within the context of the LTCs during the period under review, counters are asked to record roosting birds, including wildfowl 'loafing' on the

water, in the 'number roosting' column of the recording form.

Saltmarsh
A vegetated area experiencing periodic inundation by tidal water.

Section
Within the context of the LTCs, a section is a discrete subdivision of a site for which a counter provides the finest level of count detail.

Site
An area described as a site within the context of the LTCs does not necessarily have the same geographic boundaries as a site given the same name by any other scheme (including the WeBS Core Counts).

Special Protection Area (SPA)
An area classified under Article 4 of the EU Directive on the Conservation of Wild Birds (79/409/EEC).

SPA network
The total UK network of all classified or proposed SPAs.

Subtidal
Within the context of the LTCs, the subtidal zone is used to describe water-covered areas of a count section. The area of the subtidal zone is calculated as the area of that part of the section below mean low water.

1% Threshold Value
The number of birds that are used as the nominal 1% of the relevant population for the purposes of site selection. The data used within this review span the period 1992–93 to 1998–99 and thus the 1% Threshold Values used are those listed in Musgrove *et al.* (2001a) and based on population reviews by Kirby (1995), Cayford and Waters (1996), Way *et al.* (1993), Smit and Piersma (1989) and Rose and Scott (1997).

United Kingdom (UK)
The United Kingdom comprises England, Scotland, Wales and Northern Ireland (but excludes the Channel Islands, the Isle of Man, the Overseas Territories and Crown Dependencies).

Visit
Within the context of the LTCs, a visit refers to the counts made on a single section on a single date.

Waders
Within the context of the LTCs, used to refer to species of the families Haematopodidae, Recurvirostridae, Charadriidae and Scolopacidae.

Waterbirds
The term 'waterbirds' is a somewhat artificial grouping, comprising a number of distinct avian families linked by habitat preferences as opposed to strict taxonomic relationships (Rose and Scott 1997). Within a UK context, waterbirds include divers (Gaviidae), grebes (Podicipedidae), cormorants (Phalacrocoracidae), herons (Ardeidae), wildfowl (Anatidae), rails (Rallidae), waders (Haematopodidae, Recurvirostridae, Charadriidae, Scolopacidae), gulls (Laridae) and terns (Sternidae), although a few additional species are discussed within this book also. The term 'waterbirds' has superseded 'waterfowl' (which was used in the UK until quite recently), since the latter is used commonly in North America as a label for only the Anatidae.

Wildfowl
Generally used to refer to species belonging to the Family Anatidae, *i.e.* ducks, geese and swans.

Wildfowl and Wader Counts
The annual report of the Wetland Bird Survey (see References).

Winter
Within the context of the LTCs, a winter refers to the four months November to February inclusive. It should be noted that this definition is different to that used for the WeBS Core Counts.